U.S. ARMY

MATERIEL DEVELOPMENT AND READINESS COMMAND

MANUFACTURING METHODS & TECHNOLOGY

PROJECT SUMMARY REPORTS

(RCS DRCMT-302)

DECEMBER 1982

PREPARED BY

USA INDUSTRIAL BASE ENGINEERING ACTIVITY

MANUFACTURING TECHNOLOGY DIVISION

ROCK ISLAND, ILLINOIS 61299

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US ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY
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SUBJECT: Manufacturing Methods and Technology Program Project Summary Report (RCS DRCMT-302)

SEE DISTRIBUTION (Appendix II to Inclosure 1)

1. In compliance with AR 700-90, dated 15 March 1982, the Industrial Base Engineering Activity (IBEA) has prepared the inclosed Project Summary Report.

2. This Project Summary Report is a compilation of MMT Summary Reports prepared by IBEA based on information submitted by DARCOM major subordinate commands and project managers. These projects represent a cross section of the type of efforts that are being conducted under the Army's Manufacturing Methods and Technology Program. Persons who are interested in the details of a project should contact the project officer indicated at the conclusion of each individual report.

3. Additional copies of this report may be obtained by written request to the Defense Technical Information Center, ATTN: TSR-1, Cameron Station, Alexandria, VA 22314.

1 Incl
as

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains summaries of 119 projects that were completed under the Army's Manufacturing Methods and Technology (MMT) Program. The MMT program was established to upgrade manufacturing facilities used for the production of Army Materiel. The summaries highlight the accomplishments and benefits of the projects and the implementation actions underway or planned. Points of contact are also provided for those who are interested in obtaining additional information.

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INTRODUCTION

Background

The Manufacturing Methods and Technology (MMT) Program was established to upgrade manufacturing facilities used for the production of Army materiel, and as such, provides direct support to the Industrial Preparedness Program. The Manufacturing Methods and Technology Program consists of projects which provide engineering effort for the establishment of manufacturing processes, techniques, and equipment by the Government or private industry to provide for timely, reliable, economical, and high-quality quantity production means. The projects are intended to bridge the gap between demonstrated feasibility and full-scale production. The projects are normally broad based in application, are production oriented, and are expected to result in a practical process for production. The projects do not normally include the application of existing processes, techniques, or equipment to the manufacture of specific systems, components, or end items, nor do they apply to a specific weapon system development or a product improvement program.

MMT Program Participation

MMT Programs are prepared annually by DARCOM major subordinate commands. These programs strive for the timely establishment or improvement of the manufacturing processes, techniques, or equipment required to support current and projected programs.

Project proposals (Exhibits P-16) are submitted to the appropriate MMT Program Office. A list of offices is provided in Appendix I. Additional information concerning participation in the MMT Program can be obtained by contacting an office listed or by contacting Mr. James Carstens, AUTOVON 793-5113, or Commercial (309) 794-5113, Industrial Base Engineering Activity, Rock Island, IL 61299.

In anticipation of the lengthy DOD funding cycles, projects must be submitted in sufficient time for their review and appraisal prior to the release of funds at the beginning of each fiscal year. Participants in the program must describe manufacturing problems and proposed solutions in Exhibit P-16 formats (see AR 700-90, 15 march 1982, for instructions). Project manager offices should submit their proposals to the command that will have mission responsibility for the end item that is being developed.

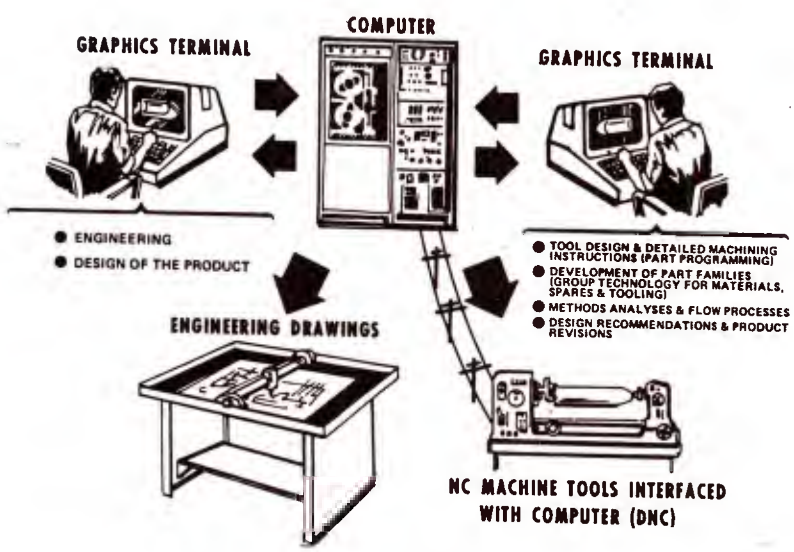
Contents

This report contains summaries of 119 completed projects that were funded by the MMT Program. The summaries are prepared from Project Status Reports (RCS DRCMT-301) and Final Technical Reports submitted by organizations executing the MMT projects. The summaries highlight the accomplishments and benefits of the projects and the implementation actions under way or planned. Points of contact are also provided for those interested in obtaining additional information.

The MMT Program addresses the entire breadth of the Army production base and, therefore, involves many technical areas. For ease of referral, the project summaries are grouped into six technical areas. The technical areas are: CAD/CAM, Electronics, Inspection and Test, Metals, Munitions, and Non-Metals. A page of abstracts leads off each of these groups. Abstracts were prepared to highlight projects which achieved significant accomplishments.

The Summary Reports are prepared and published for the Directorate for Manufacturing Technology, DARCOM, by the Manufacturing Technology Division of the US Army Industrial Base Engineering Activity (IBEA) in compliance with AR 700-90. The report was compiled and edited by Mr. Andrew Kource, Jr. and ably assisted by Mrs. Eileen Griffing and Mrs. Sally Weckel with the typing and graphics arrangements.

COMPUTER AIDED DESIGN/
COMPUTER AIDED MANUFACTURING
(CAD/CAM)



INFORMATIONAL FLOW IN A COMPUTER SYSTEM

ABSTRACTS

Project Number	Project Title	Page
G80 0001	Voice Controlled Programming of Computers	C-3

This project implemented voice control as an input to computer controlled graphics. The commands which were frequently used and had low or moderate cursor control requirements were chosen for voice input. Supplementing current inputs with voice commands is expected to reduce the cost of preparing numerically controlled machine tool tapes by $45,000 per year at Tobyhanna Army Depot.

570 4147, 574 4147	Computer Control Application to Continuous TNT Manufacture	C-12

This effort indicated computer control over two TNT production lines in an effort to reduce cost and danger to operators engaged in manual process control within the immediate production area. Both a direct digital control (DDC) method and a digitally directed analog control (DDAC) method were tested. DDC resulted in a 16% yield increase, a reduction in the required operating personnel of 48, and the installation of a similar system at Joliet AAP.

579 6682	Simulation of Ammunition Production Lines	C-16

This project used digital simulation techniques to predict equipment requirements for new production lines or modification of existing lines. Needed buffer sizes and expected production thruput can be predicted more accurately using this simulation technique. The methodology is expected to optimize output and cost. It has been implemented at ARRADCOM and Louisianna AAP.

580 6736-03	Army Support for Initial Graphics Exchange Specifications (IGES)	C-19

Exchanging CAD/CAM data between companies and suppliers utilizing different software was a major factor because of conversion cost and loss of time. In a joint effort with the Navy, Air Force, NASA and with assistance from 45 companies, this project created an Initial Graphics Exchange Specification (IGES) document to facilitate communication between different graphics interfaces. IGES was adopted as ANSI Standard Y.14.26M and ten vendors now plan to support IGES software within their turnkey graphics systems. Over 1,000 requests for IGES have been received, and work on an improved Version 2.0 is continuing.

677 7649, 678 7649 Computerized Powder Metallurgy Forging Design C-34

This project attempted to establish a rational design of a preform for powder forging, without conventional extensive trial and error. The effect of each process parameter on the overall powder metallurgy process was identified and a computer-aided design approach was determined. The chosen non-axisymmetric component part was analyzed and found to have no cracks, laps or areas of incomplete filling. Additional effort is needed to create more useable software.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project G80 0001 titled "Voice Controlled Programming of Computers" was completed in September 1982 by the US Army Depot System Command at a cost of $92,000.

BACKGROUND

The preparation of programs for computers and preparation of part programs and tapes for Numerical Control (NC) Machine Tools is typically done by manual input via a keyboard. This traditional input methodology is susceptible to error and is time consuming. Prior to this effort, there were many different types of commercially available user specific voice recognition units which had made it possible to communicate with a variety of computers. This project was undertaken to incorporate voice controlled programming equipment into existing computer systems and to establish compatible software programs.

SUMMARY

The objective of this project was to accomplish an increased NC programming workload with the available manpower and existing programming equipment. The traditional graphics input methods were keyboard, menu, function keyboard and pen stroke recognition. Voice input was not intended to replace any of the traditional input methods, but to compliment them and make the whole graphics system more efficient.

The approach taken in this effort was to review the available systems and select a unit as a "best fit" to the existing system. The next step was to install the system and establish a library of commands and a vocabulary for these commands for use with NC software package. A photograph of the installed system is shown as Figure 1.

Figure 1 - Operator Utilizes Graphics With Voice Input

The voice unit selected was an Interstate Electronics Corporation Model VRT-101 which was plug compatible with existing parts of the Applicon graphic system. External diskette drives were attached to store the operator's vocabulary and assist in processing data prior to transmission to the graphics host computer. This enabled the graphic system to view the voice unit as other peripheral devices such as a keyboard or tablet as illustrated in Figure 2.

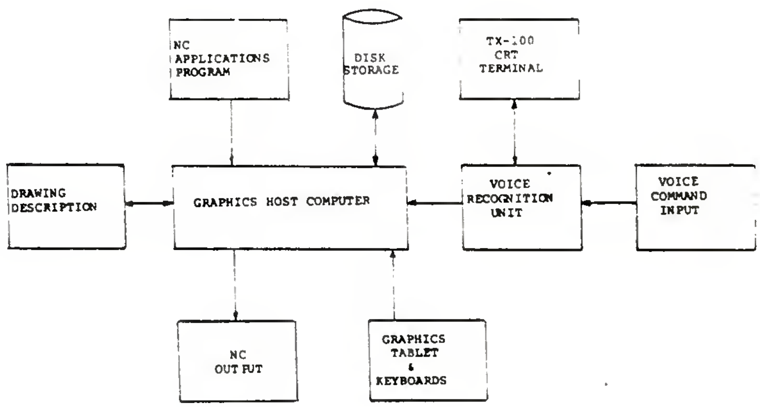


Figure 2 - Block Diagram of NC/Graphics/Voice Assisted System

An analysis of the strength and weaknesses of voice recognition indicated that commands frequently used but having low or moderate cursor control requirements were best suited for voice input. The graphic system control command set contained more commands that were appropriate for voice input than existed in the graphic system manipulation of geometry command set. The selection of words for the command vocabulary was based on a logical and unique association with the command function. A key factor in the system design and efficiency of system operation was to keep the vocabulary size small or in easily accessible sets. Specific vocabularies were generated but more importantly, a methodology for establishing new vocabularies was established.

The voice input was linked physically and logically with a turnkey graphics system. The integrated system was demonstrated to function effectively and with little or no degradation to the graphic controller for voice input to the NC software package. Recommendations were formulated for additional work on the association of words and commands. The results of this project can reasonably be extended to the 2-D drafting, 3-D drafting and electrical design software packages of the Applicon graphics system.

BENEFITS

The initial benefit from this project will be to reduce the cost of the preparation of NC machine tool tapes by approximately $45,000 per year at Tobyhanna Army Depot.

Potential benefits may be derived from the extension of this capability to other applications for tool design and testing of electronic components at Tobyhanna.

IMPLEMENTATION

This project was self implementing. The integrated system is operational at Tobyhanna Army Depot.

MORE INFORMATION

Additional information can be obtained from the project officer, Mr. Frank Estock, Tobyhanna Army Depot, AV 795-7099 or Commercial (717) 894-7099. A technical report titled "Voice Controlled Computer Programming for Numerical Control Tape Preparation," 1 September 1982, was prepared by Dr. Emory Zimmers, Lehigh University, 443 Whitaker Lab 5, Bethlehem, PA 18015.

Summary Report was prepared by Steve McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 474 4568, 475 4568 and 47T 4568 titled "Technical Data/Configuration Management System (TD/CMS)" were completed by the US Army Tank-Automotive Command in November 1982 at a cost of $820,000.

BACKGROUND

Prior Army efforts had established a computer system in 1966 called the Technical Data/Configuration Management System (TD/CMS). Implementation was completed in 1968 at the Tank-Automotive Command (TACOM). Similar systems were installed at the other major subordinate commands of the US Army Materiel Development and Readiness Command (DARCOM). The TD/CMS has two functions: the technical data function which includes the management of the receipt, storage, retrieval, and reproduction of end item drawings and other technical documentation; and the configuration management function which includes the management and control of the changes that occur to the end item documentation.

The time required to compile a current and accurate technical data package for an end item was labor intensive, time consuming and error prone. This effort was undertaken to reduce the time required to compile a technical data package for procurement of end items and to standardize and improve the management of technical data for end items.

SUMMARY

The objective of this effort was to establish a DARCOM standard TD/CMS. The approach was to establish and install the initial system at TACOM and then implement equivalent systems at the other DARCOM Major Subordinate Commands and improve the Automated Microfilm Storage and Retrieval System (AMSR).

As a result of this effort, an improved method of storage and retrieval of technical documents was established and is illustrated in Figure 1.

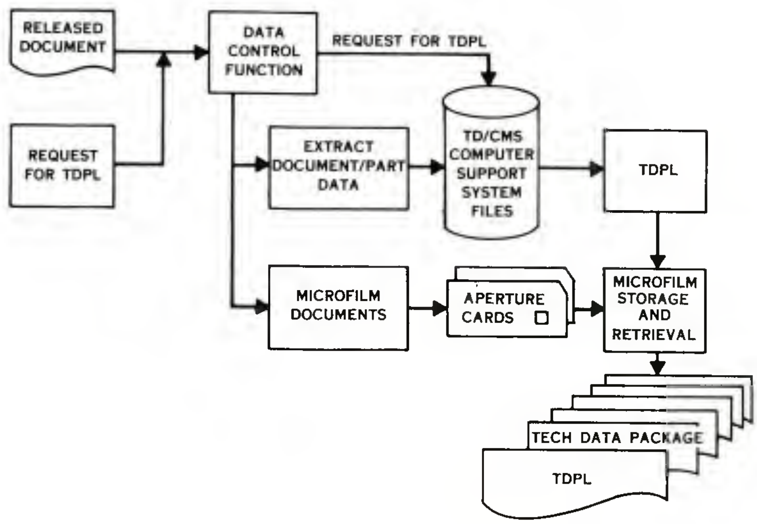


Figure 1 - Method for Storage and Retrieval of Technical Documents

The DARCOM standard TD/CMS was established to perform on an IBM 360-65 computer in a batch mode operation. The software programs were written in American National Standards Institute (ANSI) COBOL version 3.0 except for a few communications programs written in IBM Assembler Language. The DARCOM Automated Logistics Management Systems Activity (ALMSA), St. Louis, MO, is charged with the overall supervision and maintenance of TD/CMS and implements approved changes submitted by one or more of the commands.

The technical data and TD/CMS at TACOM were improved. The Technical Data Packages for 15 tracked combat vehicle items were reviewed and validated. The interface between the TD/CMS and the Automated Microfilm Storage and Retrieval System (AMSR) was improved. TACOM utilizes the AMSR system for on-line storage, retrieval and display of up to 1.2 million engineering drawings and technical documents. TACOM can now automatically produce large technical data packages.

BENEFITS

The currentness, accuracy and completeness of the data was improved for DARCOM Technical Data Packages. The administrative lead time for DARCOM procurement actions was reduced. The availability of data for more effective configuration management was improved.

IMPLEMENTATION

The TD/CMS was mandated as a DARCOM standard system by all the Major Subordinate Commands in 1977. Recommendations for major improvements to the TD/CMS have been deferred pending the design and establishment of a new hardware and software for a DARCOM standard TD/CMS.

MORE INFORMATION

Additional information can be obtained from the project officer, Mr. James Capehart, TACOM, AV 786-8714 and Commercial phone (313) 573-5372.

Summary report was prepared by Stephen A. McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project T77 5014 titled, "Improved Foundry Casting Processes Utilizing Computer Aided Flow and Thermal Analysis (CAD/CAM)," was completed by the US Army Tank-Automotive Command in December 1981 at a cost of $560,000.

BACKGROUND

The casting process is wasteful in raw materials and energy. Less than 50% of the melted material is utilized in the final cast configuration. The inefficiency of the process control results in a cost penalty to the casting, since the scrap and waste are charged to the individual casting. Prior industrial effort had centered on R&D studies to simulate heat flow and temperature using the finite difference method. Industrial R&D studies indicated that the finite element method could be successfully used to simulate heat flow in castings. This project was undertaken to apply advanced fluid flow and thermal analysis techniques for the simulation of the casting process.

SUMMARY

The objective of the project was to simulate the casting process and produce a high quality and lower cost casting. The simulation used fluid flow and thermal analysis of molten metals and models of the mold and pattern design. The approach used was to, (1) incorporate computer aided drafting techniques with a number of computer software procedures, (2) predict the casting process for simple configurations, (3) fabricate samples to evaluate predicted characteristics. A planned follow-on effort will extend the simulation process to more complex shapes, and incorporate criteria for casting soundness.

Some computer procedures for the casting solidification process have been completed. Initial simulation results are in good agreement with test results for simple shaped castings. The overall design of the resultant CAD/CAM casting process is illustrated in Figure 1. The casting engineer is the planned user of this system. The user makes decisions concerning the heading and gating based on an automatic analysis of the detail input. The computer procedures are intended for simulation of armor steel castings, but the system will be applicable for steel castings in general. The mold cavity design utilizes a function keyboard, and digitizing tablet for input and a graphics screen for display.

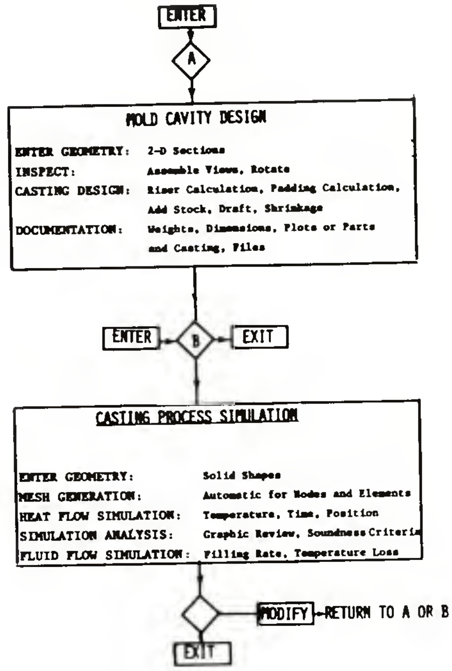


Figure 1 - Overall Design of CAD/CAM
Casting Process

The analysis procedures consist of automatic mesh generation coupled with 2-D and 3-D finite element analysis for heat flow simulations of castings in sand molds. The initial shapes implemented were plates (bricks) and cylinders. Figure 2 illustrates the division of the drag of the mold into five zones for a test plate casting, plus one additional zone for the sand in the core box.

Experimental data was obtained at a production foundry for thermal analyses during freezing of castings to the model illustrated in Figure 2. Computer simulations for the test castings were found substantially in agreement with the experimental results for cooling curves, thermal gradients and temperature versus distance plots.

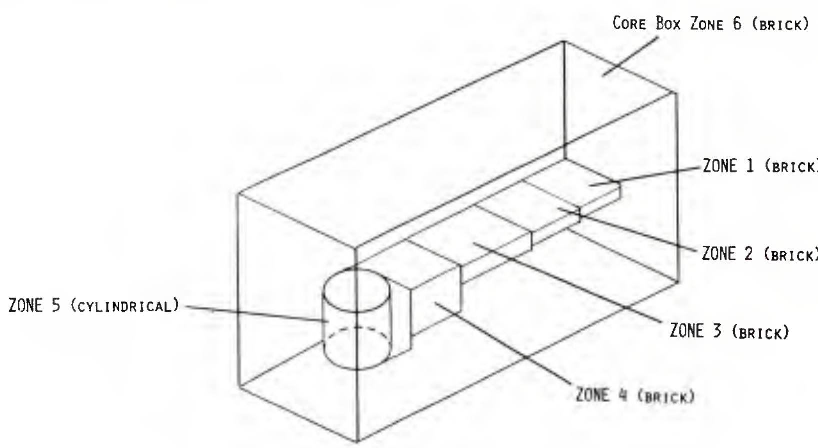


Figure 2 - Drag Portion of Stepped Plate Casting Model
Used for Mesh Generation

BENEFITS

The anticipated benefits from this project are improved foundry castings. The tangible benefits will be (1) reduced scrap losses, due to better material utilization, (2) high quality castings, due to improved mold design. An intangible benefit is that the foundry engineer does not require programming experience to exercise the system.

IMPLEMENTATION

The CAD/CAM casting process is designed to be used either on a time-share basis with the University of Pittsburgh or in a dedicated mode on a foundry computer system. Additional planned effort continues on MMT Project T78 5014. Preliminary results from this project are under evaluation for use at Lebanon Steel Foundry and Blaw Knox Foundry, for torsion bar housing castings.

MORE INFORMATION

Additional information on this effort is available in a technical report titled, "Improved Foundry Castings Utilizing CAD/CAD," October 1981, Contract No. DAAK-30-78-C108. The project officer is Mr. Mike Holly, TACOM, DRSTA-RCKM, AV 786-6467 or Commercial (313) 573-5814.

Summary report was prepared by Stephen A. McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 570 4147 and 574 4147 titled "Computer Control Application to Continuous TNT Manufacture" were completed by the US Army Armament Research and Development Command in December 1980 at a cost of $2,153,000.

BACKGROUND

In the mid 1960's, the US Army made a decision to modernize the batch trinitrotoluene (TNT) line at an Army Ammunition Plant (AAP). This modernization involved replacing the old World War II vintage batch process TNT lines with a new continuous nitration and purification process. The replacement process chosen was a continuous type purchased from Canadian Industries Limited (CIL). The CIL process has advantages over the batch process in that it makes much more efficient utilization of manpower, land area and equipment. Radford AAP was the first plant to install the new continuous process lines. Additional continuous process lines were installed in the late 1960's and early 1970's - 5 at Newport AAP, 6 at Joliet AAP, and 6 at Volunteer AAP. This effort was undertaken to support the modernization of TNT production facilities at Volunteer AAP and Radford AAP with the results being applicable to all TNT producing AAP's. Due to the emphasis of manual controls, operators have to be present in the immediate production area. This is an obvious safety problem. Also, due to the emphasis on operator control, the process is labor intensive, inefficient and yields were low.

SUMMARY

The broad based objective of this effort was to improve the safety, reliability and efficiency of the continuous TNT process. The approach taken was to design, procure, install and evaluate an advanced control system on a prototype basis to a full scale TNT production line at both Radford and Volunteer.

The control system at Volunteer AAP was designed around the computer-based direct digital control (DDC) method. See Figure 1. The system is based on a dual computer design (Foxboro, Model PCP-88) in which one computer controls the process while the other serves as a backup and, in addition, executes supervisory calculations. The prototype system itself consists of four major subsystems: field equipment (valves, sensors, transmitter cables, etc. for the process), interface hardware (analog signal conditioning and conversion gear analog panel and 1/0 system), control room hardware (operator's console) and software. The first ever acceptable TNT from a computer controlled line was produced in November 1974 on line 1 at Volunteer AAP. The line was operated from October 1975 to March 1977. The production averaged 50 tons per day. The maximum capability of the line was achieved several times.

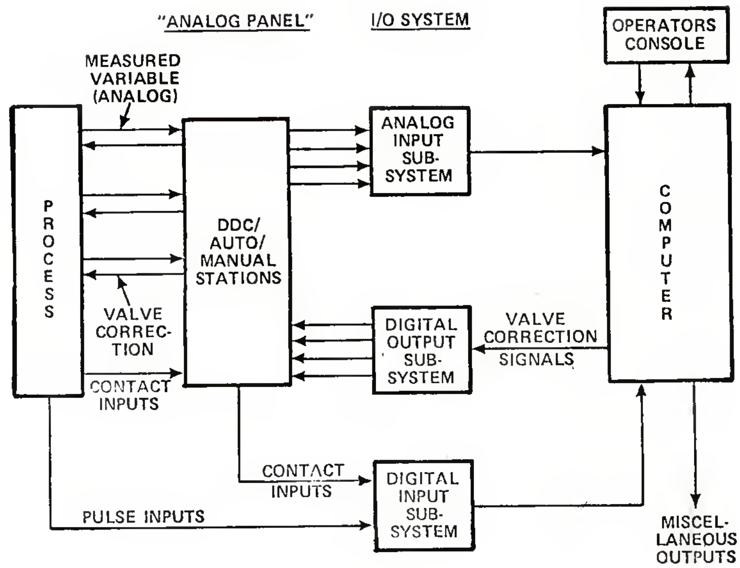


Figure 1 - Simplified Structure of a DDC System

Radford AAP. An electronic analog control system was designed and installed on C-line of the Radford AAP TNT manufacturing area. The control system at Radford AAP is a digitally directed analog control (DDAC) system which can be interfaced with the supervisory computer at a later date. See Figure 2.

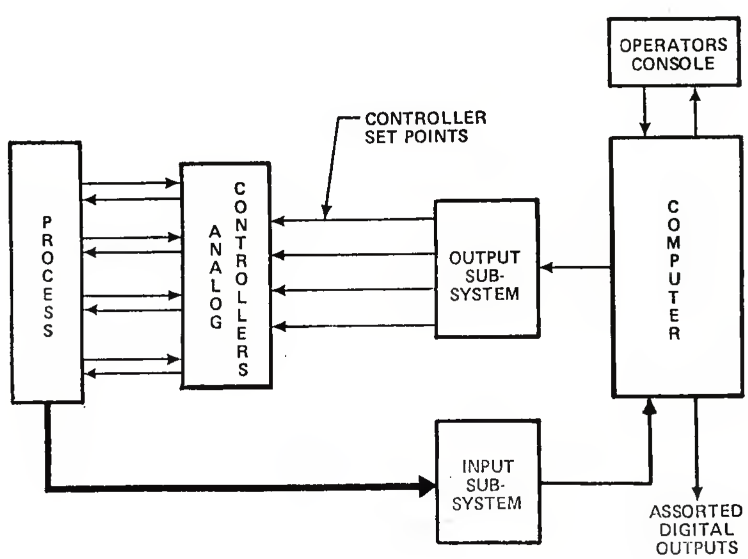


Figure 2 - Simplified Structure of a DDAC System

The system itself consists of 3 major subsystems: the interface (utility) room, operator's station, and field equipment. See Figure 3. Most of the equipment is located in the utility building which is environmentally conditioned to protect the microelectronic components. The VIDEOSPEC operator's console has been inclosed and separated from its microprocessor and placed in the nitration and purification area. The operating contractor was reluctant to operate the line in a remote mode. The installed system controls nitrator temperatures and process ingredient flows. Since there was no scheduled TNT production, the installed system has not been evaluated in the manufacture of TNT. Recommendations were formulated for additional control system installations and the use of a supervisory computer.

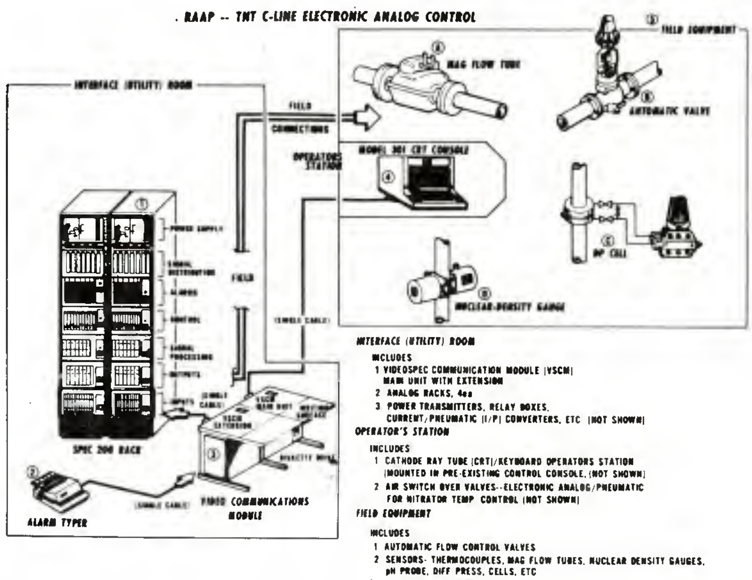


Figure 3 - TNT Analog Electronic Components and Automatic Equipment

BENEFITS

The desireability and advantage of a remote automated control DDC was demonstrated under this project at Volunteer AAP. Analysis of production data indicated a 16 percent increase in production rate over the best previous rate attained under manual control. When compared to the manual operation on round the clock 10 line production basis, operation under DDC was shown to require 48 fewer operating personnel. An improvement in process safety was demonstrated since people were not in direct contact with the process and the computer took immediate action to prevent problems.

A real assessment of the benefits to the DDAC system at Radford AAP is not possible due to a lack of actual production data. Estimated benefits include increased yield, reduced material usage, reduced utilities consumption.

IMPLEMENTATION

As a result of the DDC system at Volunteer, a similar system was installed for line 16 at Joliet AAP. The DDAC system at Radford could be easily implemented on other lines at Radford and Newport AAP's.

MORE INFORMATION

Additional information on this effort is available in the following technical reports:

AAP	TITLE	DATE	AUTHOR
Volunteer	Final Report on MMT Project 570 4147	Nov 79	ICI Americas, Inc.
Radford	Computer Control Application to Continuous TNT Mfg. at Radford AAP	Mar 81	HERCULES/ARRADCOM

The Defense Technical Information Center access number for the Radford report is ADE400 578. The project officer is Mr. Raymond Goldstein, ARRADCOM, DRDAR-LCM-E, AV 880-4122 or Commercial (201) 328-4122.

Summary Report was prepared by Steve McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 579 6682 titled "Simulation of Ammunition Production Lines" was completed in March 1981 by the US Army Armament Research and Development Command at a cost of $170,000.

BACKGROUND

An automated production line consists of production equipment such as a lathe, mill, press, or heat treat unit. Other key elements in the line are automated material handling equipment and automated in-process inspection. Many digital simulation languages were available to model production lines. However, no definite procedure existed on sizing the buffers for material handling equipment. The project was undertaken to apply existing simulation techniques as an aid in the system design of ammunition metal parts production lines. Prior Army efforts had established a user oriented computer program General Modeling System (GEN MOD) to analyze the design and performance characteristics of automated production lines.

SUMMARY

The objective of this project was to establish a methodology using digital simulation techniques to predict production thruput for an automated ammunition metal parts production line. Methods were needed to aid the design of functional production lines subject to machine breakdown and scheduled maintenance. The approach was to use the GENMOD simulation program with equipment availability data supplied from current producers. The next step was to analyze the adequacy of the simulation predictions as they applied to actual production lines. The simulation technique was then applied to predict the equipment requirements for new production lines or modifications to existing production lines.

As a result of establishing this methodology, a key finding was the validity of using the binomial distribution to predict the buffer size of material handling equipment. The buffer size applies between operations for the entire sequence of operations in a given production line. A relationship between buffer size and monthly production rate is illustrated in Figure 1.

The GENMOD software program and the binomial distribution math method were used to simulate three production lines. These lines manufacture the 155mm M483 projectile metal parts for improved convention ammunition. For the Norris Industries, Vernon, CA, line, data was collected during equipment prove out. Results indicated that a correlation existed between actual and predicted performance. Changes were made in production equipment quantities and material handling equipment buffers. These changes were made during the prove out phase based on the computer simulation predicted performance.

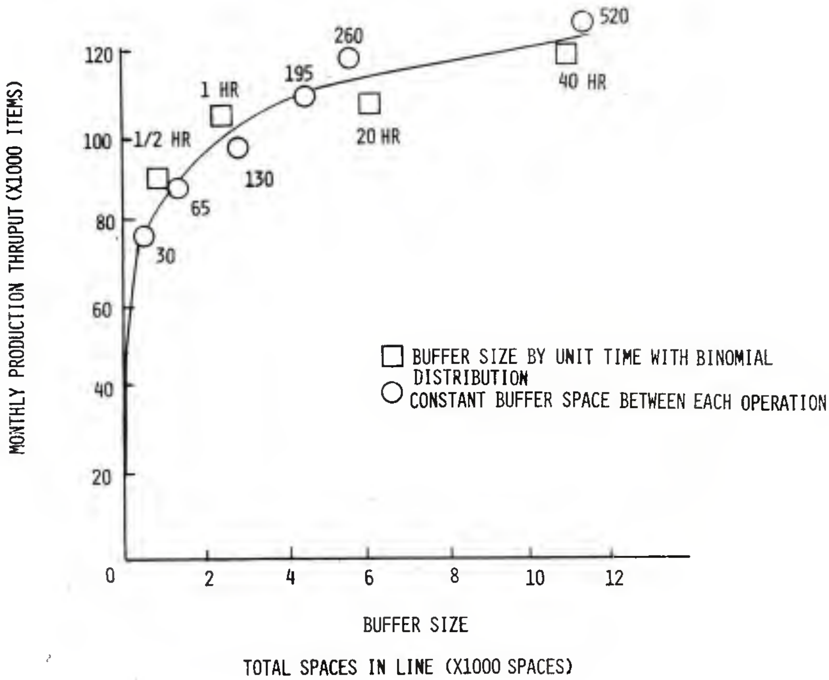


Figure 1 - Monthly Production Thruput Vs. Total Buffer Size

The metal parts line for Mississippi Army Ammunition Plant was simulated. The data generated after the analysis of the Norris Industries prove out was used. A sensitivity analysis of the buffer capacity for operation No. 130 was prepared. Several simulation runs were used to determine the requirements for that buffer. With the aid of the simulation methodology, an overall expected buffer capacity was established for the entire metal parts material handling equipment. The Louisianna AAP operating contractor has successfully used this simulation technique. Three aspects of their production lines were modeled for existing lines and planned improvements.

BENEFITS

A methodology for using a simulation model has been established for a projectile metal parts production line. Equipment requirements, buffer sizes and expected production thruput can be more accurately predicted. Material handling requirements can now be analytically approached for the first time based on the models generated. Trade off analyses can be done between the cost of a larger buffer versus extra production equipment. It is expected that the design of future facilities can be optimized for thruput and cost.

IMPLEMENTATION

This project was self implementing. The methodology is now operational at ARRADCOM, Dover, NJ and Louisianna AAP. The methodology has already been applied to other ammunition production lines.

MORE INFORMATION

Additional information is available from the project officer, Mr. Richard Meinert, ARRADCOM, AV 880-3298 or Commercial (201) 328-3121. A technical report has been prepared and is titled "Simulation of Ammunition Production Lines." The Defense Technical Information Center access number is ADE400 931, November 1982.

Summary Report was prepared by Steve McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 576 6736, 578 6736, 579 6736-01 and 580 6736-01 titled "Technical Readiness Acceleration Thru Computer Integrated Manufacturing (TRACIM)" were completed in March 1982 by the US Army Armament Research and Development Command at a cost of $691,000.

BACKGROUND

Army ammunition metal parts manufacturing facilities must be able to meet mobilization requirements from a layaway status. Each facility start-up is much too long and unpredictable. This effort was undertaken to identify how computer technology should be applied to improve the management of manufacturing data for ammunition metal parts. Prior MMT efforts had concentrated on Government owned production facilities. No prior efforts had identified the computer system requirements for the management of manufacturing data at ammunition contractor plants.

SUMMARY

The primary objective of the TRACIM effort was to improve the mobilization responsiveness of the ammunition metal parts industrial base. Two goals were established. The first goal was to establish a plan for an automated data storage and retrieval system which would provide rapid access to current manufacturing data. The second goal was to demonstrate that programmable automation could be used to reduce the need for highly skilled manufacturing craftsmen in ammunition manufacture. The approach was to perform a survey and analysis of existing ammunition producers and identify factors effecting excessive production lead times for mobilization. The next step was to evaluate the feasibility of using group technology techniques and interactive graphics systems. The techniques would be part of an overall data base system for use at specific producers. The third step was to establish a composite model based on several factory models, and then use this composite model to determine the requirements for the tooling wedge data base system. The last step was to establish a prototype manufacturing data base system based on the composite model requirements.

The results from the survey and analysis indicated causes for the excessive mobilization lead times. The 2 main causes were the lack of up-to-date and readily accessible manufacturing data and the lack of skilled and trained manpower. The hierarchy for manufacturing activities of an improved conventional munition was completed as illustrated in Figure 1.

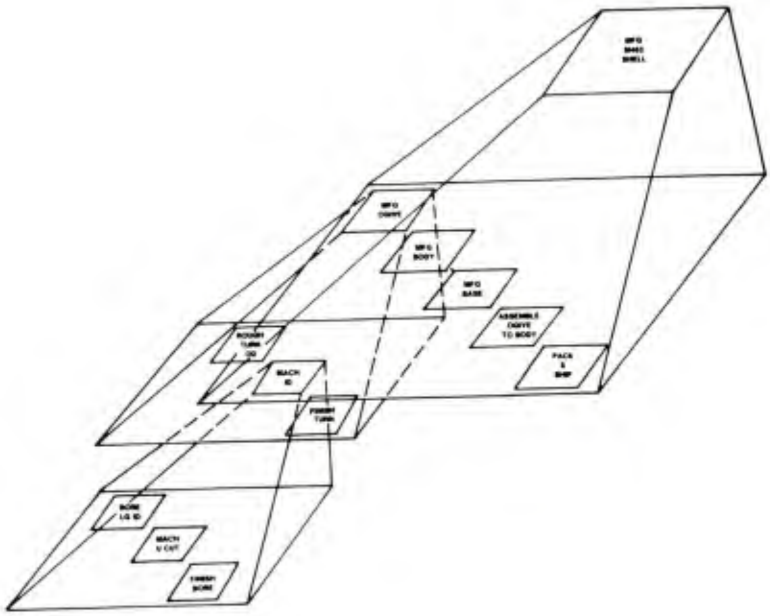


Figure 1 - Manufacturing Activities Sub-Divided or "Decomposed" on a Hierachal or level Structure

The computer graphics tests that were conducted illustrated that the design of tooling was practical and could be instrumental in reducing lead time. Data used for these tests was obtained from process sheets, drawings, and tooling and gage drawings. An example of a function model for tank ammunition that was used to generate the composite model and system requirements is illustrated in Figure 2.

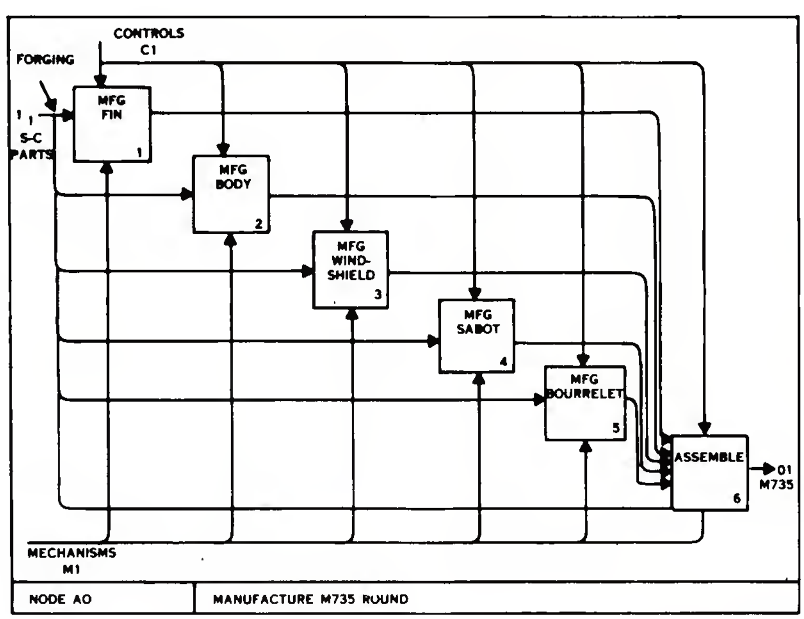


Figure 2 - Function Model For Tank Ammunition Manufacture

A prototype computer system was developed on a Data General NOVA 3 mini-computer utilizing a 16 bit word length and a 64 K-Byte internal memory with 10 megabyte hard disc storage. Data that can be stored in the prototype system is illustated in Figure 3.

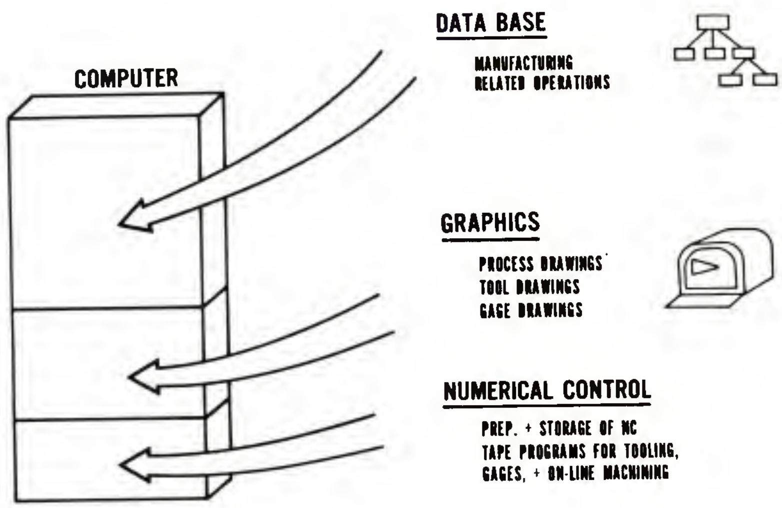


Figure 3 - Mini-Computer System Capable of Handling the Tracim Data Base, Graphics and Numerical Control Part Programming

The prototype system was demonstrated with manufacturing data from the ogive of the 155mm M483 projectile as manufactured by Chamberlain Corp., New Bedford, MA.

BENEFITS

This prototype system or a commercially available equivalent would make it possible to readily retrieve information. Ammunition lines in layaway could be activated to maximum production capability in a minimum amount of time. This prototype system or a commercially available equivalent also provides a means for reducing manufacturing costs.

IMPLEMENTATION

The TRACIM project was discontinued after publication of the final report. The implementation of a engineering and manufacturing data base system will be addressed for Government owned facilities. A concurrent ARRCOM and ARRADCOM effort is planned for CAD/CAM systems procurement.

MORE INFORMATION

Additional information is available from the project officer, Mr. Robert Katz, ARRADCOM, AV 880-3482 or commercial (201) 328-3404. A 5-volume technical report has been prepared titled "Technical Readiness Acceleration Through Computer Integrated Manufacturing," October 1981. Contract reference is DAAK 10-79-C-0319.

Summary Report was prepared by Steve McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 579 6736-02 titled "Data Acquisition Feasibility Study" was completed by the US Army Armament Research and Development Command in June 1981 at a cost of $166,000.

BACKGROUND

A lack of accurate and timely manufacturing data at a specific plant was causing inefficiency and excessive labor. More timely data was needed in production control and quality assurance of ammunition manufacture and the maintenance of production equipment. Vendors of data acquisition systems had already installed similar systems with varying functional requirements at many industrial sites. This project was undertaken to identify how a manufacturing control system could be adapted in a long established plant. Minimal modifications to existing equipment was a restriction.

SUMMARY

The objective of this project was to demonstrate how the manufacturing costs at a specific plant could be reduced through the use of a manufacturing control system. The approach was to adapt a selected system to specific operations in an existing ammunition production line. A time-share host computer was used in lieu of a dedicated computer system. A manufacturing control system was installed at Chamberlain Manufacturing Corp., New Bedford, MA. The system consisted of 15 proximity sensors with appropriate mounts, an intelligent industrial communications controller, and telephone equipment consisting of 4 Vu-Sets with automatic dialers and a 40/2 communications terminal with a modem and printer. The communications layout of the installed system is illustrated in Figure 1.

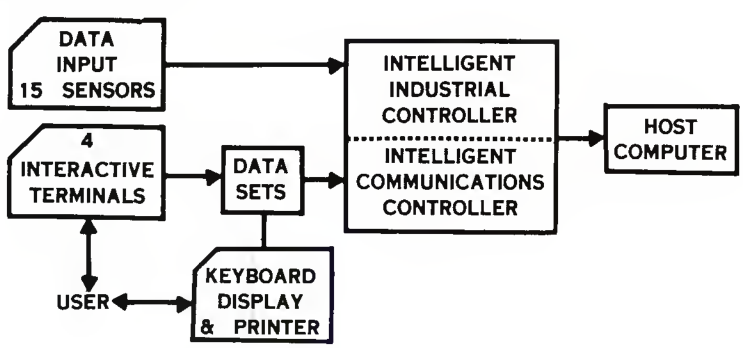


Figure 1 - Communications Layout of Manufacturing Production Control System

Two manufacturing operations were monitored from the production line of the body for the 155mm M483 projectile. The first operation was the finish outside diameter turn operation. The second operation was the finish inside diameter bore operation. Each operation consisted of at least 4 machine tools and an inspection station. The sensors monitored workpiece flow through the material handling equipment. The system was designed so that workpiece counts could be transmitted to the host computer every 30 minutes or as required. Data was collected and analyzed for equipment downtime, reject treads, daily production rates, and machine utilization.

Reports could be generated from the data analyzed. Downtime reports and reject and scrap reports proved to be the most valuable reports generated by the system.

A unique feature of the manufacturing control system was the incorporation of a relational data base management system. Report generation was very flexible using this system. Recommendations were formulated for implementation of a dedicated or time share manufacturing control systems at 2 ammunition production facilities.

BENEFITS

A reduction in the manufacturing cost was estimated for several operations. Improved control was estimated in dispatching of maintenance and repair personnel, material control, production control, management assessment of production data, and quality of product. The estimated benefits were a minimum 20% reduction in manufacturing costs for each operation on an old established production line.

IMPLEMENTATION

The results of this project have not been implemented into the production of any Army materiel. The system demonstrated under this project or commercially available equivalent was considered too difficult to install into the existing long established production line. Adjustments would be required to ingrained work habits. The contractor would need some assurance of continued production for an adequate return on investment. Control systems at new production facilities are competitively procured from a pool of capable vendors.

MORE INFORMATION

Additional information is available in a technical report titled "Final Report of 155mm M483 Feasibility Study of the Body Bore Module Control Room." The project officer is Mr. Robert Katz, ARRADCOM, AV 880-3482 or Commercial (201) 328-3404.

Summary report was prepared by Stephen A. McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 580 6736-03 titled "Army Support for Initial Graphics Exchange Specifications (IGES)" was completed in September 1982 by the US Army Armament Research and Development Command at a cost of $50,000.

BACKGROUND

Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) systems were in widespread use in the defense industrial base. Problems were associated with communicating and interpreting data between turnkey CAD/CAM systems. The exchange of data between companies and their suppliers each utilizing different graphic software had become a major factor with regard to cost of conversion and loss of time. This project was undertaken to support a joint Air Force, Army, Navy and National Aeronautics and Space Adminstration (NASA) effort through the National Bureau of Standards. The joint effort scope was to create and maintain an Initial Graphics Exchange Specification (IGES) type document to meet the needs of industry and Government. Prior efforts had been expended by several large companies. A proliferation of translators and individual company standards with their expensive maintenance overhead was a result of these individual efforts. The American National Standards Institute (ANSI) and other standards groups were already addressing various interface areas.

SUMMARY

The objective of this project was to create IGES by early 1980 and formulate two committees to support its implementation. The three Services and NASA jointly funded the National Bureau of Standards (NBS) to chair the initial technical committee and direct the program in its initial years. The Air Force Integrated Computer Aided Manufacturing office coordinated the funds for NBS, who directed and organized the IGES work. The considerable participation by Boeing and General Electric through the initial technical committee was voluntary and the cost was borne by those organizations. Extensive coordination of specification requirements was achieved with system suppliers, corporate system designers, standards groups, and the interested public. Two public meetings were held while the specifications were being drawn up.

The first IGES document was published in January 1980 through the efforts of the initial technical committee. The information flow for the IGES communication file is illustrated in Figure 1. Additional committees were established to address Coordination, Management Briefing, Extensions and Repairs, Technical Briefing, Newsletter, Test/Evaluate and Support, Publicity and ANSI Coordination.

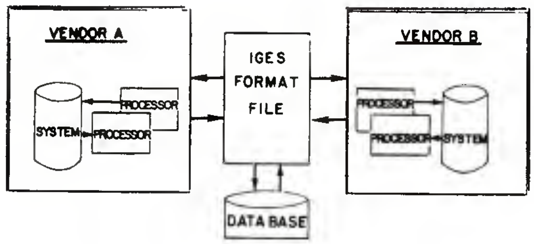


Figure 1 - Information Flow of Initial Graphics Exchange Specification (IGES)

As a result of the various committee actions, the ANSI approved the proposed Standard Y 14.26M, "Digital Representation for Communication of Product Definition Data," on 21 September 1981. IGES is parts 2,3, and 4 of that Standard. Ten vendors now have plans to support IGES software within their turnkey systems.

A public demonstration of IGES was successfully conducted at the National Computer Graphics Association '82 in Anaheim, CA. The demonstration was organized by NBS in cooperation with five CAD/CAM graphics vendors. The five vendors were Applicon, CALMA, Computervision, Gerber and Manufacturing Consulting Services. McDonnell Douglas Automation and Control Data Corporation provided prerecorded tapes with sample part geometries in IGES format. In the demonstration, a mechanical part design containing drilled holes, milled pockets and profiled edges was loaded from an IGES file into a CAD/CAM system. The part design was then modified according to suggestions from the audience. The part design was then transmitted back to the IGES file, and from there it was transmitted to a different CAD/CAM system for further display and modification.

IGES is not perfect, it will not solve all the information needs of CAD/CAM systems. IGES will need further extension beyond its current definition. However, IGES goes a long way toward alleviating the current data exchange problems and is a significant response to today's needs.

BENEFITS

Cross translation is the focal point of IGES and its principle benefit. Cross translation is the database exchange between interactive graphics design-drafting systems of different brand names. Users of IGES will be able to exchange the structure of the databases in question versus the exchange of plotting pen position information.

IMPLEMENTATION

This project was self-implementing. Over 45 companies were involved in the IGES effort as evidenced by their having one or more members on several of the IGES committees and subcommittees. The individual implementation of the IGES results is dependent on the specific organization hardware and software requirements. Examples of two organizations that have implemented the IGES are Bendix, Kansas City, MO and Sandia National Laboratories, Livermore, CA. The NBS has filled over 1000 requests for Version 1.0 of IGES. Version 2.0 is scheduled for release in December 1982 and will address improved geometric representations and electrical and electronic applications. Within the Army, over 30 organizations receive IGES documentation on a regular basis. The implementation of IGES within the Army owned facilities will have to be addressed, through implementation of ANSI Standard Y.14.26M, at each appropriate command and organization. The Test, Evaluate and Support Committee is working on a Recommended Practices Guide and a new Glossary of Terms. These documents will assist implementation of IGES. The Air Force has awarded a contract to McDonnell Aircraft Co., St. Louis, MO to test IGES. The 2-phase effort is designed to test vendor translators and to establish procedures for use from engineering to manufacture.

MORE INFORMATION

The project officer for this project is Mr. Robert Katz, ARRADCOM, AV 880-3482 or Commercial (201) 328-3404. For additional information on IGES, contact Joan Wellington of NBS, Commercial (301) 921-3691.

Summary Report was prepared by Steve McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 674 7332 titled "Manufacturing Data for Optical Elements, Tools, and Materials (CAM)" was completed in July 1979 by the US Army Armament Research and Development Command at a cost of $90,000.

BACKGROUND

Standard Army fire control instruments contained approximately 1500 different optics. Approximately 1,000 additional optics were used in limited standard Army instruments. The manual handling of the associated data has proven sluggish and time consuming. Data would include physical characteristics groupings, element drawings, specifications, tool listings, test glass listings, process sheets and assorted plans pertinent to the manufacture of precision optics. This project was undertaken to determine the feasibility of establishing a small computer oriented data base management system for optical manufacturing data. There were no prior Army efforts.

SUMMARY

The objective of this project was to reduce or eliminate duplication in the management of manufacturing data for optics at Frankford Arsenal. The approach was to select a commercially available mini computer system with a data base management system. Then the data base would be designed, data loaded and the system proved out. Data was collected for optical design, methods engineering, production planning and quality control. A data base hierarchy was established using a Hewlett Packard (H-P) Image 1000 data base management system and an H-P 2100 series computer system.

The data schema was processed for the optics data base which consisted of 5 master data sets and 5 detail data sets. The 5 master data sets addressed optical processing equipment and processing tools/inspection gauges and test glasses. The 5 detail data sets addressed spherics, prisms, and flats. The collection of data entries was processed and stored in data sets. The query subsystem of Image/1000 DBMS was used to format process sheets via an interactive display terminal.

BENEFITS

The data base on optics manufacturing methods will be available for use by design engineers at ARRADCOM. Private industry will also access this data base.

IMPLEMENTATION

The computer system is now installed at the Army Test Range at Ft. Dix, New Jersey. Telephone link has been established with terminals at ARRADCOM. This project has been continued under another MMT project titled "Group Technology for Fire Control," project no. 679, 80 7963.

MORE INFORMATION

Additional information can be obtained from the project officer, Mr. Nathaniel Scott, ARRADCOM, AV 880-6945 or Commercial (201) 328-6945.

Summary Report was prepared by Steve McGlone, Manufacturing Technology Division, Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 674 7334 and 676 7334 titled "Ion Beam Surfacing of IR Optical Elements (CAM Related)" were completed by the US Army Armament Research and Development Command in July 1975 and December 1977 at costs of $90,000 and $100,000, respectively.

BACKGROUND

Many infrared (IR) optical components are made of non-glass i.e. crystalline materials differing from conventional optics. The manufacture and testing of IR optics is very labor intensive and manufacturing procedures produce dysfunctional consequences. Due to the nature of these elements, the substance used for polishing the surface diffuses into grain boundaries and accumulates at defect sites. The results of this concentration of impurities near the surface is a degradation of the optical transmission characteristic. Polishing infrared materials with an ion beam would avoid the problems and difficulties associated with conventional polishing techniques.

SUMMARY

A computer controlled optical figuring and polishing facility using an ion beam sputtering technique was available for optical surfaces. The purpose of this program was to upgrade the capabilities of the existing system to include IR optics. The FY74 project established the necessary metrology system. Eleven of the most common crystalline materials used for IR optics were studied. The ion beam induced sputter yield and radiation damage was experimentally determined for each material. Promising metrology techniques for defining the physical characteristics were studied. These techniques included x-ray back-scatter, optical scattering, interferometry and phase contrast differential interference microscopy. The FY76 project established the process for final figuring and polishing. Operating procedures varied significantly from those used to polish glass optical elements because of the crystalline rather than amorphous nature. The in-house ion beam polishing facility was modified increasing its operational capability to include IR as well as visible optics.

BENEFITS

An in-house facility for precision final figuring, polishing, and testing of crystalline and polycrystalline optical elements was established. The facility provides the capabilities of quick reaction and small lot production of infrared optical elements.

IMPLEMENTATION

The equipment is housed at ARRADCOM providing a new production process not previously available.

MORE INFORMATION

Contact Mr. Kopacz, ARRADCOM, AV 880-2873 or Commercial (201) 328-2873.

Summary report was prepared by James H. Sullivan, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 676 7455 titled "(MMT) Computer Generated Masters for Graphical Firing Tables" was completed by the US Army Armament Research and Development Command in December 1978 at a cost of $60,000.

BACKGROUND

Manual drafting techniques are used to prepare and analyze firing table data and generate a graphical firing table for ammunition. The project was undertaken to provide a better method using computer technology to prepare masters for graphical firing tables. The existing manual methods are time consuming and lack flexibility for updates and changes. There were no prior efforts in this area.

SUMMARY

The objective of this project was to provide a more timely and less costly method of producing masters for graphical firing tables for conventional artillery and mortars. The approach was to use commercially available automated drafting equipment and establish computer software for generating necessary analysis and artwork.

A software procedure labeled Graphical Firing Scales (GFS) was established for preparing master drawings. GFS was used to generate eight master drawings for the 4.2 inch M30 mortar. The master drawings were found acceptable for layout, presentation and contrast. The masters prepared are listed in Table 1.

TABLE 1 - MASTERS FOR 4.2 INCH M30 MORTAR

AMMUNITION	Quadrant Elevation (MILS)	Scale (METERS)
High Explosive Shell (M329A1E1)	800	1:12,500 M
	900	1:12,500 M
	1065	1:12,500 M
	800	1:25,000 M
	900	1:25,000 M
	1065	1:25,000 M
Illuminating Shell (M335A2)	900	1:12,500
	900	1:25,000

A preliminary cost analysis prepared by ARRADCOM comparing the new method versus the previous method indicates a saving of at least 25%, mainly in direct labor savings. A Tridea plotter was used in conjunction with a McDonnell Douglas Automation Co., Unigraphics drafting system and the GFS software to generate these masters.

BENEFITS

The potential benefits that could be realized include:

-- Reduction in preparation time and cost of producing a graphical firing table.

-- Reduction in the skill required to produce firing tables.

-- Reduction in the ballistic errors in the firing table.

-- Possible elimination of hardcopy of masters.

-- The techniques are applicable to all types of artillery in the inventory.

IMPLEMENTATION

One Army user of this data - the Artillery School at Fort Sill, OK, was informed of the project results. There is no plan for the implementation of the results of this project within the Army. Additional coordination would be required between several organizations within ARRADCOM, the Fire Control and Small Caliber Weapon System Laboratory and the Ballistics Research Laboratory. Also, additional coordination would be required on needs analysis, economic analysis, and firm requirements between the developer (DARCOM) and user (TRADOC). Various command and control systems developments have to be considered in the overall DARCOM coordination effort.

MORE INFORMATION

Additional information can be obtained by contacting Mr. William West at the US Army Armament Research and Development Command. His commercial phone number is (201) 328-5733 or AV 880-5733.

Summary report was prepared by Stephen A. McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

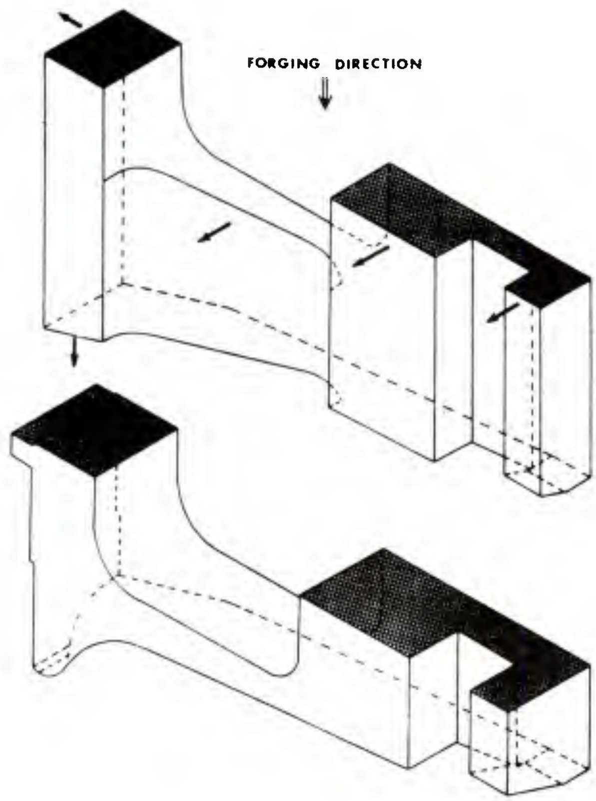
Manufacturing Methods and Technology Projects 677 7649 and 678 7649 titled "Computerized Powder Metallurgy Forging Design" were completed by the US Army Armament Materiel Readiness Command in June 1979 for a cost of $202,000.

BACKGROUND

Powder forging is a process in which preforms made by press and sinter powder metallurgy (P/M) techniques are hot forged in closed impression dies. Proper preform design is necessary for the production of high strength P/M parts using the powder forging process. Prior to this effort, the determination of P/M preform design and processing conditions was empirical, time consuming and error prone. Prior university R&D effort identified that proper preform design was an important processing parameter. Guidelines were previously established for axisymmetric shapes. This effort was undertaken to establish a rational design of preforms for powder forging, without extensive trial and error effort.

SUMMARY

The objective of this effort was to reduce the time and cost required to establish acceptable tooling for P/M preforms. The approach included the identification of the effects of each process parameter on the overall P/M process. A logical basis was determined for an interactive Computer-Aided Design (CAD) approach. The CAD approach was demonstrated in the design and fabrication of a preform for a specific component. As a result of this effort, a general computer-aided preform design technique was established. A practical general approach was established to input data regarding the shape of the finished part and material, and to determine a preform design scheme for an acceptable part. For a specific Army part, a preform was designed and acceptable components were fabricated using the predicted preform shape and forging dies. The Cartridge Guide Ramp (Part No. 7793232) of the M85 Machine Gun was the part selected based on its relative complex configuration and non-axisymmetric shape. The flow directions in the designed preform due to the forging operation are illustrated in Figure 1.



Preform Before Forging Operation

Preform After Forging Operation

Figure 1 - Metal Flow Directions In Preform During Forging

The component fabricated was analyzed for its mechanical and metallurgical properties. No cracks or laps were observed; there was complete filling of material at critical sections; the forged part had near-net shape and distribution of density was uniform. The software established was written for the most part in Fortran 10, except for some routines which were written in assembly language. The current version of this software was operational on a Digital Equipment Corporation PDP-10. Computer graphics capability was provided using Tektronix Plot-10 software.

Recommendations were formulated for additional effort to reduce the level of difficulty in the use of this program and to achieve a more integrated powder forging design process.

BENEFITS

Additional effort is needed to establish more useable software. This effort identified the feasibility of the approach and techniques which were established. The potential benefits of tool design savings will not be fully realized until the additional efforts are completed.

IMPLEMENTATION

The software established by this effort is being used by TRW, Inc. Preforms for a TACOM MMT project 47X 5083 on Army tank gears were designed with this software by TRW, Inc. Some modules of the existing software are planned for use by Borg Warner, Inc. and Heogenoes Corp. in the designing of forging dies for P/M parts.

MORE INFORMATION

Additional information on this effort is available in a technical report titled, "Computerized Powder Metallurgy (P/M) Forging Techniques." The Defense Technical Center Information access number for this technical report is ADA090043. The project officer is Mr. Mukesh Solanki, ARRCOM, Rock Island Arsenal, phone (309) 794-6198.

Summary Report was prepared by Steve McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 679 7724 titled, "Group Technology of Weapon Systems," was completed by the US Army Armament Materiel Readiness Command in April 1981 at a cost of $83,000.

BACKGROUND

In most manufacturing organizations, a proliferation of designs and parts is a major problem. Duplicate part drawings, the lack of standard process plans, and the lack of information supporting scheduling are common and lead to inefficient practices. One approach to eliminate this problem is through the application of a classification and coding/group technology (CC/GT) system. CC/GT is a manufacturing concept where parts are systematically classified and coded into families based on their manufacturing and design similarities. From this manufacturing data base, a number of application programs supporting/analyzing manufacturing can be executed.

SUMMARY

The object of this project was to reduce manufacturing costs and improve throughput time via the application of CC/GT. Previously, the Army had purchased a commercially available CC/GT system from the Organization for Industrial Research (OIR). A contract was awarded to OIR to perform a study demonstrating the applicability of group technology at Watervliet Arsenal. A total of 474 parts were coded using the MICLASS system relating part characteristics to machining requirements. Analyses were made and part families identified. The results are as follows:

a. There was a considerable variation in manufacturing process plans for the same or similar parts. A computer assisted process planning system could eliminate this costly duplication in manufacturing and increase the productivity of process planning personnel, reduce the time required to understand manufacturing process plans on the shop floor, reduce the time spent preparing process plans, and reduce confusion on the shop floor before the part is actually made.

b. Grouping similar parts, routing via standardized process plans, and using dedicated machine tools will reduce direct labor, set-up time and work in progress.

c. The reduction in set-up time will increase production capacity.

d. It was estimated that approximately 4-8% of existing drawings could be used for new designs. Of the 474 parts coded, it was determined that about 10% could have been designed by modifying previously existing drawings.

Based upon these results, it was decided to pursue the implementation of a computer aided process planning system (see Figure 1). This task is being continued under a follow on project, 681 7724.

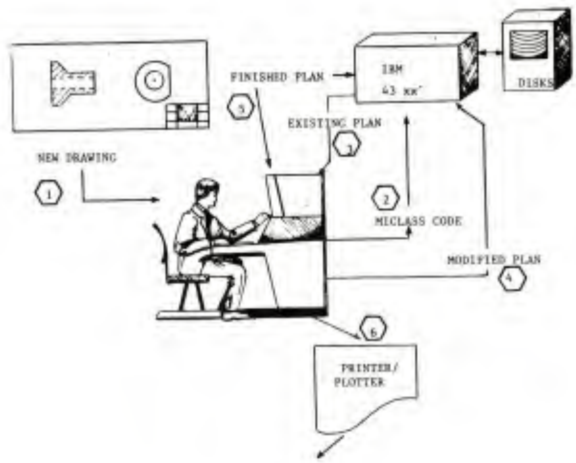


Figure 1 - System Configurations

BENEFITS

This project has produced a positive attitude towards CC/GT at Watervliet Arsenal. Significant benefits will result once a system is fully implemented. A manufacturing data base with 474 coded parts was created.

IMPLEMENTATION

The application of CC/GT via an automated process planning system is being pursued.

MORE INFORMATION

Contact CPT Walter Olson, Watervliet Arsenal, AV 974-5827 or Commercial (518) 266-5827.

Summary report was prepared by James H. Sullivan, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 679 7949 titled, "Application of Group Technology to Rock Island Arsenal Manufacturing (CAM Related)," was completed by the US Army Armament Materiel Readiness Command in June 1981 at a cost of $123,002.

BACKGROUND

Weapon systems are typically manufactured without the use of mass production techniques. At Rock Island Arsenal (RIA), over 4600 component and subassembly drawings are maintained. These parts are produced in a job shop environment due the small quantities required annually.

One approach that attempts to obtain the economics associated with mass production in industries characterized by batch or job shop machining is group technology (GT). GT is a manufacturing philosophy that identifies the similarities in design and manufacture of discrete parts. Based upon the similarities, part families are formed and processed together.

SUMMARY

The objective of this project was to reduce manufacturing costs and lead times at RIA. This will be accomplished through the implementation of a classification and coding/group technology (CC/GT) system.

A commercially available CC/GT system (MICLASS) was installed on the in-house computer system. The MICLASS software uses an interactive program to assign code numbers to parts. The code number identifies the part shape, size, machining tolerance, etc. These code numbers then provide the basis for analysis via the group technology programs; advantages are depicted in Table 1.

RIA personnel were trained in the use of the MICLASS CC/GT system. A total of 3288 production parts were coded forming the MICLASS data base. This data base is being analyzed under a follow-on project, MMT 680 7949 to identify part families and establish work cells.

• Formation of groups of parts (part families) and machine groups • Quick retrieval of designs, drawings, and production plans • Design rationalization and reduction of design costs • Reliable workpiece statistics • Accurate estimation of machine tool requirements, rationalized machine loading, and optimized capital expenditure • Rationalization of tooling setup and reduction of setup time and overall production time • Rationalization and improvement of tool design and reduction of tool design and fabrication times and costs • Rationalization of production planning procedures and scheduling • Accurate cost accounting and cost estimation • Better utilization of machine tools, workholding devices, and manpower • Improvement in numerical control (NC) programming and effective uses of NC machines.

Table 1 - Some of the advantages of group technology

BENEFITS

This project established a CC/GT system at RIA. The application of this technology will produce the following benefits:

- standardize process plans
- increased productivity
- reduce setup times
- decrease material handling
- reduce cost
- improve scheduling
- improve cost estimating
- reduce work-in-process inventory

IMPLEMENTATION

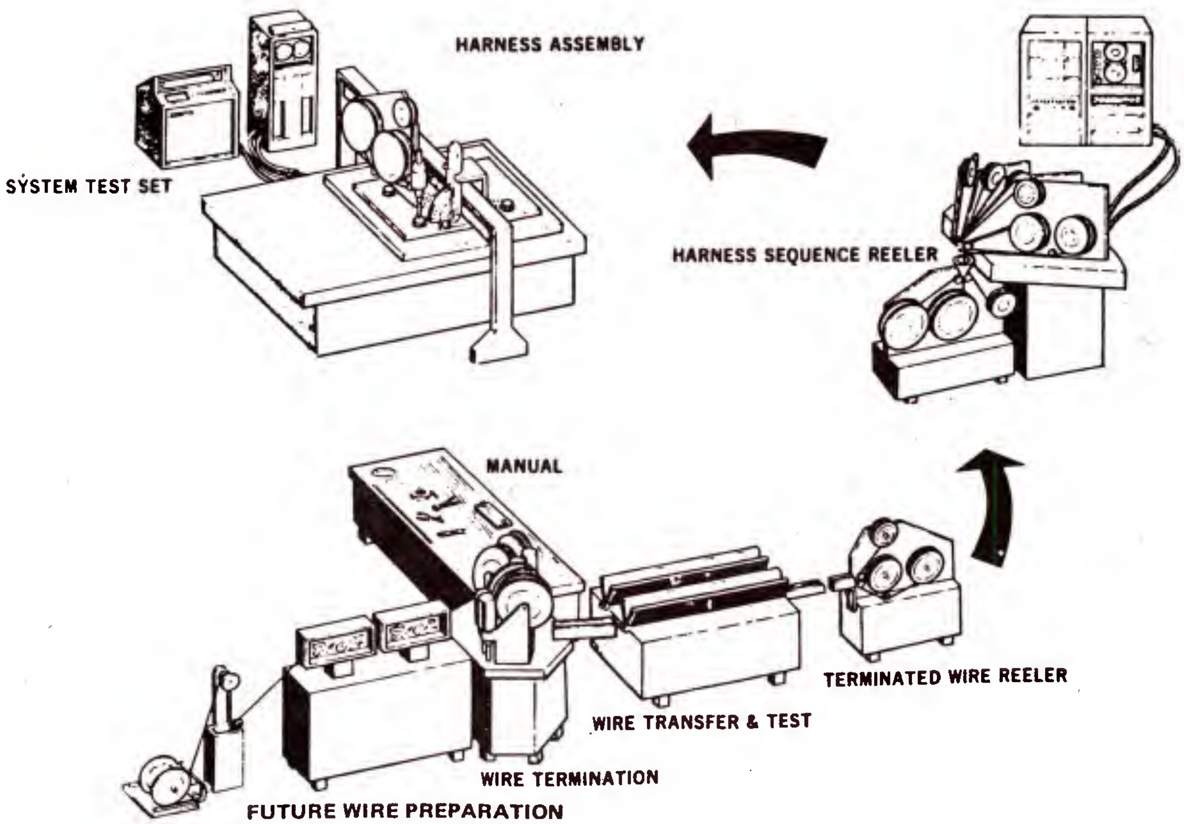
This technology is being implemented under a follow on project. GT machining departments will be organized and established under RIA's modernization program. An FY83 project is planned (683 8306) to establish an automated process planning system driven by the MICLASS data base constructed during this project.

MORE INFORMATION

Contact Mr. John Wilkins, Rock Island Arsenal, AV 793-5897 or Commercial (309) 794-5897.

Summary report was prepared by James H. Sullivan, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

ELECTRONICS



CONCEPTUAL APPROACH TO FIXING ELECTRICAL CONNECTORS TO CABLES

ABSTRACTS

Project Number	Project Title	Page
276 9631	Integrated Circuit Fabrication Using Electron Beam Technology	E-4

Electron beam lithography allows for smaller pattern definition on semiconductor wafers and mask sets. Several electron beam exposure columns and computer control systems were developed to allow e-beam writing directly on the wafer and the redrawing of 256 bit random access memory mask sets. Results of this project have been implemented at several firms contracting for submicron device lithography with Very High Speed Integrated Circuits.

276 9774	Improved Plated-Through Holes by Altering Drill Geometry and Finish	E-7

This project optimized production techniques in order to provide better fabrication of multilayer circuit boards by improving hole surface quality. An infrared temperature sensor was utilized and indicates that a microtube drill coating and slower drilling speed reduced epoxy smear in holes. Findings detailed in the technical report also include effects of varying drill geometry and techniques for quantitative epoxy smear analysis.

F76 9776	Fabrication Methods for Low Cost Hybrid Silicon Photodetector Modules	E-9

Photoreceivers built using discrete components on individual substrates are very expensive due to a large amount of handling. This project developed a low cost, reliable method to semi-automatically fabricate two models of hybrid photodetector modules for fiber optic communications and for laser range-finders. This technology is directly transferrable to other silicon photodetectors and has resulted in a cost reduction by a factor of 10 for the tested models.

276 9778-A	Production of Long Life Emitters for Fiber Optics	E-11

High yield production processes were developed for the GaAlAs/GaAs double hetrojunction injection laser. These developments were in the areas of the epitaxial process, copper-nylar pill package assembly, parameter testing, burn-in and life testing. The cost per laser was $19.61 and a significantly lower cost is expected when volume production is implemented.

276 9778-B Production of Long Life Emitters for Fiber Optics E-14

This project devised production processes for the volume manufacture of long life, "Burris" type, double-hetrojunction GaAlAs/GaAs light emitting diodes. The areas of emphasis were the epitaxial process, the coaxial configuration with pigtail assembly, parameter testing, burn-in and life testing. The cost of each diode was $36.90 and a lower price is expected when they are produced in volume.

H78 9793 Production of Intagliated Fiber Optic Phosphor Screen E-42

This project established methods for successfully intagliating fiber optic inverters. The optimum pit depth for phosphor efficiency, metal for coating the sidewalls, and acid strength for a flat etch pit bottom were determined. A solution to the problem of phosphor poisoning was found. Spinoff uses of this technology include heads-up displays and cathode ray tubes.

277 9842 MMT Third Generation 0.9 Micron Photocathode E-25

Third generation 0.9 micron photocathodes demonstrate sensitivity improvements of four to six times over conventional photocathodes. Third generation cathodes may also be surface etched and reactivated, thus making them a recyclable component. This project developed the technology to mass produce these photocathodes and implemented the resulting processes as standard manufacturing procedure at the two contractors.

R79 3217 Automated Production Methods for Traveling Wave Tubes E-30

A significant advance in the cost reduction and reliability of TWTs with fast warm-up requirements was achieved through superior manufacturing techniques and TWT design. Projected cost of the 6,000th unit is $6,344 versus an initial cost of $20,000.

Page

R78 3254, R80 3254 — Low-Cost Semi-Flexible Thin-Film Semiconductors — E-33

This effort improved thin-film transistor (TFT) fabrication processes by optimizing transistor materials and defining the TFT by using photolithography instead of conventional metal masking techniques. Accurate seven micron channel lengths and adequate strain sensitivity were observed in the final transistor. This project resulted in a 26% cost reduction per semiconductor. The technology was used in fabrication of TFT's for the model GC 2000 Accelerometer, a device used by both the military and commercial firms.

R79 3438 — Delidding and Resealing Hybrid Microelectric Packages — E-36

This project modified a delidding saw machine and developed delidding and resealing techniques for hybrid microelectronic packages. Tests were run on resealed packages to inspect fine and gross leaks, particle impact noise detection and maintenance of electrical properties. Virtually no failures occurred. Survey data shows industry savings of $2.5 million/yr from delidding and resealing currently done via waivers. Total potential savings are estimated to exceed $10 million/yr if this method is implemented industry wide.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 276 9631 titled, "Integrated Circuit Fabrication Using Electron Beam Technology," was completed by the US Army Electronic R&D Command in January 1980 at a cost of $783,000.

BACKGROUND

With the need for ever smaller pattern definition for use in manufacture of semiconductor integrated circuits has come increased use of electron beam lithography. The electron beam can be made smaller and controlled more accurately than a light beam and has been used to expose photoresist on both semiconductor wafers and on mask sets.

SUMMARY

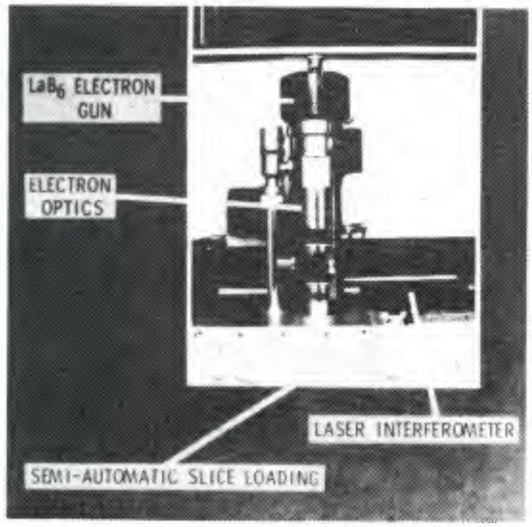
With Army Electronics R&D Command financial support, Texas Instruments expanded its emphasis on company developed baseline processes and equipment for exposing electron beam (e-beam) resist directly on the wafer. This permits pattern generation directly on the silicon slice without using a mask, thus generating finer geometry circuits. Fine geometry is required for the very high speed integrated circuit (VHSIC) program and for a number of large scale integrated (LSI) circuits needed by ERADCOM. Writing directly on the wafer eliminates the need for artwork and masking processes and can lead to fewer pattern defects and an improvement in yield.

Electron beam exposure can also be used to generate mask sets where a small increase in size as compared to direct writing is not a disadvantage. Mask sets greatly speed exposure time and thru-put and are the preferred method if size permits.

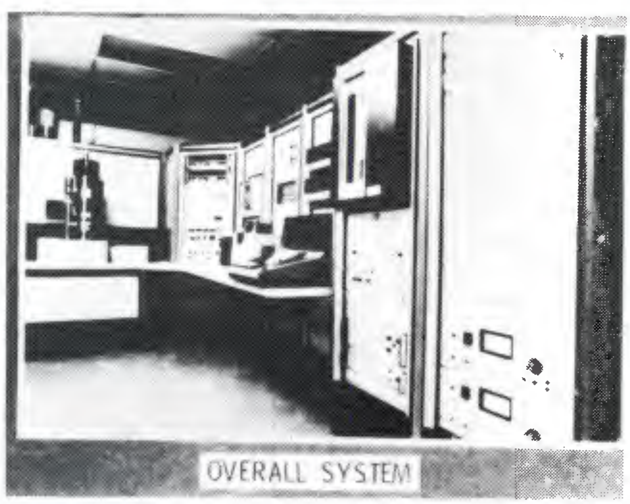
A wafer transport system was also developed to move the wafers from a rack, into the e-beam column, and return them to the rack, all within the vacuum chamber. This eliminates repeated drawdown of the vacuum area. Another feature developed was the provision for small and large beam diameters; all small areas are exposed first with the smaller beam, then all large areas are exposed with the broad beam to reduce exposure time.

BENEFITS

A benefit of this program was the development and manufacture of several electron beam exposure columns and computer control systems. See the accompanying illustrations. Texas Instruments machined components for several e-beam columns in England and assembled the columns and wafer transport equipment in this country. Two companies in the USA now manufacture complete systems.



Electron Beam Machine III



Overall System

Another benefit of this early Government support of direct on-the-wafer electron beam exposure was to encourage industry to commit substantial amounts of capital to expand their use of this technology on complex integrated circuits. At least a 10 for 1 multiplication of Government funding was achieved.

Substantial company investment was made in electron beam exposure, computer control equipment, and software development. Without Government encouragement, this would not have occurred as rapidly or as widely.

A third benefit of this contract was the work TI performed on the 256 bit random access memory (RAM) mask sets. The masks were completely redrawn using 4 to 5 micron design rules and a computer-driven electron beam. This resulted in a reduction in pinholes and improvement in registration and thus, substantial gain in yield. A side benefit was TI's work on electron beam resists; both a positive and a negative type resist were developed and used in this project.

In spite of the several advancements made by TI, slow electron beam writing and low thruput of completely exposed wafers has hampered the adoption of this method for writing on the wafer. Although improvements were made in resist sensitivity to permit more rapid exposure, and in beam switching methods to permit faster exposure of broad areas, the speed of full wafer exposure thru a mask has not been approached. One remedy is to use e-beam to generate the mask sets which are used in full wafer exposure. Another method is to expose the bulk of the circuit thru a mask and use e-beam on the critically fine areas.

IMPLEMENTATION

Results of this effort were put into use at several firms which are contracting for submicron device lithography within VHSIC phase I and II contracts. VHSIC contractors include TI, IBM, Westinghouse, Honeywell, Hughes, and TRW/Motorola/Sperry. Electron-beam writing has also found increased use in exposure of fine lines for microwave transistors. The technique is economical in this application because the pattern is simple and can be exposed in a very short time.

In addition to the VLSI circuits mentioned above, a microprocessor was fabricated with 1 micron minimum feature size.

MORE INFORMATION

Additional information may be obtained from the project engineer, Mr. William Glendinning, US Army Electronics R&D Command, DELET-IA-D, AV 995-4396, Commercial (201) 544-4396. The contract number was DAAB07-76-C-8105. The Final Technical Report is number DELET-TR-76-8105-F.

Summary report was prepared by Charles E. McBurney, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 276 9774 titled "Improved Plated-Through Holes by Altering Drill Geometry and Finish" was completed by the US Army Electronics Research and Development Command in February, 1980 at a cost of $125,000.

BACKGROUND

Current and future military systems continue to use high reliability multilayer boards whose specifications are governed by various military standards containing necessarily stringent quality requirements. It is widely recognized that the most common failure is in the area of plated-through holes. Fabricators of multilayer boards have been concerned with the recurring problem of drilled hole degradations such as epoxy smear, nail heading, burrs, and epoxy gouging. This concern is justified since the sidewall of the drilled hole is the surface upon which copper is chemically deposited and electroplated to make electrical contact between the internal layers and the external circuitry. The condition of the hole surface is also important in determining the quality of the electroplated interconnections and affects the ultimate reliability of the multilayer board.

SUMMARY

The major objective of this project was to optimize methods and techniques in order to provide for better fabrication of multilayer printed circuit boards through improved hole surface quality. Various techniques for detecting drill wear were evaluated. The most effective method was determined to be an infared temperature sensing device to measure drill temperature as the drill exited the hole.

Various drill finishes and point geometries were evaluated using the infared temperature sensing system shown in Figure 1. Approximately 3500 holes were drilled and the following results were obtained:

o Exit temperature was higher for standard finish drills than for microfinish drills.

o Microlube coating did not improve hole quality or result in lower exit temperature.

o No significant differences in exit temperature or hole quality was observed using various drill point geometries on microfinish drills.

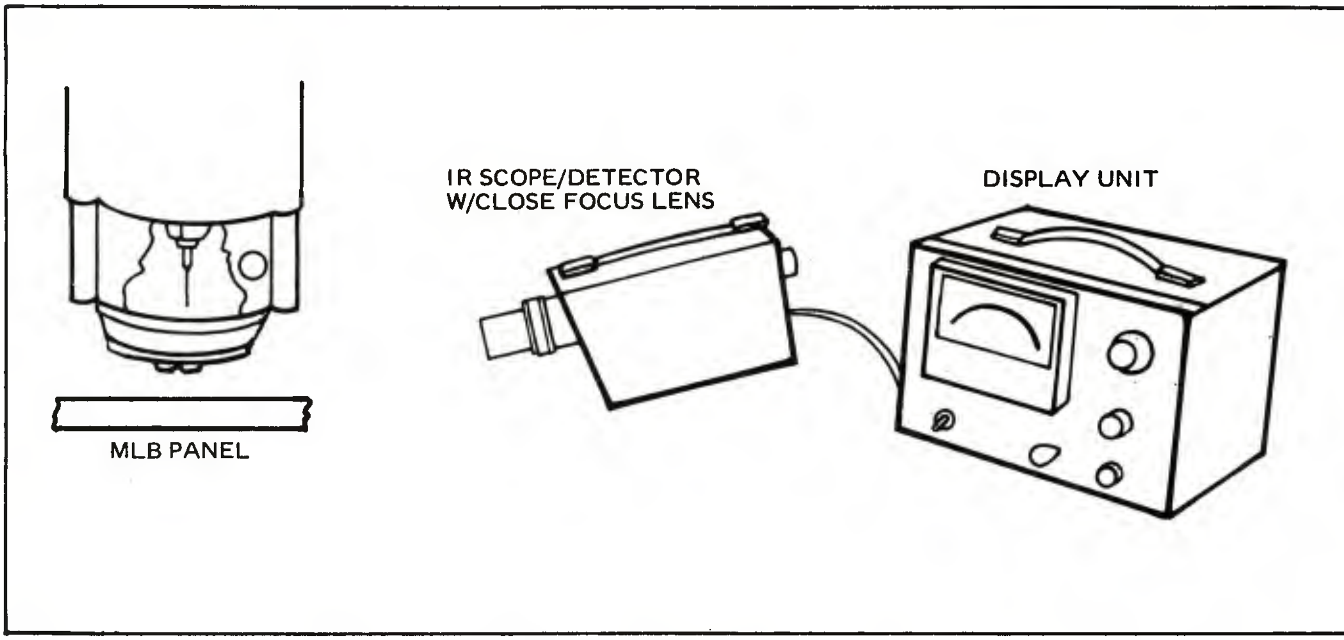


Figure 1 - Infared Scope System for Monitoring Drill Bit Temperature

It was found that hole quality is primarily related to drill finish but not drill geometry, and that reducing drilling speed from 80,000 RPM to 50,000 RPM, with the feed rate held constant, reduced the smear factor for all drill sizes tested.

BENEFITS

This project has isolated the causes of epoxy smear in drilled holes, developed a real time method for detecting the start of smear and/or drill failure, developed a technique for quantitative analysis of smear, and evaluated alternate drill geometries.

IMPLEMENTATION

The technical report associated with this project has been distributed to Government agencies and to industry.

MORE INFORMATION

Additional information may be obtained by calling Mr. Dave Ruppe, US Army Communications and Electronics Command, AV 995-4251 or Commercial (201) 535-4251.

Summary report was prepared by Alan Peltz, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project F76 9776 titled "Fabrication Methods for Low Cost Hybrid Silicon Photodetector Modules" was completed by the US Army Communications and Electronics Command in July 1980 at a cost of $446,500.

BACKGROUND

Fiber optic communication links and laser rangefinders require photodetector receivers for operation. These receiver modules were being built using discrete components on individual substrates with poor yields. They were expensive since they were fabricated with a large amount of handling.

SUMMARY

The object of this project was to develop low cost and reliable manufacturing processes to semi-automatically fabricate two models of hybrid photodetector modules for fiber optic communications and for laser rangefinders. RCA Limited was awarded the contract to develop the processes. Their approach was to mount the SCS467 avalanche photodiode, a positive feedback preamplifier, a temperature sensing diode and a temperature compensation unit on a ceramic substrate in the fiber optic photodetector module. The rangefinder module, a drawing of which is shown in Figure 1, does not contain the temperature compensation unit.

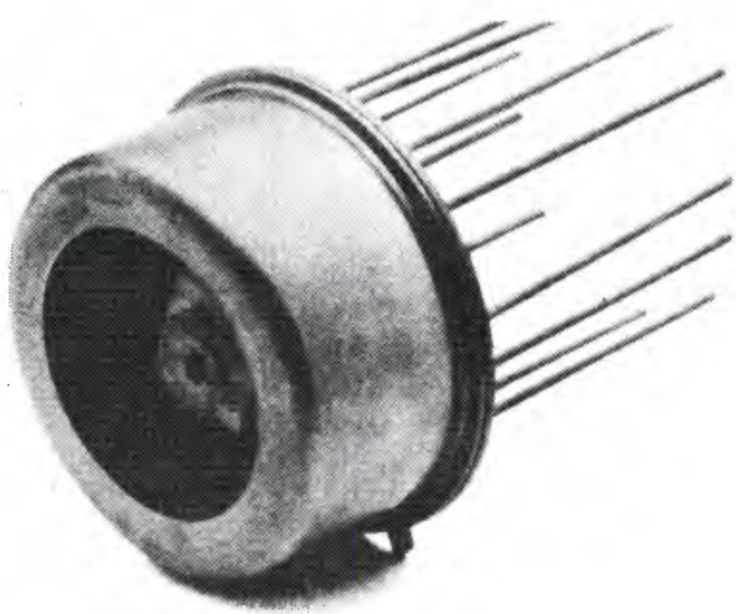


Figure 1 - Rangefinder module

The final fabrication processes were very similar to the original approaches. All resistors, except for the load resistor, and all conductors are thick film on an alumina substrate for economy and reliability. A non-conductive alumina filled epoxy, H70E, was used to bond the substrate to the TO-8 header with a Kovar spacer in between. The bond separated in the constant acceleration test due to insufficient adhesion to the gold plated header. This was remedied by nickel plating the Kovar tabs and soldering with tin-silver solder. A better solution was to spot weld nine molybdenum tabs to the header, metalize the substrate and solder it to the tabs.

Solder paste was applied from a hand dispenser to pins, chip capacitors, and the detector pedestal. The paste was then reflowed. This provided a good mechanical adhesion of heavier components. A conductive silver filled epoxy, H20E, was used to attach three RF transistors, a temperature sensing diode and a load resistor for economical assembly, repairability, and minimum stray capacitance for optimum circuit performance. After thermosonic wire bonding, electrical tests were performed to insure the yield. The detector was soldered to a molybdenum tab and H20E epoxy bonded to the pedestal. Again, after thermosonic wire bonding, the electrical tests were performed.

After a vacuum bake, an antireflective SiO coating was then applied to the window and optimized for a wavelength of 1060 nm. The window cap was resistance welded to the TO-8 header for a good hermetric seal. Helium leak testing was then performed.

BENEFITS

This project has made available to the Army two small ruggedized detector module designs for use in laser rangefinders and fiber optic communications. The fabrication technology developed is maturing and is directly transferrable to fabrication of a variety of silicon photodetector modules. It has been estimated that for these particular modules, there has been a cost reduction by a factor of ten.

IMPLEMENTATION

The particular modules developed in this project are not currently in production. The processes developed are used to manufacture a variety of RCA fiber optic communication receivers. Pilot line production modules were in the AN/TYC-39 Message Switch, the FOTS Transmission Test Unit and the Mini-Laser Rangefinder development units.

MORE INFORMATION

Additional information may be obtained from Mr. R. J. McIntyre, Manager R&D, RCA Limited, Commercial (514) 457-9000. The contract number was DAAB07-77-C-0489.

Summary report was prepared by Dan Richardson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 276 9778-A titled "Production of Long Life Emitters for Fiber Optics" was completed by the US Army Communications Research and Development Command in August 1981 at a cost of $216,400.

BACKGROUND

Past developments in fiber optic communications have demonstrated the feasibility and desirability of replacing conventional cabling with fiber optic links. Among fiber optic communications advantages are weight and volume reduction, EMP proof and no channel crosstalk. At the outset of this project, injection laser diodes were expensive and did not meet military requirements. If the 26 pair cable (CX-4566) was to be replaced by a fiber optic cable, production processes for the volume manufacture of GaAlAs/GaAs injection laser diodes and testing procedures need to be developed. In particular, the areas of concern were the epitaxial process, copper-mylar pill package assembly,(Figure 1) parameter testing, burn-in and life testing.

SUMMARY

This project is subtask A of a two subtask effort whose goal was to optimize the production processes for long life double hetrojunction GaAlAs/GaAs injection laser diodes. Some of the specifications for the injection laser diodes are:

Peak Wavelength:	800-830nm
Ip:	3A
Vf:	2.0V@3A
Output Power @25°C:	18.9-21mW

The device structure is synthesized via liquid phase epitaxy (LPE). See Figure 2 for a cross-section view of the post-epitaxy substrate. The LPE system in use at Laser Diode Labs has many optimization features. Some of these are:

i) Isothermal heat pipe furnace
ii) Molecular sieve Vac Sorb pump
iii) Fuel cell oxygen monitor

An ultra high purity, high density graphite eight bin boat utilizes a built-in indexing mechanism for accurate stepping of the substrate through each bin. The careful preweighing of GaAs for each bin has been eliminated by a self-saturation scheme in which GaAs is dissolved from polycrystalline source wafers at 850°C to exactly saturate each melt.

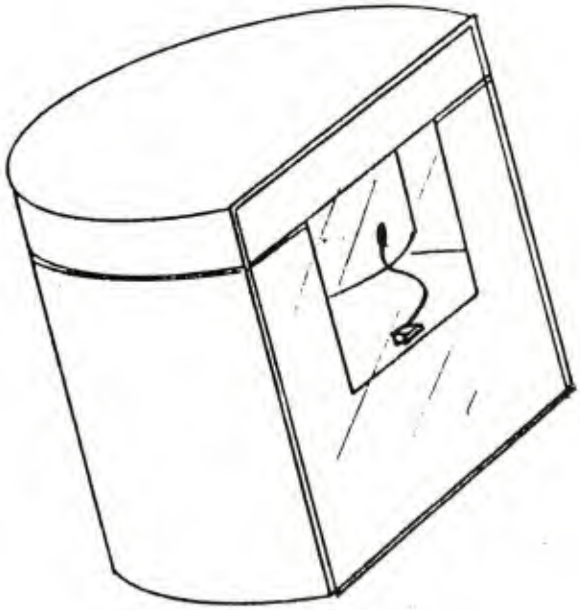


Figure 1 - Triple Stripe Laser Package

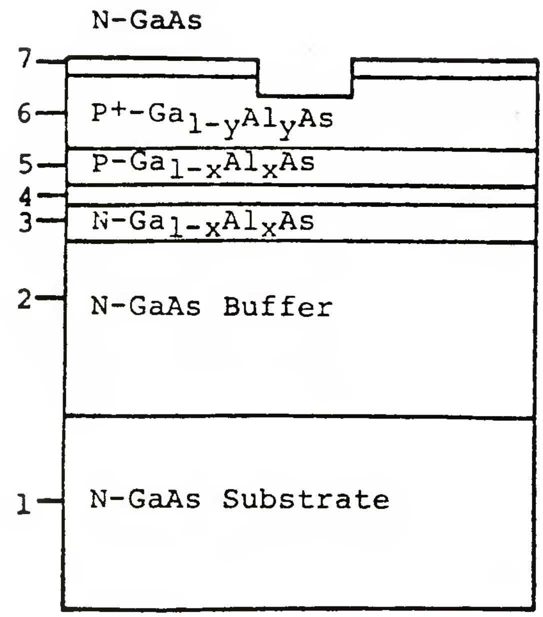


Figure 2 - Epitaxial Structure

The following process steps complete the injection laser chip after the LPE process.

1. Preprocess cleaning to remove residual Ga from the surface.

2. Cleave mutually perpendicular <110> reference planes and use for channel stripe alignment.

3. Deposit, expose and develop photoresist channel pattern which is aligned with the reference planes.

4. Etch through the n-type GaAs blocking layer with 3:1:1 H_2PO_3:H_2O:H_2O_2.

5. Remove photoresist.

6. Thin wafer to 3.5 mils.

7. Evaporate Sn metalization on n-side of the wafer.

8. Electroplate Ni-Au contacts to both sides of the wafer.

9. Cleave wafer into slivers 10 mils long by 300 mils wide, forming mirror surfaces at the ends of the channels.

10. Vacuum deposit a reflective coating of SiO (.2 microns), Cr (.005 microns), Au (.4 microns), Cr (.01 microns) and SiO (.03 microns) on the back facet to improve the reflectivity.

11. Cut individual slivers with a gauged wire saw with a 3.5 mil kerf so that each chip has 3 stripes.

The packaging design had many options including copper-ceramic, copper-mylar, epoxy on mylar film carrier preform for window attachment, heat curing epoxy and UV curing epoxy. Analysis showed that the copper-ceramic package was not desirable because of the disparity in the hardness of the two materials. In the lapping operation for the window frame flatness, the copper wears faster than the ceramic, lending itself to rounding. The copper-mylar package was found to have no adverse electrical characteristics.

The packaging steps for the copper-mylar design are rather straightforward. The disc shaped positive (copper) and negative (brass) electrodes are turned from round stock on a lathe and degreased. They are bonded with a heat curing Albestik type 539 epoxy preform. The window surface is milled flat, lapped, deburred and cleaned. The package is then Ni-Au plated. A mil gold fly wire is soldered to the upper electrode with 60/40 Pb/Sn solder. The bottom electrode is tinned with In. The chip is reflow soldered to the bottom electrode and the gold fly wire is soldered to the top of the chip with an In preform. The window is sealed to the package with a thin bead of Norland Optical Adhesive 61 in a dry nitrogen atmosphere. The adhesive is cured with UV for 2 seconds and the excess is removed. The cure is completed with a 15 second UV exposure.

The circuitry for driving the laser during the parameter tests was a 3.0A 10MHz 10ns pulser. The circuitry for driving the laser during the Burn-in and Life Tests was similar and included fault indicators. An avalanche diode regulator was built which gives the diode temperature compensation. The avalanche diode was used in the Goniometer beam divergence measurements and the optical power measurements.

BENEFITS

High yield production processes were developed for the GaAlAs/GaAs double hetrojunction injection laser such that it meets specification SCS-516. These processes insure a minimum cost for these lasers. The cost of the lasers in the pilot line production was $19.61 each. A significantly lower unit cost can be achieved when they are produced in volume.

IMPLEMENTATION

This laser diode design may be used in the Army's long haul and missile weapon systems.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Jeff Paul, NV&EOL, AV 354-5310 or Commercial (703) 664-5310. The final technical report number was CORADCOM-76-0040-F. The contract number was DAAB07-76-C-0040.

Summary Report was prepared by Dan Richardson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 276 9778-B titled "Production of Long Life Emitters for Fiber Optics" was completed by the US Army Communications Research and Development Command in August 1981 at a cost of $221,400.

BACKGROUND

Past developments in fiber optic communications have demonstrated the feasibility and desirability of replacing conventional cabling with fiber optic links. Among fiber optic communications advantages are weight and volume reduction, EMP proof and no channel crosstalk. At the outset of this project, light emitting diodes were expensive and did not meet military requirements. If the 26 pair cable (CX-4566) was to be replaced by a fiber optic cable, production processes for the volume manufacture of "Burrus" light emitting diodes (LED) and testing procedures needed to be developed. In particular, the areas of concern are the epitaxial process, the coaxial package configuration with pigtail assembly (Figure 1), parameter testing, burn-in and life testing.

SUMMARY

This project is subtask B of a two subtask effort whose goal was to optimize the production processes for long life "Burrus" type double-hetrojunction GaAlAs/GaAs LED. Some of the specifications for the LED's are:

Peak Wavelength:	845±45nm
V_f:	1.9V @ I_f=100ma
V_{br}:	3.0V @ I_r=10ua
Output Power @25°C:	75uW @ I_f=100ma

The device structure is synthesized via liquid phase epitaxy (LPE). See Figure 2 for a cross-section view of the post-epitaxy substrate. The LPE system in use at Laser Diode Labs has many optimization features. Some of these are:

i) Isothermal heat pipe furnace
ii) Molecular sieve Vac Sorb pump
iii) Fuel cell oxygen monitor

An ultra high purity, high density graphite eight bin boat utilizes a built-in indexing mechanism for accurate stepping of the substrate through each bin. This system was also used in subtask A of this project.

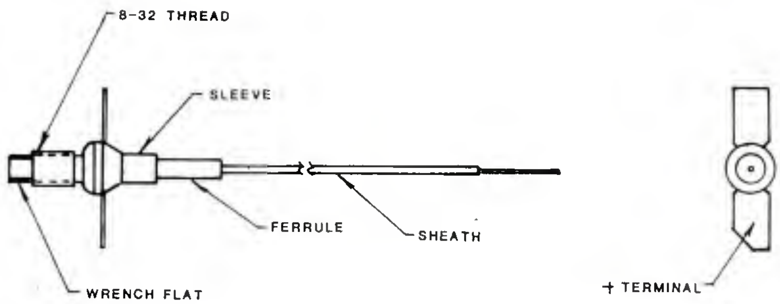


Figure 1 -
Fiber Coupled Led

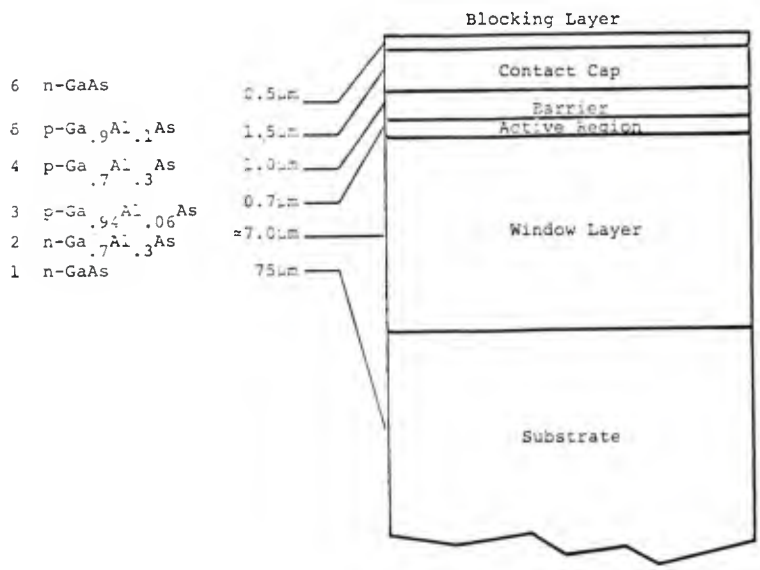


Figure 2 -
Epitaxial Structure

The following process steps complete the LED chip after the LPE process.

1. A 0.08 micron layer of Si_3N_4 is CVD deposited on the p-side of the diode.

2. A 0.5 micron layer of photoresist is spun on and baked on both sides of the wafer.

3. The wafer is UV exposed on both sides in a hinged mask set. This mask set maintains concentric alignment of the 40 micron dot pattern on the p-side with the 9 mil dot pattern on the n-side.

4. The photoresist is developed and the n-side is etched 2 microns in depth to imprint the dot pattern for further lithography. The p-side is protected by the Si_3N_4.

5. The Si_3N_4 is plasma etched through the photoresist pattern and the photoresist is then removed.

6. A zinc diffusion is then performed through the Si_3N_4 pattern on the p-side and on the entire n-side to a depth of 2 microns. This provides a p-type contact through the n-type blocking layer to the p-type contact cap.

7. The Si_3N_4 pattern is removed by plasma etching. The p-side is then masked with wax.

8. The n-side is etched to remove the zinc diffusion layer and then the wax is removed.

9. The wafer is metalized on the p-side with 0.05 microns of Ti, 0.1 microns of Pd and 0.1 microns of Au. On the n-side, 0.15 microns of AuGe and 0.1 microns of Au are deposited.

10. Die area contacts on the wafer are plated on the p-side to 1/2 mil using standard lithography.

11. The 9 mil dot pattern was again photolithographically exposed on the n-side by realigning the mask with the previous etch impression.

12. The AuGe was etched in the dot pattern with KI. The GaAs substrate was etched with a H_2O_2 solution. NH_4OH was in the etch solution to prevent oxidation. The etched well reaches 4.2 mils in depth.

13. The wafer is gauged wire sawed into individual LED's.

A standard JEDEC MT-90 RF transistor package modified for fiber optic attachment is used to house the LED. The package contains a mounting stud and low inductance "wings" brazed to a B_eO substrate. The LED is soldered to the metalized B_eO substrate using a graphite 25 unit chip soldering fixture and heating with an Infra-red Belt furnace. The soldering cream is 60/40 SnPb. Two 2 mil gold wires are used to double wire bond the chip. A 3-axis micromanipulator is used to set in position the fiber/ferrule/sleeve assembly for bonding with Epoxy Technology X304 adhesive.

BENEFITS

High yield production processes have been developed for the "Burris" light emitting diode such that it meets specification SCS-511. These processes insure a minimum cost for producing this GaAlAs/GaAs double hetrojunction LED design. The cost of these LED's in the pilot line production was $36.90 each. A significantly lower unit cost can be achieved when they are produced in volume.

IMPLEMENTATION

These LED's may be utilized in the production version of the AN/TYC-39 Store and Forward Module.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Jeff Paul, NV&EOL, AV 354-5310 or Commercial (703) 664-5310. The final technicl report number was CORADCOM-76-8135-F. The contract number was DAAB07-76-C-8135.

Summary Report was prepared by Dan Richardson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 276 9781 titled "MMT - Thin Film Transistor-Addressed Display" was completed by the US Army Electronics Research and Development Command in June 1980 at a cost of $590,000.

BACKGROUND

Large scale display integration through active matrices formed by thin-film deposition techniques is a technology currently undergoing extension in several directions.

Westinghouse developed a small 256-character flat panel, active-matrix addressed Thin Film Transistor (TFT) electroluminescent display for the Army under R&D contract DAAB07-72-C-0061. This device was built in the laboratory with manually-operated vacuum systems using "variable-aperture" masks and evaporation deposition techniques to define thin film patterns on glass substrates. Manufacturing techniques for multiple evaporations that reduce blemishes and cycle time while maintaining TFT uniformity over the glass substrate were now needed for production.

SUMMARY

Westinghouse at Pittsburg, PA, won a multi-phase MMT contract to establish low cost production methods for flat panel Thin Film Transistor addressed displays. The display was formed in two identical parts in order to utilize existing TFT processing equipments which were restricted to maximum 4 inch x 4 inch substrate sizes. The active panel display area consisted of 222 x 77 (17,094) elements (PIXELS), each controlled by two TFT transistors, a capacitor, and set of interconnecting busbars. The display medium is a powder AC electroluminescent (EL) phosphor. A simplified thin film pattern cross section is depicted in Figure 1.

Mask sets with fixed apertures "dedicated" to a particular design were constructed utilizing computer aided design.

The automated thin film deposition system is shown in Figure 2. The basic vacuum equipment configuration was specified by Westinghouse and built by Vacuum Technology ASSC. Fabrication capacities were eight, one-half panel display circuits in one vacuum cycle. TFT materials deposited were

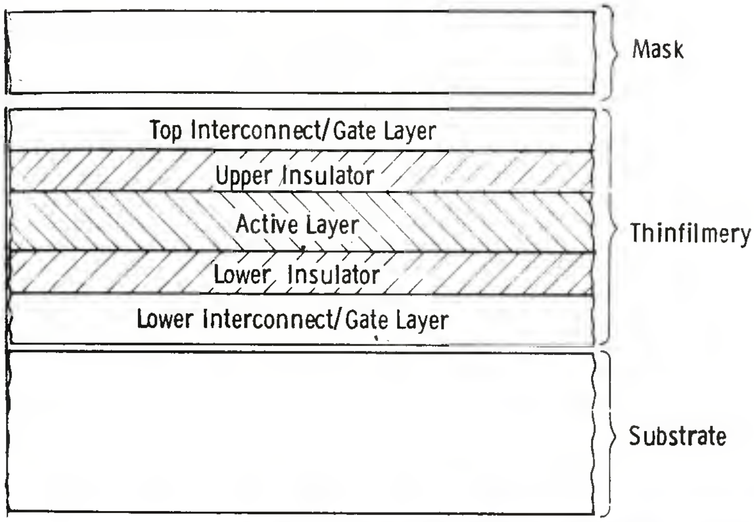


Figure 1 - General conceptualization of thin film pattern cross section as five separate layer grouping

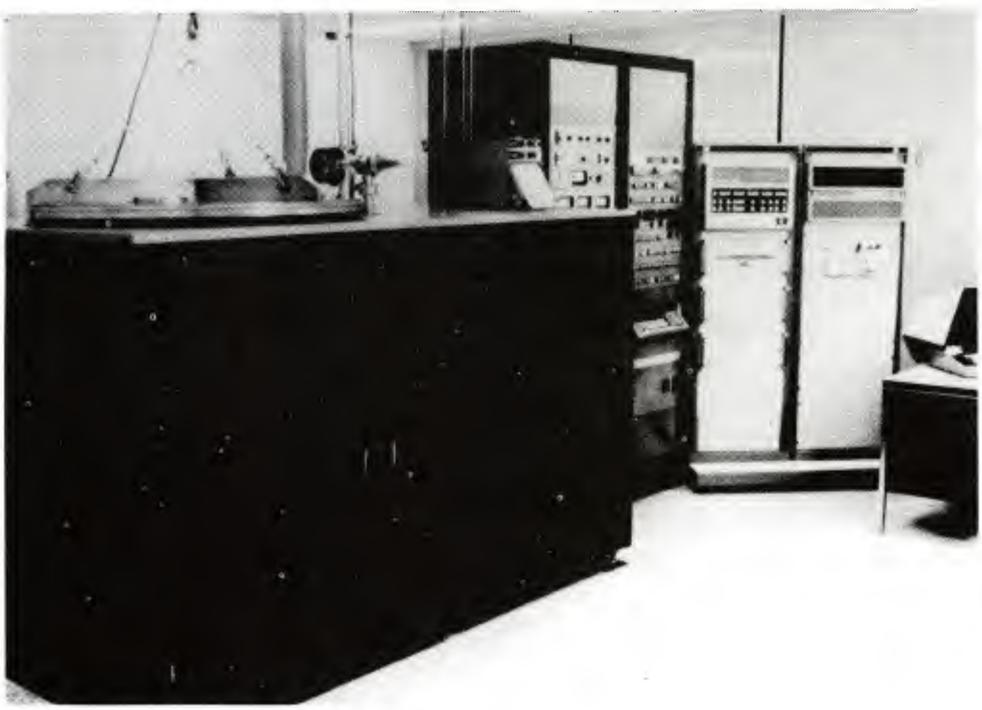


Figure 2 - The Automatic Vacuum Deposition System

Aluminum Oxide (Al_2O_3) for the insulator and metal contacts, Cadmium Selenide (CdSe) for the semiconductor, and Gold Indium (Au-In) for the source-drain. The entire operational sequence including vacuum pumpdown, source, mask and substrate alignment, evaporation rate, film-thickness, pressure control and fail-safe shutdown is completely monitored by minicomputer.

Subsequent steps (packaging processing) involved coating the TFT circuitry with a laminated photoresist to insulate and passivate the active components, generating vias (holes) to the output pads, spraying the EL phosphor powder, and depositing the semitransparent top electrode.

After the sequential dispositions, half panels were tested, matched, aligned and sealed between two glass plates with silicon RTV. See Figure 3. Approximately 18 months were spent fabricating one-half panels and attempting to resolve numerous problems associated with aperture masks, line and spot defects and material vacuum deposition performance.

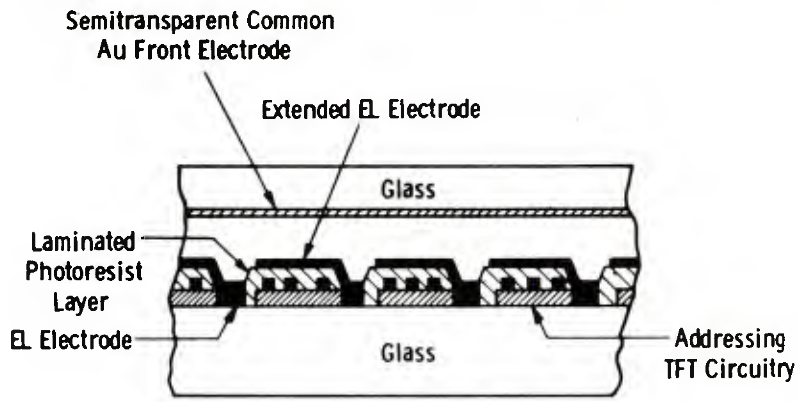


Figure 3 - Second level concept for increased lit area

Results included a basic cell redesign and a greatly simplified aperture mask set which changed substrate processing from a 4-hour, 13 mask, 43-step process to a 1 and 1/2 hour, 9-mask, 26-step process. In addition, multiple and distributed test structures with test probe pads which were built permitted a previously developed automatic probe test unit to be used. However, despite these improvements, project goals were not attained and an in-depth evaluation of the technology determined that continuation was unwarranted.

BENEFITS

Yield problems inherent in this approach precluded continuation of the work. Another approach is being pursued by Aerojet under projects F79 9835 and F82 9835.

IMPLEMENTATION

Because of failure to achieve stated objectives, this MMT project was not directly implemented.

MORE INFORMATION

Additional information may be obtained from Mr. Robert Miller, CECOM, Ft. Monmouth, NJ, AV 996-5205 or Commercial (201) 544-5205. The contract was DAAB07-76-C-0027.

Summary report was prepared by Stephen C. Yedinak, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 276 9788 titled "Fabrication of Low Voltage Start Sealed Beam Arc Lamps" was completed by the US Army Night Vision & Electrooptic Lab in March 1980 at a cost of $324,000.

BACKGROUND

At the outset of this project, a requirement existed for a one-kilowatt, sealed-beam, xenon arc lamp with a low-voltage ignition system. R&D versions of this lamp had been developed, but a producible version was needed in order to be implemented in a timely manner on the M60 Tank.

SUMMARY

The objective of this project was to develop manufacturing technology for producing the low voltage starting lamp so as to increase its survivability and reliability. The model selected for production was the X6257. The resulting version is X6335.

The lamp is comprised of tungsten electrodes positioned in a ceramic/metal structure with a reflector and sapphire window. The arc is located at the focal point of the reflector so that a direct beam is obtained coaxially with the electrodes. The low voltage starting mechanism includes a moveable electrode called the "stinger" which is coaxial with the anode. Figure 1 shows a cross-sectional view of the X6335.

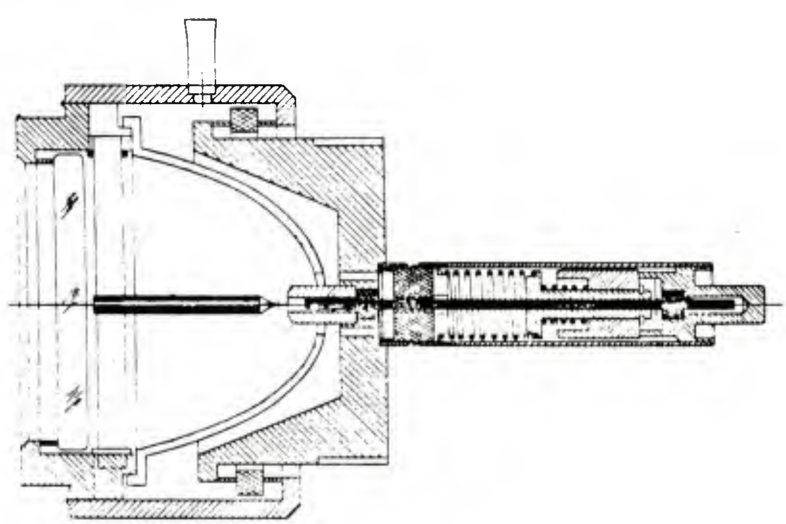


Figure 1 - X6335 Sealed Beam Arc Lamp

The lamp is filled with up to 20 atmospheres of high purity xenon at room temperature. The lamp spectral output is a typical high pressure xenon arc spectrum as reflected from a silver mirror and transmitted through a sapphire window. The silver reflector coating was selected for maximum output in the visible and near IR bands. The lamp operating voltage is 19 volts d.c. ± 10%. The lamp voltage is determined primarily by the interelectrode gap and the lamp pressure. It acts much like a constant voltage device, that is, large changes in current result in small changes in operating voltage.

The lamp is composed of three major subassemblies: the anode shell assembly, the stinger assembly and the reflector-cathode-window assembly. In each of these assemblies, modifications were identified in order to achieve the project's goal. Although these early identified modifications were made, new problems persisted. Porosity and leaks in the ceramic-to-metal seals, cathode burn-back, anode melting, bearing chipping and focal point location were persistent problems.

The contract for this work was terminated for the convenience of the Government in March 1980. The reason for termination was that the tank commanders did not want active search lights on their vehicles and thus, the requirement for lamps no longer existed.

BENEFITS

At the termination of this project, the X6335 had not met the requirements of the Army. No benefits to the Army were derived from this project.

IMPLEMENTATION

Lack of success and lack of a requirement negates implementation.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Clifton Fox, NV&EOL, AV 354-4931 or Commercial (703) 664-4931.

Summary report was prepared by Dan Richardson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 277 9834 titled "Series Transducer Delay Line" was completed by the US Army Electronics Research and Development Command in June 1980 at a cost of $270,600.

BACKGROUND

Microwave acoustic (bulk) delay lines have numerous applications. These include radar signal height/time function setting delay, ECM enhancement, low noise oscillators and high Q stable oscillator control.

The device achieves matching by series connecting separate transducers in a compact matrix which includes matching inductances. The entire unit is fabricated on the end of a delay line rod using thin film techniques.

Previous MMT 575 3061 proved that the required processing technology was viable. Work was now needed to adapt, identify and extend these techniques to be compatible with production pilot line requirements.

SUMMARY

This project's objective was to establish a manufacturing capability for monolithic microwave integrated circuit (MIC) delay lines in which all elements were fabricated by common processing steps. Westinghouse, Defense and Electronics Systems Division at Baltimore, Maryland, demonstrated the technology by performing the following tasks:

1. Fabricated monolithically matched series-connected mosaic piezoelectric transducer with series inductors and integral tuning. Hand tuning was eliminated.

2. Developed a metal mask delineation process to eliminate wet photo-processing.

3. Introduced a mass analyzer for on-line monitoring transducer zinc oxide (ZnO) thin film deposition.

4. Controlled transducer zinc oxide thickness with laser interferometer.

5. Provided near immediate evaluation of gold bottom contact and zinc oxide transducer films with reflection electron diffraction (electron microscope).

MIC matched delay lines were fabricated on both sides of X-cut alpha quartz crystal substrates. A series transducer was formed by dividing the active area into six triangular sections each with an area of 6.55 mils^2. These sections were positioned in a circular pattern to maximize the number of interconnect squares. The rectangular inductor was placed to one side of the transducer so that coupling between inductors was minimal. See Figure 1.

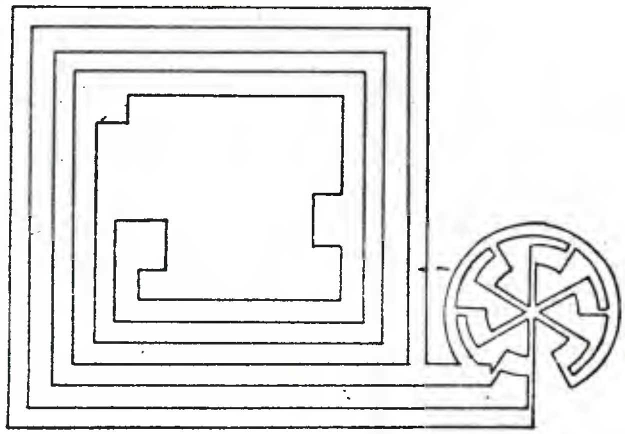


Figure 1 - Series Transducer with a 6 nH Inductor

Essential wafer processing steps included chromium-gold flash evaporation for ground layer metalization, RF sputtered zinc oxide deposition, and chromium-aluminum evaporation for top layer metalization.

A Materials Research Corporation, Model SEM 8620 sputter system was used to perform the ZnO vacuum deposition. This equipment was capable of processing four 1-inch square quartz substrates at one time. A typical 1-inch square metal mask processed wafer is shown in Figure 2.

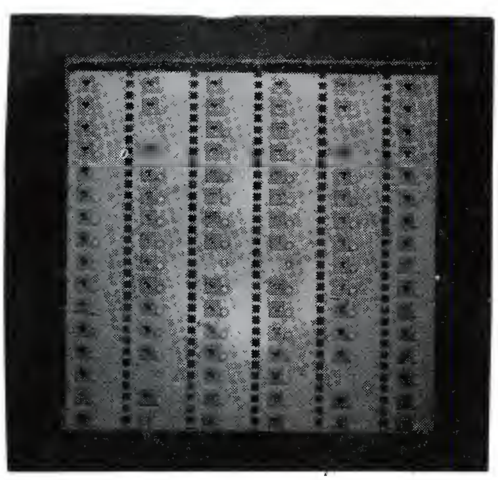


Figure 2 - Typical Metal Mask Processed Wafer

Electrical probe testing determined which delay line chips on the wafer met specifications. Probes were designed to be 50 ohm transmission lines right to the delay line transducer. Insertion loss, feedthrough suppression and triple transit suppression were measured at center frequency and upper and lower band edges. Following probe test, wafers were diced with a microprocessor controlled Tempress Model 604 saw.

Delay line die edges were coated with A25 conductive polyimide prior to mounting chips in machined kovar packages. Gold wire was thermocompression bonded to inductor bonding pads on both sides of the crystal substrate and to the kovar package center conductors. The wires were then reinforced with polyimide. Due to integral tuning, only two bond wires were required. Polyimide was used in lieu of epoxy because of its low resistivity, low outgassing properties, and superior physical properties. Package lids were sealed by seam welding. The entire assembly was oven cured at 150° C for 16 hours. The machined kovar package is shown in Figure 3.

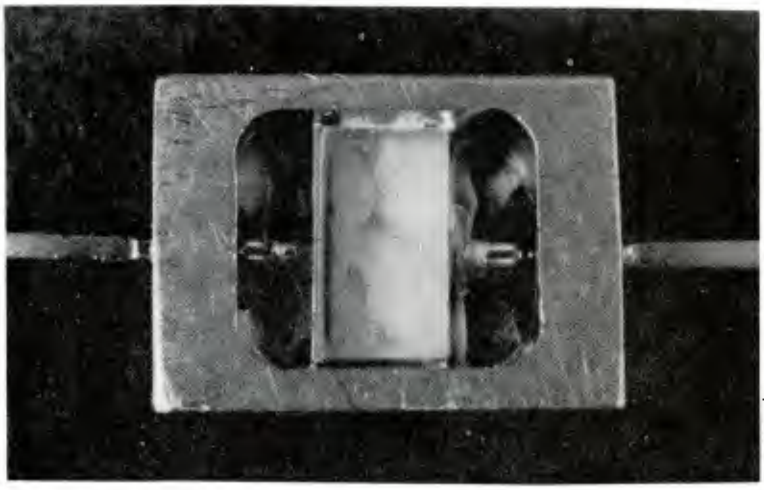


Figure 3 - Machined Kovar Package

Final electrical tests consisted of pulse tests in the time domain and sweep tests in the frequency domain. These included VSWR (max), insertion loss, impedance, and leakage attenuation.

BENEFITS

As a result of this effort, a manufacturing capability for monolithic MIC delay lines now exists. The first crystal wafers fabricated, using metal masks, yielded excellent results and demonstrated the production rate goal of 500 units per month. Production man-hours per delay line was reduced from 10 to approximately 2.5.

IMPLEMENTATION

Follow-on project H80 3510 was funded with Westinghouse to increase yields from the ZnO deposition. Preliminary results indicate yield was increased from 10 percent to nearly 50 percent. Motorola is currently using this technology to support Army programs.

MORE INFORMATION

Additional information may be obtained from Mr. Stuart Lieberman, Harry Diamond Laboratories, Adelphi, MD., AV 290 3110 or Commercial (202) 392-3110. The contract was DAAB07-77-C-0569.

Summary Report was prepared by Stephen C. Yedinak, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 277 9842 titled "MMT Third Generation 0.9 Micron Photocathode" was completed by the US Army Electronics Research and Development Command in June 1980 at a cost of $1,893,000.

BACKGROUND

Third generation (GEN III) 0.9 micron photocathodes represent a radical departure from conventional photocathodes used in image intensifiers.

The basic difference lies in the fabrication method. A conventional (second generation) photocathode is a polycrystalline thin film formed by evaporating constituents, usually antimony, sodium, potassium, and cesium. This cathode is highly reactive and must be transferred to the image tube and sealed without intermediate air exposure.

Conversely, a third generation photocathode is a single crystal material, usually gallium arsenide (GaAs), which is epitaxially grown in hydrogen at atmospheric pressure. The GaAs structure is bonded to a 7056 glass faceplate, air processed and transferred to a vacuum system. There its surface is heat cleaned and sensitized with a monatomic layer of cesium and oxygen. It is then sealed into the image tube structure.

Sensitivity improvements of four times the second generation device at quarter moonlight and over six times at starlight have been demonstrated. GEN III cathodes can be removed from the image tube, given a slight surface etch, and reactivated in vacuum by the heating and cesium-oxygen treatment.

Thus, they can be a recyclable component in image tube fabrication.

SUMMARY

The primary function of the contract was to establish GEN III photocathode production processes. Work was contracted to Varian Associates Inc., Palo Alto, CA and ITT ElectroOptics Products Division, Roanoke, VA. The device developed by Varian is the high sensitivity InGaAs/AlGaAs/glass photocathode shown in Figure 1. The 7056 glass serves as the third generation image tube input faceplate, as well as the substrate for sealing the semiconductor wafer.

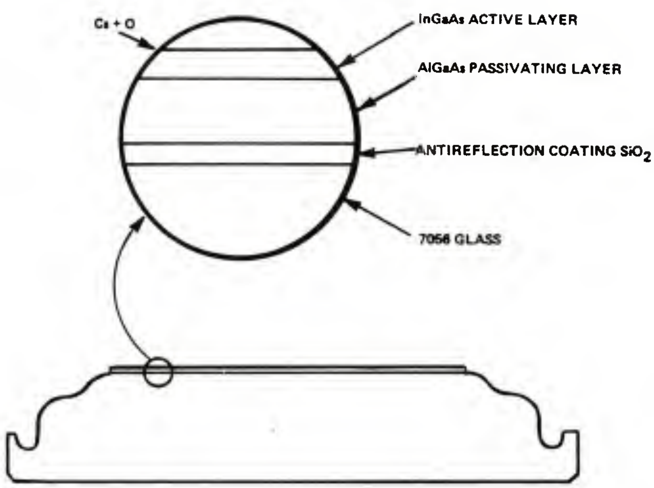


Figure 1 - Varian InGaAs/AlGaAs/Glass Photocathode

Varian efforts comprised automating the Liquid Phase Epitaxial (LPE) growth and the antireflection coating systems, and building a multilayer boat and glass sealing apparatus. Test equipment including a vacuum test system, a contact resistance test fixture and a reflectivity measurement fixture, were also designed and fabricated.

ITT developed a device consisting of the five alternating GaAs/AlGaAs layers depicted in Figure 2. ITT efforts included automating push-pull epitaxial multi-growth systems, optimizing saturation methods, temperature sequences, temperature profiles and gas flow rates.

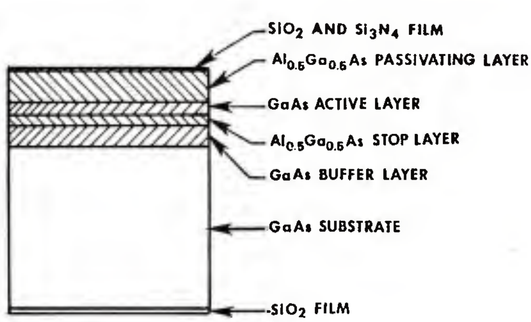


Figure 2 - ITT Photocathode Structure in Prebonded Stage

An RF plasma sputter process for applying Si_3N_4/SiO_2 Antireflective Coating (ARC) layers reduced average reflectivity and improved cathode/faceplate bond yields. Glass sealing, re-entrant window cutting and cathode/faceplate bonding processes were optimized and completely automated. Antireflection coating parameters and electrical contact material thickness were determined. Techniques for removing GaAs substrates and nonactive layers were developed.

Figure 3 shows the photocathode bonded to the 7056 glass faceplate with substrate and buffer layer removed.

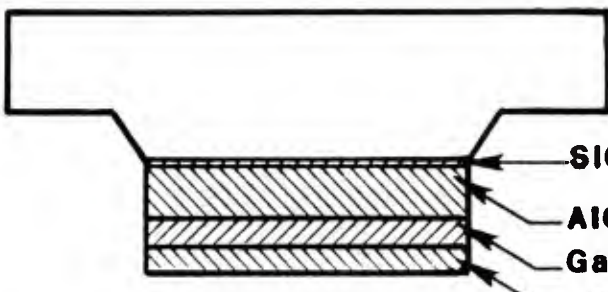


Figure 3 - ITT Photocathode Bonded Stage With Substrate and Buffer Layer Removed

BENEFITS

As a result of this investment, both contractors developed the technology and capability to mass produce 0.9 micron photocathodes. Actual cost saving for the automated processes will not be available until the first third generation buy, schedule for late 1982. However, it is estimated that this MMT will result in a 50 percent per item cost reduction.

IMPLEMENTATION

The processes developed by this effort were incorporated into the standard manufacturing procedures both at Varian and ITT. Technology for improving tube yields and production techniques has been made available to all interested tube manufacturers.

MORE INFORMATION

Additional information may be obtained from Mr. Kurt Villhauer, Night Vision and Electro-Optics Laboratory, Ft. Belvoir, VA, AV 354-1725 or Commercial (703) 664-1725. The contract was DAAB07-77-C-0616.

Summary report was prepared by Stephen C. Yedinak, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology Project 381 1109 titled "Robotized Wire Harness Assembly System" was completed in August 1981 at a cost of $150,000.

BACKGROUND

Wire harness fabrication is a very labor intensive process used in electronic manufacturing. This problem is further compounded by the varieties of harnesses. Currently, manual fabrication procedures require multi-stations and a significant amount of handling and transporting of material. An estimate of time allotment revealed that approximately 50% is devoted to operations such as handling, sorting, and identification which are all done by hand.

Since there were no previous efforts prior to the initiation of this project, the Army decided to use an integrated system approach towards wire harness fabrication. The key element is a computer controlled industrial robot for wire preparation and assembly of the harness.

SUMMARY

The objective of Phase I was to establish the basic parameters of the robotic equipment, to evaluate the design, and to conduct an analysis on the domain of wiring feasible for automation and robot wire handling techniques.

The work accomplished by Hughes Aircraft, in partnership with Unimation, is summarized as follows: The feasibility study phase of the Robotics Harness Assembly project has been completed with highly successful results. Critical feature demonstration by the program contractor team such as terminating wires, handling twisted pairs and installing them, controlling wide ranging lengths of wire, installing the pre-prepped wire onto a harness form board, and using a computer controlled robot machine equipped with a special purpose end effector, have been successfully accomplished. These features can be demonstrated with model shop type hardware located at the Unimation facility in Mountain View, CA. Computer studies have been made to establish the most effective domain of the initial pilot line demonstration machine. A preliminary system specification has been developed for a continuing project. A management team and multi-company working relationship has been established which is qualified to assure successfully meeting the product and systems specifications.

BENEFITS

This project will ultimately result in a reduction in wire harness assembly cost as a result of reduced labor requirements and productivity. However, this project potential will not be fully realized until the completion of the option under project 382 1109.

IMPLEMENTATION

The studies and tests performed under this scope of work provide firm support for a continuation of the project to completion and demonstration of a prototype machine and control system.

ADDITIONAL INFORMATION

Additional information on this project is available from Mr. Anderson, US Army Missile Command, AV 746-2147 or Commercial (205) 876-2147. A final report for this phase from Hughes Aircraft Company, Report No. 1509-81-0001, is dated 28 August 1981.

Summary report was prepared by T. Locke, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project R79 3217 titled "Automated Production Methods for Traveling Wave Tubes" was completed by the US Army Missile Command in September 1982 at a cost of $853,000.

BACKGROUND

This project is the second in a series of three to improve the manufacturability, and therefore reduce the cost, of traveling wave tubes (TWT) targeted for implementation in the PATRIOT missile system. At the outset of this effort, these TWT's were hand fabricated to rigid military specifications. Phase I of this effort, Project R77 3217, explored and finalized the manufacturing technology for the collector, packaging configuration, RF circuit, helix tube, attenuator pattern and brazing techniques.

Work on the electron gun was also begun but continuing failure plagued the project. The last cathode design in Phase I was a tungsten-iridium matrix, heated by a bifilar wound tungsten-rhenium heater wire. Cathode-to-heater insulation was hard, flame sprayed alumina. Turn-to-turn isolation was provided by soft fired alumina potting. Evaluation of this design revealed several problems.

1. Fast warm-up requirements for linear gains were not met, due to the poor thermal conductivity of the interfaces between materials.

2. Adhesion of the flame sprayed layer to the cathode was poor, resulting in uneven heating of the cathode.

3. Cathode impregnation was completed on a fully potted assembly, giving rise to barium penetration and loss of insulation.

4. Turn-to-turn and heater-to-cathode breakdown was occurring during the heater overvoltage cycle.

SUMMARY

The goal of this project was to continue the manufacturing technology evaluation of the electron gun designs, seeking one that is low cost and meets the PATRIOT requirements. The pilot line capability was to be demonstrated by delivering five tubes from not more than seven starts.

Alternative approaches to the electron gun design were evaluated. In one approach, the backside of the cathode was flame sprayed with alumina to a thickness of 3 mils. The bare heater wire is held in place against the alumina layer while sufficient alumina is flame sprayed to lock the wire in place. The fixturing is removed and the process is continued until the wire is completely covered. The cathode is then impregnated. Evaluation of this process indicated that the adhesion of the alumina to the cathode and barium migration in the alumina remain unsolved problems.

During this time, heaters cataphoretically coated with pure alumina became available. It was decided to abandon the alumina potting approach and pursue another approach. In this approach, the cathode is first coated with molybdenum-nickel and flowed at brazing temperature. The alumina coated heater is then placed against the moly-nickel and covered with moly-nickel powder. Sintering then completes the operation. This process eliminates the barium migration problem. See the cathode-heater assembly in Figure 1. Poor emission characteristics were observed and found to be caused by nickel contamination. This contamination was caused by the sintered moly-nickel shrinking and receding from the heater, resulting in a thermal runaway condition.

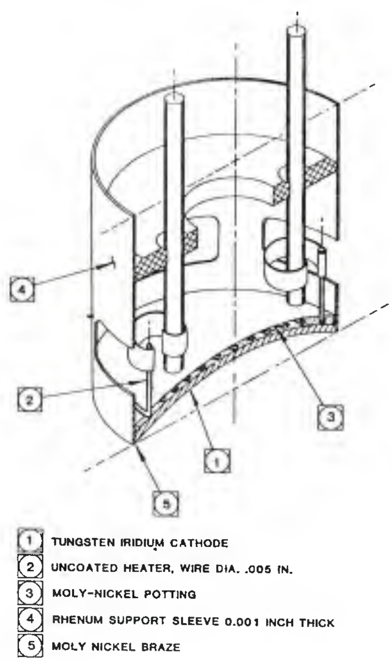


Figure 1 - Cathode-Heater Assembly

The potting was subsequently changed to moly-ruthenium. This eliminated all of the heater failures by eliminating the problem of potting shrinkage. A poisoning phenomenon was still appearing in the form of significantly reduced emission. Many causes for this problem were explored. It was eventually realized that the specification overvoltage was so high that emission material on the cathode was being blown off. An overvoltage of a few volts less would result in performance which is within the required specification. After considering many solutions to the dilemma, it was decided to increase the mass of the cathode from 7 mils to 20 mils. The problem was eliminated and the performance of the electron gun met the requirements.

A different cathode material, scandate, was proposed to replace the tungsten-iridium cathode. Among its advantages are lower cost and better control over its fabrication. In comparison tests, it exhibited similar properties.

Assembly procedures were developed for the electron gun, RF circuit, depressed collector and tube packaging.

BENEFITS

Lower cost manufacturing technology has been developed for the production of the PATRIOT downlink TWT. The economic goal of the effort was to bring the unit cost of $8,600 per tube down to $4000 at the 6000th unit. Litton's cost analysis shows that the unit cost will be $6,344 with the 6000 unit. Current cost of the tube is about $20,000.

IMPLEMENTATION

The benefits of the projects have been implemented into the PATRIOT program which is in the third procurement block. The results are also planned to be used in Raytheon's downlink TWT program.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Robert Tony, PATRIOT Program Office, Commercial (205) 895-3530. The final technical report number is MMT-3217. The contract number was DAAK40-77-C-0002.

Summary report was prepared by Dan Richardson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects R78 3254 and R80 3254 titled, "Low-Cost Semi-Flexible Thin-Film Semiconductors," were completed by the US Army Missile Command in July 1981 at a cost of $857,400.

BACKGROUND

This effort was funded to improve fabrication processes for thin film transistors (TFTs). The process parameter correlation between device characteristics and processing parameters was established. An additional task included strain sensitivity evaluation for TFTs built on ultrathin glass and silicon (semiflexible) substrates.

SUMMARY

The contract was awarded to Microelectronics Engineering Corporation. Work was divided into two phases. Phase I evaluated existing industry equipments, processes, and materials used for fabricating TFTs. A complete computer controlled deposition system consisting of Varian 3118 vacuum system, Sloan electron beam gun source, Sloan MDC-9000-1A process controller, and a Digital Equipment Corporation computer were selected. Both metal masking and photolithographic fabrication techniques were investigated. Optimum transistor materials selected were chromium for the source-drain, cadmium selenide for the semiconductor, aluminum oxide (sapphire) for the gate insulator and aluminum for the gate metallization.

The phase II effort optimized selected steps in the metal mask and photolithographic fabrication cycles. The metal masking process used a structure with the source-drain on the device lowest layer. The cadmium selenide semiconductor, aluminum oxide gate insulator, and aluminum final gate metallization were then sequentially deposited through metal masks. See Figure 1.

The metal mask sequence was improved by photolithographic definition of the critical source-drain spacings. Succeeding work defined the entire thin film transistor photolithographically thereby eliminating all metal masks from the process.

The photolithographic process provided for a metal gate on the substrate with gate insulator, semiconductor and source-drain as the device top layers. See Figure 2. Accurate seven micron channel lengths with a length to width ratio of over 800 to 1 were achieved. TFT strain sensitivity was determined by evaluating the change in drain current as a function of strain. A special metallization pattern made electrical probing during strain possible. A test tool was designed for producing deflection in the substate which was correlated to strain by using the standard beam deflection equation.

The electrical probe yield was approximately 80 percent.

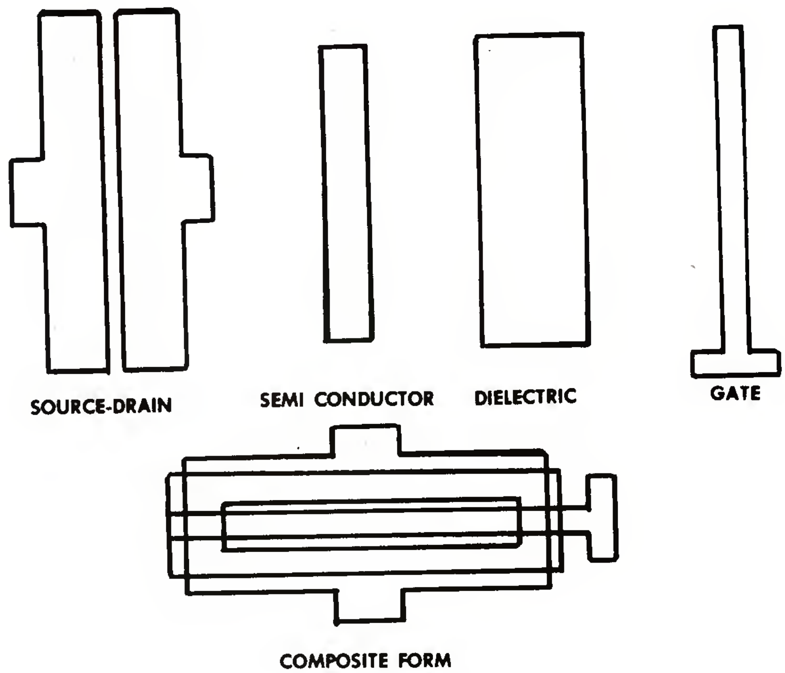


Figure 1 - Metal Mask Set

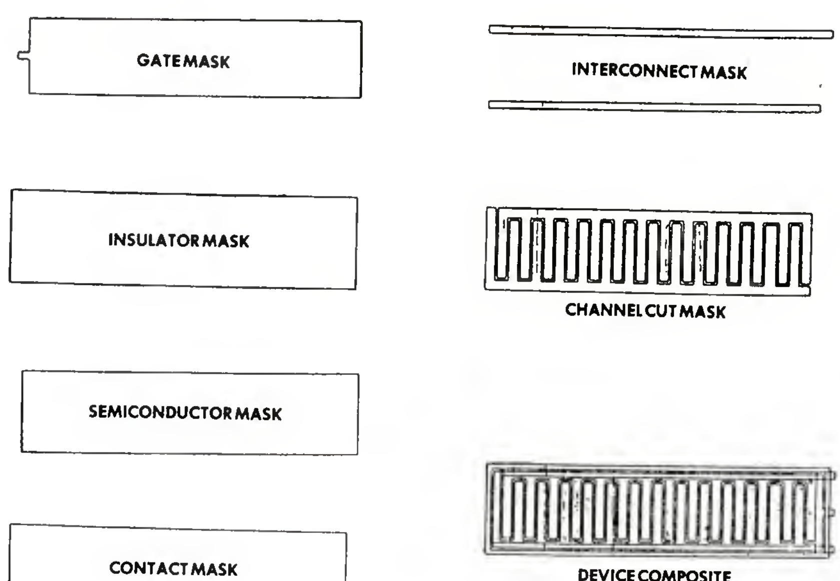


Figure 2 - Photolithographic Mask Set

BENEFITS

Significant cost reduction for the all photolithographic process compared to the metal mask process is listed below.

		Metal Mask	Photolithographic
1.	Starting Material 2x2 Glass	$ 0.60	$ 0.60
2.	Masks	8.50	2.00
3.	Chemicals, H_2O, Gases	2.75	2.75
4.	Labor (U.S.) $6.50 Average at 200% Overhead	19.50	16.50
5.	Equipment Depreciation (5 years)	5.00	5.00
	SUBTOTAL	$36.35	$26.85
	Average Cost Due to Substrate Processing Yield	6.36	4.70
	TOTAL	$42.71	$31.55

IMPLEMENTATION

The technology developed by this project was used to fabricate TFTs for the Microelectronics Engineering Corporation Model GC 2000 Accelerometer. This device has application in both military and commercial field. The utility industry potential usage is in rotating machinery and engine vibration testing.

MORE INFORMATION

Additional information may be obtained from Mr. Robert Brown, MICOM, AUTOVON 746-5321 or Commercial (205) 876-5321. The contract was DAAK40-79-C-0106.

Summary report was prepared by Stephen C. Yedinak, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project R79 3438 titled "Delidding and Resealing Hybrid Microelectronic Packages" was completed by the US Army Missile Command in December 1981 at a cost of $200,000.

BACKGROUND

Delidding and resealing offers the capability to repair hermetically sealed hybrid packages with minimum expense and degradation. Work involves removing the lid from a sealed hybrid, repairing the circuit and resealing the same package with a new lid. Hybrid manufacturers had at least a rudimentary technique for delidding and resealing hybrids; however, none were suited for volume production. New techniques which were reliable, fast, safe and production oriented were needed.

SUMMARY

Westinghouse Electric Corporation at Baltimore, Maryland won the single phase contract to develop low cost production methods for delidding and resealing hybrid packages. The approach taken involved four elements: industry survey, equipment/process selection and modification, qualification testing, and implementation.

The industry survey only covered packages likely to need delidding and resealing. Welded packages, in general, accounted for over 80 percent of total hybrid types fabricated. Hybrid package size was at least 3/4-inch square and intended for military application. Smaller or commercial hybrids including T-0 cans, were not considered in the data.

Precision sawing was demonstrated more effective than end milling at removing lids without affecting the circuit and package. Machine sawing was performed with equipment obtained from Sharp Precision at Thousand Oaks, California. See Figure 1. A delidding saw machine was modified by changing its table, clamp motor, saw blade, and pneumatic plumbing. This improved the performance, eased the adjustment and extended the machine capability. Optimum process parameters and acceptable tolerances were established. The modified machine is now available from Sharp Precision as their model SP 112.

Eighty-eight functional hybrids were built and 66 were delidded and resealed using the methods established. Those remaining were designated the control group.

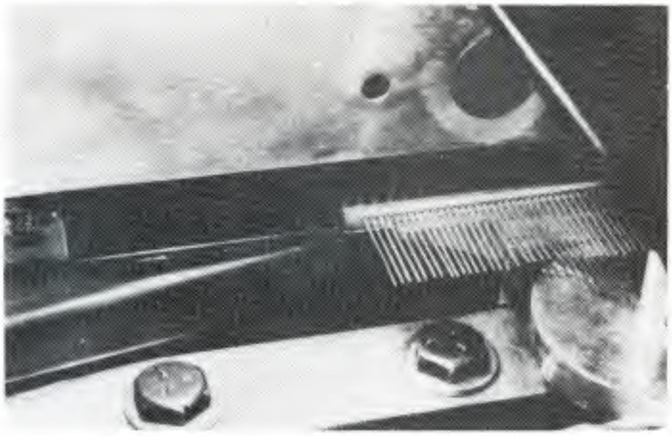


Figure 1 - Package About To Be Machined

Rigorous qualification testing was conducted to prove that the delid/reseal technique worked and that circuit performance was not impaired. All hybrid packages were subjected to MIL-STD-883 requirements for class B hybrids. This included fine and gross leak tests, particle impact noise detection (PIND), electrical test and visual examination. Environmental tests performed included stabilization bake, temperature cycle, thermal shock, centrifuge and mechanical shock. Virtually no failures were encountered. Qualification test results are shown in Figure 2.

Test Description	Composite Yield	
	Test Packages	Control Packages
F&G Leak*	100%	100%
PIND	94%	95%
Electrical**	100%	100%
Environmental	100%	100%

*All Packages $\leq 1.0 \times 10^{-7}$ cc/sec Helium
**No Significant Shift in Electrical Parameters

Figure 2 - Qualification Test Results

BENEFITS

Industry survey data reflected savings of $2.5 million/yr from delidding and resealing currently done via waivers. Total potential savings, if an effective, approved method were implemented industry wide, was conservatively estimated to exceed $10 million annually. This tremendous cost savings accrues from reduced scrap, faster rework (compared to repackaging), reduced package and circuit damage, easier scheduling, and reduced labor and material rework costs. A moderate volume of average hybrids or a low volume of expensive hybrids is sufficient to amortize the delidder machine in the first year of use.

IMPLEMENTATION

Delidding and resealing techniques developed under this contract have been implemented at Westinghouse Defense & Electronic Systems Center, Baltimore, Maryland. Resealing is performed via waiver up to two times on all programs utilizing seam welding. Some additional expense will be incurred to amend MIL-M-38510 to allow delidding and resealing up to two times per the method developed under this contract. US Naval Avionics Center (NAC) also has purchased a delidding machine for their own use.

MORE INFORMATION

Additional information may be obtained from Mr. Paul Wanko, US Army Missile Command, Redstone Arsenal, AL, AV 746-7097 or Commercial (205) 876-7097. The contract was DAAH01-80-C-0435.

Summary Report was prepared by Steve Yedinak, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects R79 3444 and R80 3444 titled "Fully Additive Processes for Fabrication of Printed Circuit Boards" were completed by the US Army Missile Command in December 1981 at costs of $200,000 and $200,000, respectively.

BACKGROUND

Fully additive printed circuit board (PCB) fabrication utilizes pattern plating techniques and an adhesive coated laminated, bare (unclad) board. Board wiring patterns are built-up only where desired using electroless metal deposition systems. This is in contrast to the substractive process in which wiring patterns are etched from copper preclad laminated boards resulting in much copper waste. This copper waste requires disposal and reclaiming of the etched metal.

SUMMARY

Hughes Aircraft Company was awarded the contract to develop the production capability for additive PCB fabrication processes that would meet military requirements. The work was divided into two phases. Phase I comprised the evaluation, selection and qualification of additive laminates and electroless copper plating baths for the additive process. These materials and processes were subjected to tests outlined in MIL-P-55110C. Phase II established a pilot line and optimized the processes investigated in Phase I.

Additive substrates evaluated in Phase I included catatyzed adhesive-coated epoxy-glass from four vendors. All passed screening test requirements. Two additive electroless copper baths - one from PCK and one from MacDermid were found to produce one ounce copper deposits capable of passing MIL spec test requirements. In addition, several dry film photoresists and screening resists were evaluated and found capable of producing high density circuit patterns. The resists were also able to withstand a 24-hour immersion in hot, alkaline additive electroless copper baths with no deleterious effects.

The Phase II pilot line included an automatic analyzer/controller which provided continuous chemical analysis of the copper bath and automatically replenished chemicals as needed. The initial capacity was based on a production rate of 100, 12-inch by 12-inch boards per 8-hour working day. See Figures 1 and 2.

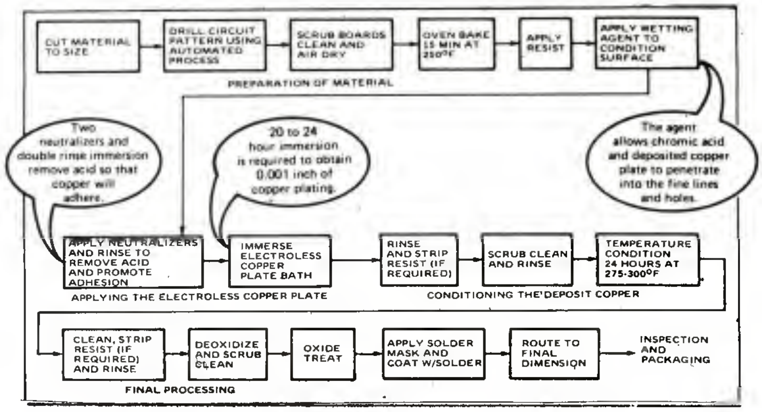


Figure 1 - Pilot Production Flow Chart

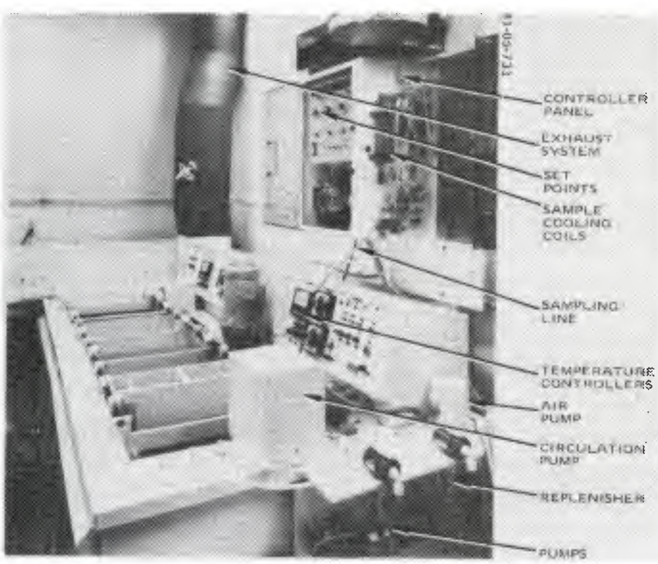


Figure 2 - Installed Processing and Control Equipment. The unique equipment for electroless copper plating is identified within the assembled system.

PCBs were fabricated in an 11-week production mode using two standard thickness (0.060-inch and 0.020-inch) adhesive-coated, precatalyzed epoxy-glass laminate material.

PCB runs using other material types (polyimide glass and metal core) tested the broader application of the process. MIL-P-55110C tests included dielectric withstanding voltage, moisture resistance, insulation resistance, thermal shock, thermal stress, solderability adhesion strength, warp and twist, and plated through-hole microsection.

Epoxy-glass boards manufactured on the pilot run met all test requirements of MIL-P-55110C except for cracks in plated through holes (PTH) resulting from the thermal stress test (solder float at 550°F for 10 seconds). The cracks which were evident were on the 0.060-inch thick material; whereas, a majority of the 0.020-inch thick boards did not exhibit cracking. The high z-axis expansion of the epoxy-glass, combined with low ductility of the electroless copper deposits (3-6% elongation), helped to produce this phenomena. Similar tests on low z-axis expansion polyimide-glass laminates and steel core boards, although processed in smaller quantities, did not exhibit any of these problems. This confirmed the theory that the use of low z-axis expansion materials for PCBs results in a more reliable product (with reference to thermal stress or solder float test).

Some problems were encountered in the develop cycle of the photoresist material. Residual traces of resist in the circuity areas were not completely removed from the laminate surface during the cleaning and adhesion promotion steps. This interfered with the build up of the copper deposit.

Twenty-five boards of high density design, 100 fine line boards, and board sets with test patterns were delivered to the Government for demonstration and evaluation.

BENEFITS

The fully additive PCB fabrication process was unsuccessful in meeting all objectives.

Data collected did show that the additive process resulted in approximately 17 percent less labor cost in addition to a reduction of the processing equipment when compared to the subtractive process. Eliminated were the sensitizing line, the electroplating tanks for copper and tin-lead (plus rectifiers) and the copper etcher. However, the advantage of fewer operators for the additive process was partially offset by the need for 24 hour cycle operation.

IMPLEMENTATION

Because of failure to achieve stated objectives, this MMT project was not implemented.

MORE INFORMATION

Additional information may be obtained from Mr. Robert Brown, MICOM, Redstone Arsenal, AL, AV 746-3848 or Commercial (205) 876-3848. The contract was DAAK 4079C-0164.

Summary Report was prepared by Steve Yedinak, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project H78 9793 titled, "Production of Intagliated Fiber Optic Phosphor Screen," was completed by the US Army Electronics Research and Development Command in February 1982 at a cost of $209,100.

BACKGROUND

Reduced resolution of image intensifer tubes is caused by many mechanisms. Some of these are: secondary emission from the original electron beam, spreading of light crossways in the phosphor layer, and reflected light from internal surfaces of the glass faceplate. There is very little which can be done for minimizing secondary emission and internal surface reflection but significant gains in resolution can be made via intagliation of the phosphor. A drawing of an intagliated fiber optic is shown in Figure 1. The Night Vision and Electro-Optics Lab performed much R&D in this area and these R&D efforts were the basis for the execution of this project.

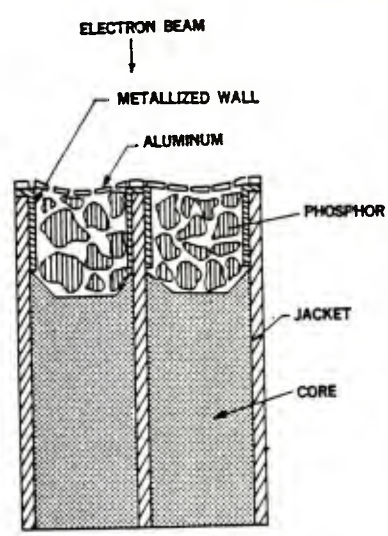


Figure 1 - Intagliated Fiber Optic with Metallized Walls

SUMMARY

ITT identified several tasks to be accomplished in order to successfully intagliate the fiber optic inverters. The processing involved is considerably more complex than uniformly coating a glass faceplate with a phosphor layer and then an aluminum film as was previously done.

Optimum Flatness of Etch Pit Bottom - In order to obtain maximum phosphor light transfer into the fiber optic core glass, the bottom of the etch pits should be as flat as possible. The first experiments indicated that the stronger the hydrochloric acid, the flatter the bottom.

Optimum Depth for Maximum Phosphor Efficiency - Different etch depths were achieved for 40, 50 and 60 minute etch times using full strength HCl. By phosphor efficiency measurements, the optimum etch time was found to be 40 minutes (6 microns depth). This determined the optimum thickness of phosphor for maximum light output at an electron beam penetration of 6 KV.

Metallization of Etch Pit Sidewalls - Aluminum was chosen for metallizing the etch pit sidewalls because of its high reflectivity. Silver would give higher reflectivity but it would poison the phosphor. The optimum evaporation angle was determined so that the metallization is restricted to the sidewalls and not the bottom of the etch pit. It was found to be 45¼ or 1/2 channel diameter.

The usual phosphor coating method involves coating the surface with an acrylic layer. After heating the layer, phosphor was brushed into it until saturation. After a bake to evaporate the acrylic and a KSIL soak, a bake was used to bond the phosphor layer in position. Scanning electron microscope photographs revealed that the deposition technique was not sufficient in that the etch pits filled only half full of phosphor.

A better method of deposition was developed which gave excellent results. Dry brushing the phosphor is now the standard for all intagliated phosphors.

When P-20 phosphor intagliation was attempted, "red spot" poisoning was noted. Analysis revealed calcium and magnesium, which was thought to originate in tap water rinses. Washing procedures were pursued to solve the situation but the purchase of P-20 phosphor with a protective coating proved to be the most successful solution.

BENEFITS

Processes and procedures for intagliating powders into fiber optic elements were developed. Reasons for and solution of the phosphor poisoning problem were discovered. The successful completion of this contract represents an important development in the improvement of fiber optic screen resolution.

IMPLEMENTATION

The results of this project were directly funnelled into the manufacture of Gen III image intensifiers. During the execution of this project, 6 micron fiber size became available in production quantity making further use of intagliated 10 micron fiber screens unnecessary on the Gen III production. Limited resolution of 10 micron MCP in combination with 6 micron phosphor inverter negates the gain of intagliating 6 micron inverters. There are spinoff uses of this technology in such equipment as heads-up displays and cathode ray tubes.

MORE INFORMATION

Additional information may be obtained from Mr. William P. Markey, NV/EOL, AUTOVON 354-1725 or Commercial (703) 664-1725. The contract number was DAAB07-78-C-2039.

Summary report was prepared by Dan Richardson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 574 3061 and 575 3061 titled "Acoustic Delay Line Fabrication" were completed by Harry Diamond Laboratories in December 1975 at costs of $150,000 and $150,000, respectively.

BACKGROUND

Process techniques for acoustic delay line fabrication have production problems which have

- kept delay devices as relatively high cost items;
- restricted the availability of quantities sufficient to establish the reliability of delay devices.

The devices are commercially available from a limited number of sources, but their range of application has been slowed by high initial cost (due in part to low yield), questionable ruggedization, matching problems at high frequencies, and some tendency to drift with time.

Private industry, almost entirely with Government support, has formulated a firm base for this project. In addition, these efforts solved various production problems (e.g., electrical matching).

This project is needed to bring the versatile delay line into the position of a highly reliable, low cost, abundant component.

SUMMARY

The purpose of this project was to establish a viable production method for fabricating series-transducer delay lines.

The devices considered consisted of a crystal delay medium with a series-connected matrix of zinc oxide transducers deposited on each end. The manufacturing process breakthrough for an acoustic delay line which eliminated the need for external electrical matching was ultimately patented (U.S. Patent 3,893,048).

The initial method was restricted to the photolithographic process. The entire sequence of art work and photomask fabrication was carried out within the Harry Diamond Laboratories (HDL). A second approach used fine-line, stainless, metal masks. The all metal mask approach was initially thought to

be attractive since it eliminated the wet chemistry required in handling photo resist. However, it did prove somewhat difficult during the ZnO deposition step. The final method was a combination of the earlier above two. Photomasks were used for both the ground pattern metallization and the ZnO deposition step, and a metal mask was used for the top metallization only.

The transducers were fabricated on rectangular, polished quartz rods since this configuration best suited the previously fabricated test fixture, and a possible application which stressed minimum device size was needed. The techniques followed would also be valid for a circular cross-section rod.

In conclusion, the project demonstrated production techniques that can produce delay lines using a self-tuned array of microwave acoustic transducers.

BENEFITS

HDL developed and patented a thin film transducer that eliminates the need for an impedance matching network at each end of a bulk wave acoustic delay element.

HDL used thin film metallization processes and photo-etching techniques to apply transducer arrays on two surfaces of a crystal.

IMPLEMENTATION

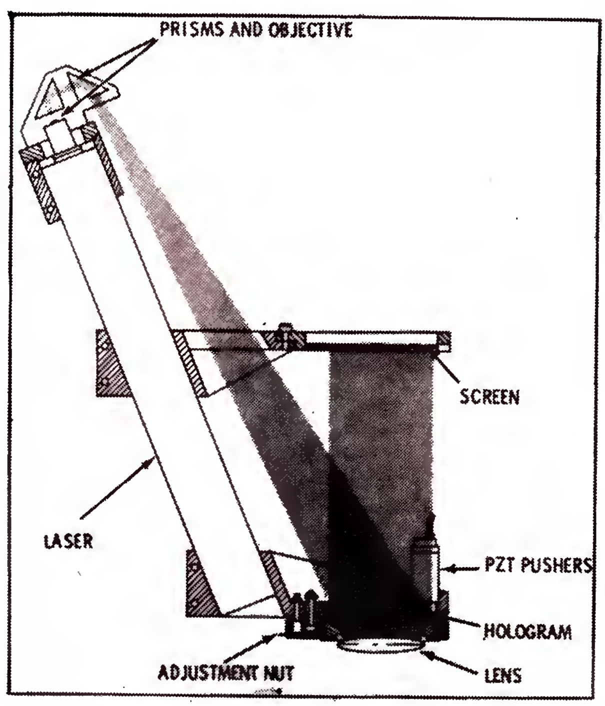
This project was implemented at Motorola, Phoenix in the late 1970's. The product of this MMT project is used in the M735 8" nuclear proximity fuse.

MORE INFORMATION

Additional information on this project is available from Mr. Julius Hoke, HDL, AV 290-1551 or Commercial (202) 394-1551. The final technical report from Harry Diamond Laboratories, HDL-TR-1820, is titled "Acoustic Delay Line Fabrication" dated July 1977.

Summary report was prepared by T. Locke, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

INSPECTION AND TEST



OPTICAL HOLOGRAPHIC TEST EQUIPMENT

ABSTRACTS

Project Number	Project Title	Page
T78 6035	Established On-Line Non-Destructive Test Procedures for Tracked Combat Vehicles	I-11

Extensive in-process non-destructive testing of many M1 tank components will be required to assure compliance with quality specifications. This project adapted five NDT methods, radiography, liquid penetrant, eddy current, ultrasonic, and magnetic particle testing, to uses with the M1 production line. The most significant benefit is ultrasonic welding, which represents a 2/3 reduction in cost over radiography. The acceptance procedure is currently a precautionary inspection at General Dynamics.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 180 7391 titled "Bearing Diagnostic and Reclamation Techniques" was completed by AVRADCOM in March 1981 at a cost of $100,000.

BACKGROUND

The bearing facility at Corpus Christi Army Depot (CCAD) is one of the largest of its kind in the country. Annually, CCAD processes approximately 200,000 bearings. Of this number, 143,000 bearings are from overhauled aircraft and the remaining 57,000 are procured to replace rejects encountered during overhaul.

Escalating inflation, uncertain delivery schedules and a general shortage of alloying materials have serious implications with respect to both the readiness and the economics facing most overhaul depots. This is particularly true of the bearings removed from overhauled aircraft. The following three-phase program was formulated to address this bearing problem:

PHASE I - Quantify the problem and establish economic justification. (This summary information represents the results of Phase I of the program.)

PHASE II - Develop improved methods for inventory control; critically evaluate procedures and standards for bearing processing; supply and install diagnostic equipment; train personnel in its use; and set operational criteria for refurbishment of bearings.

PHASE III - Expand the bearing refurbishment activity; generate new expansion plans; define, procure, and install new equipment determined by Phase I; train personnel.

SUMMARY

The objective of this effort was to assess the Corpus Christi Army Depot (CCAD) bearing maintenance capability. This entailed a statistical and economic evaluation of the bearing maintenance capability. Also, a detail analysis of CCAD bearing inventory and cost, inspection procedures, current and new approaches of bearing refurbishing and the number of bearings suitable for refurbishment was conducted.

It was concluded that the current facility is frequently overburdened. This creates a situation where bearings that normally pass inspection are placed in storage as the inspector does not have time to perform a thorough inspection. Approximately 36,000, 22 bearing types, (reasonably expensive) were placed in storage. A large number of these bearings have the potential to be refurbished. This would produce substantial savings to the Government which would also alleviate the critical bearing problem.

The feasibility of regrinding bearings has been demonstrated both from an economical and practical point of view. Tests performed by NASA indicated that approximately 90 percent of all the CCAD bearings could be refurbished. In order for CCAD to perform this type of refurbishment, the bearing maintenance capability would require additional diagnostic and restoration equipment. This additional equipment would include a modified Mechanical Technology Incorporated BDI-1000 bearing analyzer, TRW bearing restoration equipment and inventory management system. Figure 1 indicates how such a restoration facility might be configured.

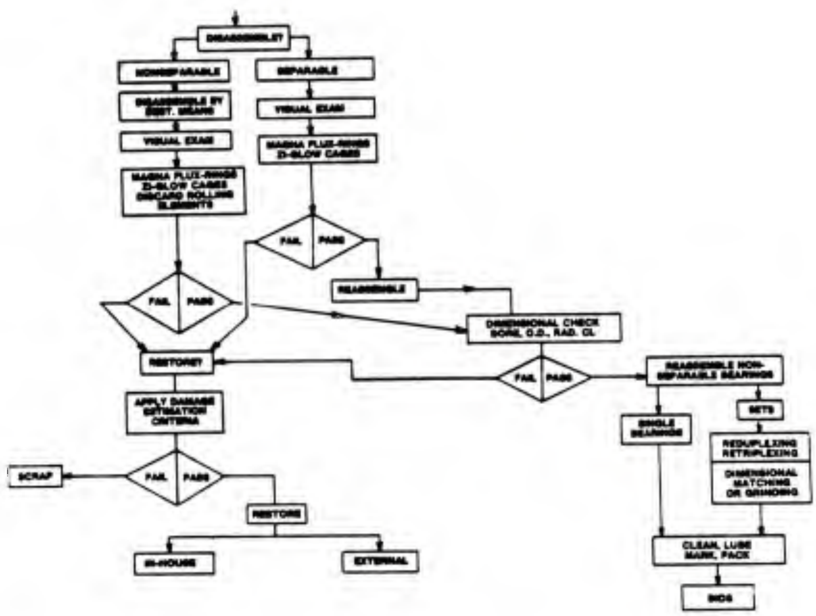


Figure 1 - Restoration Facility Flow Chart

The economic analysis revealed a payback in 24 months. The economic analysis was based on a 10-year period using a 10 percent discount rate with a present worth of $6.2 million.

BENEFITS

This effort was intended to provide the justification for the expansion of CCAD bearing diagnostics and refurbishment capabilities.

IMPLEMENTATION

The study results have been well documented in technical report AVRADCOM #81-F-16, March 1981. The technical report has been distributed to the appropriate CCAD Army depot personnel. The study results were reviewed by CCAD Production Engineering Division. It was determined that this proposed bearing restoration concept was not feasible due to the limited availability of over-sized rollers and retainers and associated inventory problems. As a result, Phase II and III will not be pursued.

MORE INFORMATION

Additional information may be obtained from Mr. J. Pratcher, AVRADCOM, St. Louis, MO, AV 693-1625 or Commercial (314) 263-1625.

Summary Report was prepared by Del Brim, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 381 1073 titled "Real Time Ultrasonic Imaging" was completed by MICOM in June 1982 at a cost of $200,000.

BACKGROUND

The evaluation of the quality of a production line item is an essential and significant part of the production process. Often the factors affecting quality can only be detected using radiation that passes through the part material. The most common forms of penetrating radiation are x-rays and ultrasound. An ultrasonic inspection method is often chosen to avoid radiation hazards and because it is uniquely effective for detecting defects. Standard production line ultrasonic testing methods use a transducer to scan the item, generating an echo whenever a void volume or inclusion is encountered. Specialized scanning techniques have been developed that generate either a cross-sectional view (B-scan) or a plan view (C scan). These scanning methods are too slow as they do not generate real-time images that would permit 100% inspections in production line situations. To develop a rapid automatic flow detection, decision logic would be difficult if not impossible using these methods. As a result, this effort was initiated to develop a real-time ultrasonic image inspection system.

SUMMARY

The objective of this effort is to develop a real-time ultrasonic imaging system (RTUIS) for inspecting fiber laminate and metallic structures. The results of this phase, Phase I of a II phased effort, demonstrated RTUIS production line inspection potential. The RTUIS consists of a liquid surface holographic inspection system to which a number of digital features have been added to provide video monitoring, 3-D flaw presentation, frame summing, computerized decision making, contract enhancement, filtering and smoothing, Figure 1.

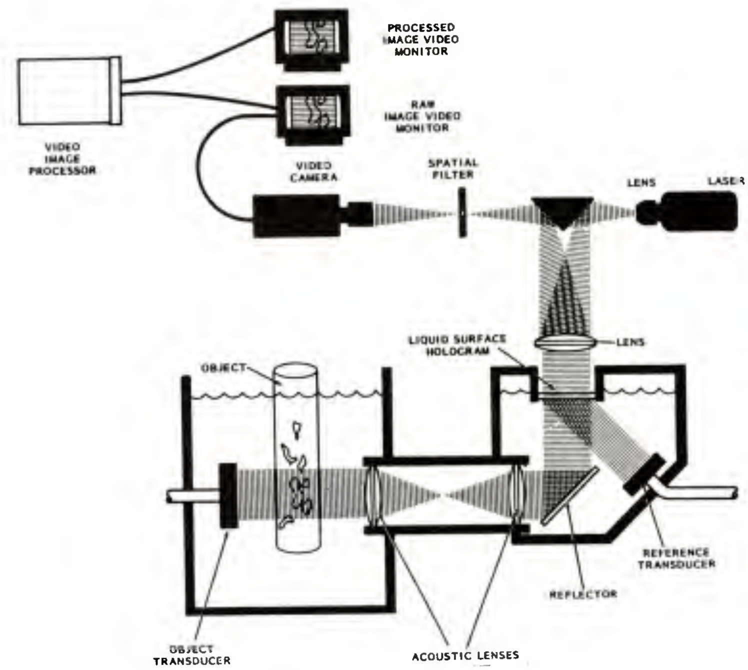


Figure 1 - RTUIS Schematic Diagram

The RTUIS concept was demonstrated by General Dynamics Convair Division at Battelle-Pacific Northwest Laboratories. During the demonstration, the imager operated at 60 frames per second. A video camera, focused upon a liquid surface detector plane, generated the initial unprocessed video image signal. Five pieces of video image processing equipment were used to provide frame averaging, video signal analysis, threshold detection, and X, Y, Z isometric display using the brightness level as the Z dimension. A special slit camera was designed and built to demonstrate the anticipated benefits of digital frame averaging. Manipulators were used to carry objects through the field of view in a manner compatible with the operation of the slit camera.

Production components were used in demonstrating the imaging characteristics of the RTUIS. These consisted of the Viper launch tubes, rocket motor cases, Tomahawk cruise missile aluminum squeeze casting and heavy austenitic steel weldments. The RTUIS concept demonstrated a real-time capability to locate flaws in composite and metallic structure.

BENEFITS

The primary benefit realized from this project was the demonstrated real time ultrasonic production line inspection capability.

IMPLEMENTATION

The results of this project will be used for Phase II of this effort to build, test and demonstrate a RTUIS production prototype inspection system.

MORE INFORMATION

A technical report titled "Real Time Ultrasonic Imaging" dated 30 June 1982, Report No. MM&T 1073, General Dynamics Convair Division, San Diego, CA. For additional information, contact A. Marsili, MICOM, AV 746-2147 or Commercial (205) 876-2147.

Summary report was prepared by Del Brim, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project R78 3454 titled "Low Cost, High Volume Radiographic Inspection" was completed by the US Army Missile Command in February 1981 at a cost of $200,000.

BACKGROUND

Many products such as the ROLAND missile, must pass an X-ray inspection prior to release from the manufacturer. This is to assure that all internal parts are present and assembled correctly. Without verification of internal structure by radiographic inspection, a defective missile could be deployed. Such a missile could malfunction and potentially cause catastrophic failure.

Radiographic examination of critical low-rate-production components and assemblies traditionally has made use of film processing methodology. The use of film-based methods is prohibitive for high rate production due to the high labor and film costs and excessive flow time. The development of a non-film radiographic inspection method was clearly necessary to reduce the costs of assembly verification of high volume products.

SUMMARY

The purpose of the project has been to develop and demonstrate a prototype non-film radiographic method for verifying the configuration of large, complex parts. The ROLAND missile final assembly inspection was chosen as the target application for this project, although the techniques developed could be used for inspecting the internal configuration of any complex missile or part.

The prototype system established the feasibility of performing assembly verification using advanced non-film radiographic techniques. The equipment is configured to provide fluoroscopic real time X-ray radiography, digital image enhancement, remote part positioning, and computer-aided inspection.

The concept of fluoroscopic real time X-ray is shown in Figure 1. The X-rays which pass through the test part fall on a fluoroscopic screen instead of a photosensitive X-ray film. The fluoroscopic screen converts the X-rays to visible light, and a camera transmits the image to a remote monitor. Remote control of part motion allows the operator to inspect the part at every angle and position. The real time image may be digitized so that image enhancement techniques can be performed upon it. The digitized image may be saved on a magnetic tape or disc associated with a computer system. Automatic control of parts positioning and image processing allows a computer-aided inspection scheme to be used.

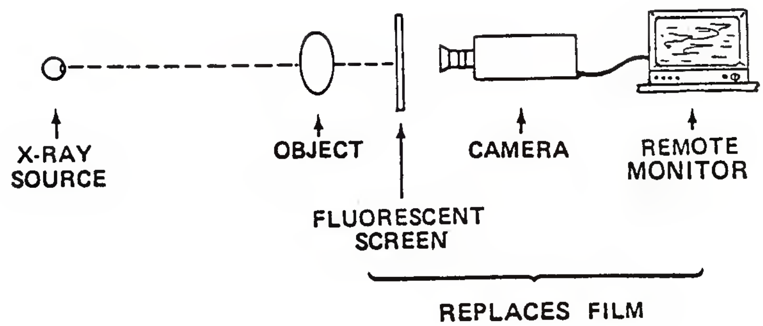


Figure 1 - Real Time Radiography - Concept

These real time X-ray techniques were applied to an inert ROLAND missile. When viewing parts of relatively uniform thickness, an X-ray image intensifier coupled to a vidicon camera provides adequate sensitivity for configuration inspection applications. However, when a part has very thick areas next to very thin areas, the high energies required to inspect the thick areas allow sufficient energy levels in the thin areas to blind or damage some vidicon cameras. Applications of this nature require use of a different camera system such as fluorescent screen and an isocon camera.

When higher resolution than provided by the real time system is required, the use of image processing is indicated to increase the image contrast and detail sharpness. A broad range of digital image processing techniques has been examined. Techniques found advantageous were video frame averaging, contrast modification, gray level slicing, Laplician and gradient edge enhancement, and pseudocolor. Useful evaluation aids included split screen for comparison of two images and profile and histogram graphics. The evaluation has produced an optimized image processing sequence for each critical inspection area on the ROLAND missile.

Also, a computer-aided system for parts positioning, image enhancement sequencing, and records storage and retrieval has been developed. The final acceptance decisions are made by the operator. Cost/benefit studies indicate that high volume manufacturing applications could benefit from computer-aided inspection procedures as well as image processing techniques.

Image storage techniques have been evaluated with respect to cost, quality, and ease of retrieval. High density digital magnetic tape is the preferred choice. However, for applications not requiring a computer for imaging processing or records management, video tape provides an adequate image storage medium.

BENEFITS

The results of this project demonstrated the feasibility of using fluoroscopic real time X-ray for high volume production situations.

IMPLEMENTATION

The production prototype fluoroscopic real time X-ray system was successfully demonstrated and judged by the Boeing Company to be an acceptable technique for inspecting Roland missiles. However, the planned Army ROLAND missile buy was substantially reduced in number. Therefore, the system was not implemented for inspecting ROLAND missiles.

The Boeing Company currently has an Air Force Manufacturing Technology project for a Real Time Radiologic System. The Air Force project is the second generation of the work completed by this effort.

MORE INFORMATION

A technical report titled "Low Cost High Volume Radiograph Inspection" published by MICOM, Report Number TR-RS-CR-81-1, January 1981 was distributed. For additional information, contact B. Parks, MICOM, AV 746-2147 or Commercial (205) 876-2147.

Summary report was prepared by Del Brim, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project T78 6035 titled "Established On-Line Non-Destructive Test Procedures for Tracked Combat Vehicles" was completed in November 1981 by Chrysler Defense, Inc. for the Tank-Automotive Command at a cost of $1,832,000.

BACKGROUND

Extensive in-process non-destructive testing of many M1 tank components will be required during production to assure compliance with quality specifications. Proper selection of NDT methods and application techniques will require extensive prior planning and evaluation to achieve an adequate confidence level. Also, effective application techniques controlled by standard operating procedures, and technician capability are essential factors required to assure quality reliability. In today's competitive market failure to provide these ingredients normally lower quality sensitivity to a level where flaws escape detection and create serious problems when discovered later during various manufacturing operations.

Similar efforts have been undertaken by other government agencies and private industry. In all cases, however, the product and quality control requirements differ sufficiently that the majority of NDT procedures established are not applicable to the M1 tank.

A practical solution to the problem would be a quality assurance NDT system to be adapted to an on-line production operation. The NDT methods implemented at the start of production will include radiography, ultrasonics and magnetic particle.

SUMMARY

The objective of this project was to formulate and implement a non-destructive test program and to establish effective non-destructive test for the verification of M1 hardware acceptance. This program included review of M1 quality control requirements, selection of appropriate NDT methods and application techniques, identification and procurement of test equipment, and the establishment of standard inspection procedures as examples. A brief synopsis of these achievements will be discussed.

Review of M1 Quality Control Requirements

About 1,000 manufacturing process drawings, machine drawings, and quality assurance requirements (QAR) representing major critical components of the tank were reviewed. The contractor determined that 107 components were suitable for four NDT inspection methods.

Select NDT Methods and Define Application

The table below exhibits the appropriate NDT method and their application.

METHOD	APPLICATION
Radiography	Hull and turret casting and weldments thickness varying from 2" to 3"
Liquid Penetrant	Hull and turret weldments castings and forgings for cracking and porosity, etc.
Eddy Current	Alloy sorting, case hardness depth checks and plating thickness measurement
Ultrasonic	Being used to locate flaws found by x-ray on hull and turret weldments
Magnetic Particle	Being used to inspect rework area of the hull and turret weldments, casting and forging repairs

Identify and Order Test Equipment

All inspection equipment and supplies required to establish production inspection procedures and application techniques were identified and ordered before March 1979.

Prepare Ultrasonic Weld Inspection Manual

All the preliminary work for the manual has been completed.

In conclusion, this program produced an efficient and sophisticated NDT inspection system for the M1 tank program for castings, forgings, and armor welds. The contractor established inspection methods and operating procedures for ultrasonics, radiography, liquid penetrant, magnetic particle, and eddy current for use directly on-line.

BENEFITS

The most significant benefit derived from the program will be the development of an ultrasonic inspection procedures and standards manual for armor welds. Application of ultrasonic as a weld inspection method will reduce inspection cost to about 1/3 of those required for radiography.

IMPLEMENTATION

At present, the acceptance procedure is currently being used as a precautionary inspection that verifies defects exposed by x-ray at General Dynamics. The future plan is to incorporate this procedure fully at a later date.

MORE INFORMATION

Additional information is available from Don Pope, US Army Tank-Automotive Command, AV 786-8328 or Commercial (313) 574-8328. Reference a final report titled "Non-Destructive Test Program for Ml Abrams Tank Systems" dated November 1981.

Summary report was prepared by T. Locke, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 574 4136, 575 4136, and 576 4136 titled "Improved Test and Evaluation Methodology" were completed in January 1981 at a combined cost of $898,000.

BACKGROUND

Munitions acceptance testing is very costly, typically amounting to 10 percent of the total cost. This effort was directed toward developing improved concepts and techniques associated with test and evaluation procedures (i.e., improved statical techniques, data acquisition, and reliability analyses) used during the procurement phase of the materiel life cycle. The program was divided into five Tasks; this report summarizes Task 3, Development of Product Assurance Math Models.

SUMMARY

The objective of this project (Task 3) was to provide generalized mathematical models through the use of advanced mathematical, statistical, and computerized modeling and simulation. The proposed models will relate system performance and effectiveness to alternative designs, design parameters, and requirements. An indepth study was initiated to ascertain how data currently being accumulated could be systematically used in models. A data base management system (System 2000) was purchased and implemented.

Work was concentrated on tank ammunition. Important performance characteristics were determined and available sources of data for assessing the munitions capability with respect to performance characteristics were determined.

The desired features of an ideal generalized product assurance model were defined. An interactive computer program for performing Bayesian statistical analyses for reliability assessments was prepared and a computerized RAM (reliability, availability, maintainability) data bank was established. An overall cartridge reliability model including ignition, trajectory, precision and penetration for APDS (Armor Piercing Discarding Sabot) ammunition was developed. The model was expanded to cover the effects of the munitions production line and its RAM characteristics.

Formulas for the computation of line availability in terms of station availability were derived for several models.

BENEFITS

The use of better test methods, optimal test designs and improved system modeling techniques will (1) provide the means to prepare improved technical data packages for future procurements, (2) reduce the procurement cycle and (3) improve the reliability of ammunition being fielded, thus lowering the probability of unacceptable material being placed in the users' hands.

IMPLEMENTATION

The system of computer programs is available for use at ARRADCOM.

MORE INFORMATION

Additional information is available from Mr. John Mardo, US Army Armament Research and Development Command, AV 880-5588 or Commercial (301) 328-5588.

Summary report was prepared by James H. Sullivan, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 576 6632 and 577 6632 titled "Automated Inspection Devices for Artillery Projectiles in Modernized Plants" was completed by ARRADCOM in June 1981 at a cost totaling $953,000.

BACKGROUND

At the present time, methods of manufacturing artillery components utilize a considerable amount of manual operations during in-process and final acceptance inspection. These operations generally involve handling of components and operation of the inspection equipment along with the use of human visual discrimination of various characteristics. These manual methods are time consuming and at times very unreliable.

Prior to project initiation there had been no MMT attempts to alleviate this problem. This project was undertaken to automate the inspection process.

SUMMARY

This project objective was to develop a fully automated inspection system to assure required product quality without compromising the functions of the modernized production lines.

The system's initial operational capabilities were to include;

(a) Handling and transferring of both finished parts and raw materials;

(b) Controlling and manipulating inspection devices through the latest microprocessor and programming techniques;

(c) Segregating material and components;

(d) Documenting reject data.

The development of a hot forge inspection system, billet tester, flash hole inspection system, and eddy current inspection system was initiated to achieve the above operational capabilities. Of these systems only the eddy current inspection will be discussed since it was the only one which provided reliable results.

Eddy Current Inspection System

Two separate automatic eddy current inspection systems were developed; one to handle the aluminum bases and the other to handle the aluminum ogives for the M483A1. Since both machines were similar in concept, only the ogive machine (see picture) is described below.

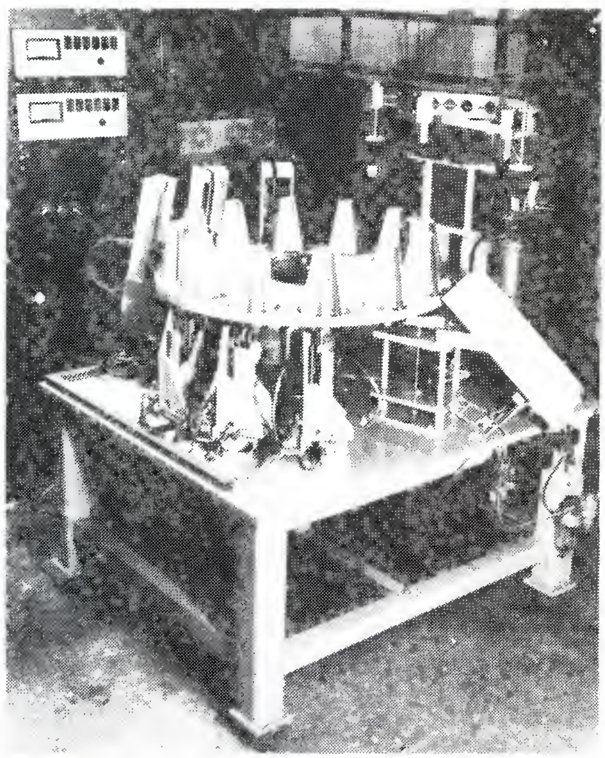


Figure 1 - Automated ogive eddy current inspection machine

The metal parts inspection system locates and measures the depths of cracks using eddy current techniques. The system is set to inspect 100 projectiles parts per hour. The machine automatically removes the parts, one at a time, from the input conveyor and places them on the inspection dial plate. Each part is indexed through six scanning stations where it is inspected. Three scanning stations, each with probe sensing coils offset 60^{o} from the previous station, scan the outside surface and three scan the inside surface. This 60^{o} offset per probe permits detection of defects in any orientation within 360^{o} in relation to the longitudinal axis of the ogive. After inspection, non-acceptable parts are automatically rejected down a reject chute into a manually clearable container or placed on a takeaway conveyor.

BENEFITS

At present, the Government has developed an eddy current inspection system to locate and measure the depth of crack in the aluminum base and ogive for the 155-mmHE M483A1, projectile.

IMPLEMENTATION

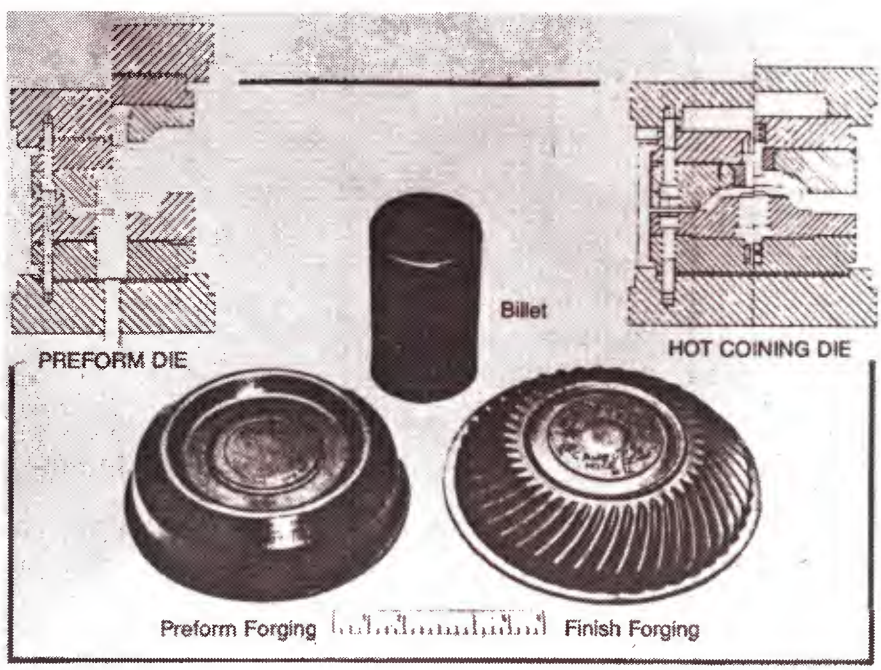
At present, the ogive inspection requirement has been eliminated and as a result, this machine has been placed in ARRADCOM storage.

MORE INFORMATION

For additional information contact Mr. Herbert Balk, ARRADCOM, AV 880-4982 or Commercial (201) 328-4982. The final report entitled "Automatic Inspection Devices for Artillery Projectiles in Modernized Plants."

Summary report was prepared by T. Locke, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

METALS



TWO-HIT FORGING PROCESS

ABSTRACTS

Project Number	Project Title	Page
178 7086, 179 7086	Abradable Seals for Compressor Blade Tip Application	ME-6

A fast and cost effective manufacturing process for chem-brazing are abradable seal surface onto the case shroud of small gas turbine engines was developed. Significant cost savings, estimated at between 43 to 74 percent, can be realized with inhibited chem-braze (ICB) bonding as compared to gold-nickel brazing. This method shows promise for refurbishment of engine seals at depots.

577 6200	Small Caliber Ammunition Process Improvement Program	ME-17

This project developed a two-draw process for forming the 5.56mm cartridge cups used in SCAMP equipment. A one million piece test run produced excellent quality cups with base thickness, outside diameter and wall thickness within limits. Three systems were installed at Anaconda, Olin and Revere and increased competition among producers is expected to lower the unit cost.

677 7727, 679 7727	Recycling of Scrap Gun Tubes by Rotary Forging	ME-22

A method was developed for recycling used gun tubes rather than scraping them. The rotary forge recycling of spent tubes was implemented at Watervliet Arsenal. An economic analysis showed that approximately $1,270 and $2,370 could be saved by recycling 105mm and 155mm preforms, respectively.

677 7943, 678 7943	Analysis for Modernization of Industrial Operations	ME-24

The objective of this effort was to reduce the cost of manufacturing at Rock Island Arsenal. Four options were investigated including no renovation with extensive contracting out, multiple shifts, some new equipment, or new construction and modern equipment acquisition. The fourth alternative was chosen and the RIA REARM project is expected to save $18 million per year upon completion.

Page

679 8005	Establishment of the Mechanical Plating Process	ME-33

The increasing cost of waste disposal and problems with hydrogen embrittlement from electroplating make this process steadily less valuable. Mechanical plating, utilizing a single tank into which each chemical is added and removed in sequence, was investigated. This process resulted in nearly evenly coated parts, eliminated hydrogen embrittlement and saves water and chemicals for future reuse. Implementation is anticipated for several series of studs, spacers, bolts, rods, and brackets.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 176 7046, 17T 7046, and 177 7046 titled "Precision Cast Titanium Compressor Casing" were completed in May 1979 by the US Army Aviation Research and Development Command at costs of $100,000, $195,000, and $207,000, respectively.

BACKGROUND

For many years, the aerospace industry has specified titanium in structural components to take advantage of its high strength-to-weight ratio. However, when titanium forgings are used, a large portion of the material must often be machined off to produce the final configuration.

Precision cast titanium components would offer the economic advantages of a near-net shape process. Commercial development of titanium casting began in the 1950's. Special furnaces capable of pouring several hundred pounds of molten alloy are in regular use today. Despite these advances, the casting of titanium presents serious obstacles because of its extreme reactivity with atmospheric gases and solid oxides.

SUMMARY

The objective of this effort was to develop a precision casting technique for producing the T700 compressor casing, shown in Figure 1. A secondary objective was to accumulate data comparing material properties of cast versus forged titanium (Ti-6Al-4V).

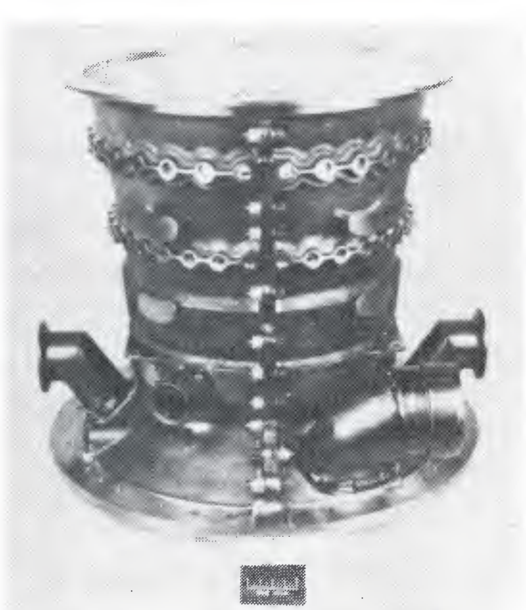


Figure 1 - Finish Machined T700 Compressor Casing Made From Casting (Air Ducts Welded On)

The approach was to use a skull melting furnace, Figure 2, to minimize reaction of molten titanium with oxygen and solid oxides. Melting was accomplished with an arc in a vacuum chamber. The crucible containing the molten alloy was tilted to fill the mold, located in the bottom of the enclosure. The mold rotated on its own axis to insure maximum filling with minimum gating.

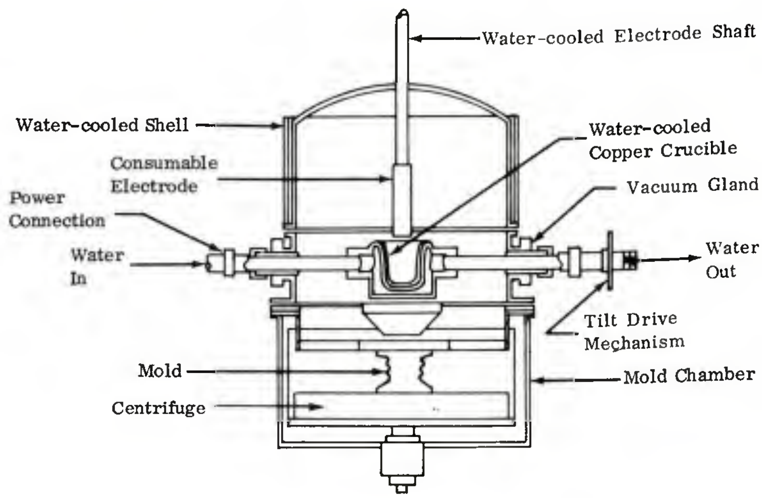


Figure 2 - Skull Melting Furnace

In Phase I, the casting process was developed. Ceramic shell molds and permanent metallic molds were evaluated, as well as mold temperatures and centrifuge speeds. As a result, the decision was made to use a conventional ceramic shell mold formed around a wax pattern. Permament tooling for ceramic molds would be less expensive and could be designed closer to net shape.

Nineteen experimental castings were poured using temporary tooling. Various methods were used to obtain uniform wall thickness, minimum shrinkage cavities, and minimum surface imperfections. Specimens were cut from castings for testing material properties. Tensile strength was about 10% lower than for forged material, crack growth rate was equal or better, and high-cycle fatigue strength was reduced about 40%. However, all cast properties were well above specifications. At the conclusion of this phase, permament tooling was designed and built.

In Phase IA, an attempt was made to integrate compressor casing air bleed elbows into the casting. However, because of the potential quality problems, this modification was dropped.

In Phase II, fifteen castings were poured using a mold preheat temperature of 1800^{o}F and rotational speed of 350 RPM. Two finished casings were assembled into test engines. A 60-hour quality assurance test and a 150-hour demonstration test were successfully completed. In Phase III, the technical data package was prepared describing the new process for the T700 compressor casing.

BENEFITS

The casting replaces a forging, providing a labor saving of 30 hours, or $992 per engine in 1980 dollars. In addition, 35 pounds of titanium alloy are conserved. Figure 3 compares the slimmer cross-section of the casting versus the forging.

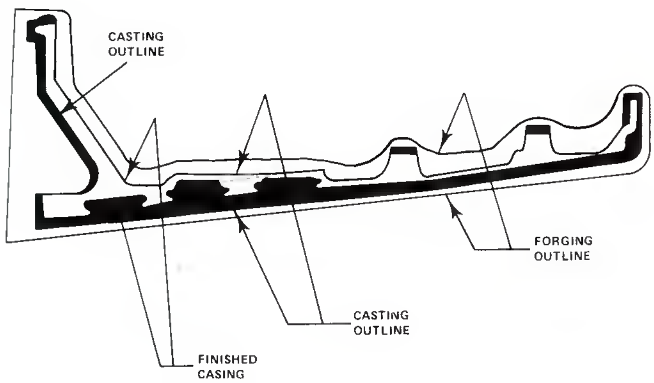


Figure 3 - T700 Compressor Casing Casting vs. Forging

IMPLEMENTATION

Implementation on GE's T700 engine began October 1980. 544 compressor casings will have been built through CY82. An additional 2,000 are planned CY83-87. Precision Castparts Corporation, Portland, OR, is supplying the castings. Since June 1981, all of the castings have been HIP'ed, resulting in zero rejects by GE. Howmet Turbine Components Corporation, Whitehall, MI, is attempting to qualify as a second supplier.

GE is planning to use this same process for titanium and steel compressor casings on newer engines being designed. They also have an approved process for T700 diffuser casings, made of Inco 718. Precision Castparts Corporation is evaluating this process for compressor casing components for the PW2037 engine used on the Boeing 757.

MORE INFORMATION

Additional information covering this project may be obtained from Richard F. Mulliken, Applied Technology Laboratory, US Army Research and Technology Laboratories (AVRADCOM), Attn: DAVDL-ATL-ATP, Fort Eustis, VA 23604, AV 927-2771, or Commercial (804) 878-2771.

Summary report was prepared by Al Spindler, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 178 7086 and 179 7086 titled, "MM&T Abradable Seals for Compressor Blade Tip Application," were completed by the US Army Aviation Research and Development Command in January 1982 at a cost of $191,000.

BACKGROUND

The attachment of sintered abradables with metallurgical brazes, although effective, is relatively costly and not suited to refurbishment. Because of these drawbacks, the Chem-braze bonding system for attaching abradable sheet metals like Feltmetal to titanium, steel or nickel-base alloy compressor case assemblies for blade tip shroud sealing, has been developed. However, there is a need for establishing manufacturing procedures to Chem-braze compressor blade tip shrouds and knife edge sealing systems in gas turbine engines. Effort is also needed to determine Chem-brazing efficiency for aluminum and magnesium alloy substrates and to develop acceptable NDI techniques and standards.

SUMMARY

The purpose of this project was to establish a fast and cost effective manufacturing process for Chem-brazing an abradable seal surface onto the case shroud of small gas turbine engines. Abradable seals were tested on titanium, steel, nickel-base, aluminum and magnesium alloy substrates, and an acceptable NDI technique for the inhibited chemical braze (ICB) bonds was chosen from scanning laser microscopy, vibra thermography, and C-scan ultrasound techniques. Full sized tooling for seal attachment and refurbishment was also fabricated.

Manufacturing guidelines were established for the ICB bond system. An addition of ten volume percent glycerin was added to the Chem-braze as an inhibitor to prevent premature drying, and a 0.001 to 0.003 inch thick undercoat of Metco 405 nickel-aluminide was used to eliminate adhesive failures.

A doctor blade and expandable ring segment were selected as the tooling to apply the 0.010 inch thick ICB, the optimum slurry thickness for attaching the abradable seals, Figures 1 and 2.

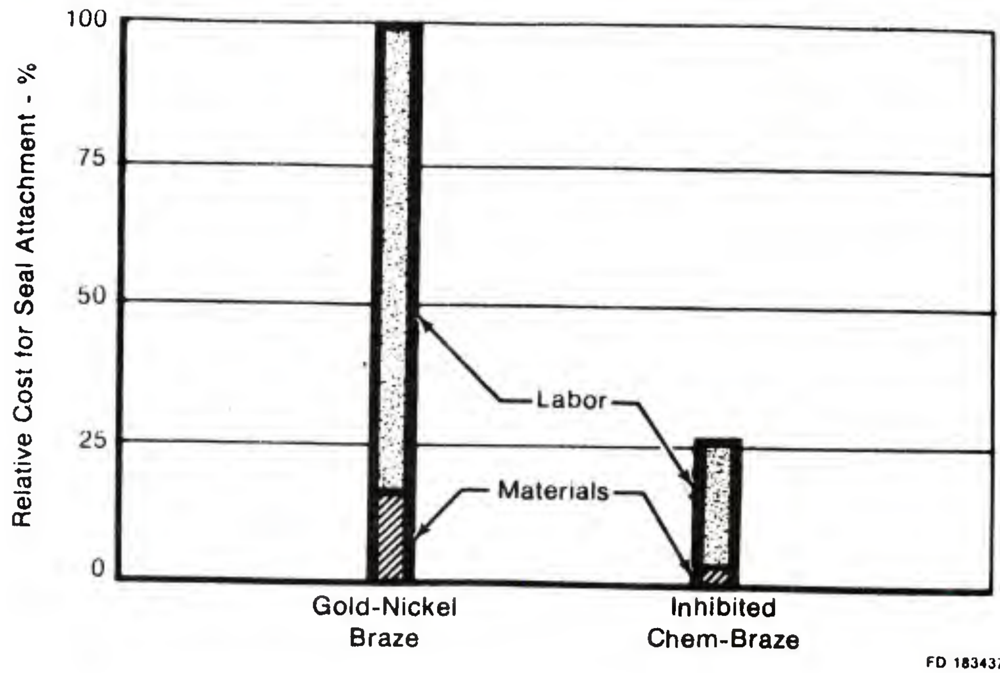


Figure 1 - Preliminary Economic Comparison of Brazing Techniques for Common Compressor Stage Seal Attachment

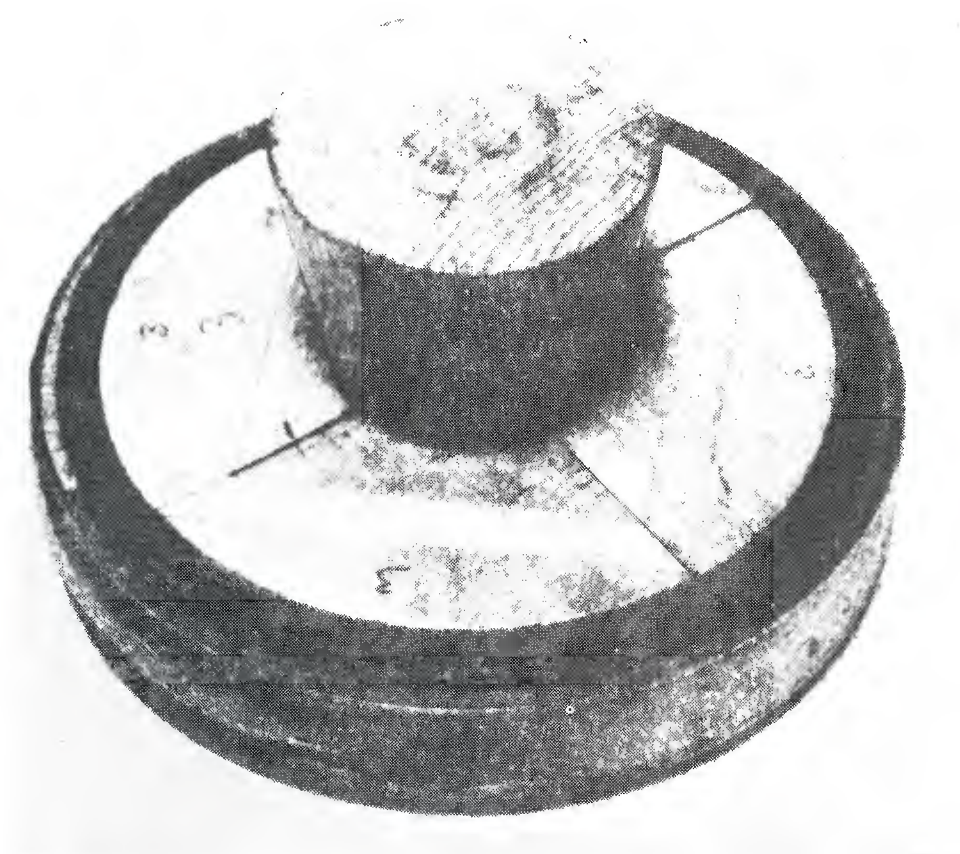


Figure 2 - Abradable Seals Fixtured in Simulated Engine Hardware

A two stage operation was chosen for drying and curing ICB bonds. Drying was accomplished by maintaining the assembly at 60 to 65°F for at least 12 hours, followed by incremental heating to 200°F at 100 to 200 psi pressure. After drying, pressure was released and the bond was cured by incrementing the temperature to 100°F. The integrity of the ICB attachment was verified by second bending mode vibration and rub abradability rig tests.

A quick, inexpensive chemical stripping technique for refurbishing seals was also developed. This consists of immersion in aqueous sodium hydroxide at 180°F for approximately two hours, followed by water rinsing and grit blasting. This production method was verified by attaching seals to simulated engine hardware, resulting in generally high quality bonds. The few voids observed were attributed to inexperience in applying the process and not to composition, manufacturing guidelines or tooling.

A number of NDI techniques for evaluating the integrity of ICB bond attachments were investigated. While laser holography proved very accurate, the more practical pulse-echo ultrasonic NDI technique was chosen as the preferred approach. The application of ICB bonding to aluminum and magnesium alloys was not successful in this investigation.

BENEFITS

Significant cost savings, estimated at between 43 and 74 percent, can be realized with ICB bonding as compared to gold-nickel brazing. Both material and labor savings account for this difference. The inhibited chem-braze seal can also be refurbished quickly and inexpensively.

IMPLEMENTATION

Final technical reports have been written and distributed. There are currently no plans to implement this technology although, if implemented, it shows promise as a method for refurbishment of engine seals at depots. Pratt and Whitney is working on an improved spray abradable seal but plans to use chem-brazing if the spray method does not work.

MORE INFORMATION

Additional information can be obtained from Mr. Fred Reed, AVRADCOM, Autovon 793-1625.

Summary report was prepared by Sandy Jackson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 177 7104 and 178 7104 titled "T700 Turbine Engine Nozzle Manufacturing Process" were completed by the US Army Aviation Research and Development Command in January 1981 at a cost of $68,000.

BACKGROUND

This project was originally oriented toward the optimization of commercially available grinding techniques. It was necessary to scale-up unconventional holding fixtures and to adjust the grinding process for the particular characteristics of T700 engine nozzles manufactured from cobalt and nickel alloys. During the execution phase of the project, it was decided to apply a computer assisted EDM process to the manufacture of the turbine nozzles instead of a grinding process.

SUMMARY

The objective of this project was to evaluate, demonstrate, and optimize the application of computer assisted EDM to the machining of trailing edge slots on the T700 stage 1 nozzle. To accomplish this objective, a series of tests were conducted using a programmable EDM power supply, Figure 1, which allowed the selection of optimum machining parameters throughout the machining cycle.

Tests were conducted to determine optimum parameters during the time the electrode is fully engaged, and during the time the electrode is partially engaged when entering and exiting the workpiece. Tests were then conducted to verify these parameters in actual workpiece geometry and to demonstrate the process.

The following conclusions were reached at the completion of this project:

o A programmable EDM power supply will reduce the cut time for the T700 trailing edge closed slot operation by one-third.

o The maximum machining rate obtainable could not be used due to microcracking.

o The reduction in planned time that can be achieved on this operation is one hour per ship set. Approximately 1250 ship sets will be required to recover the investment cost.

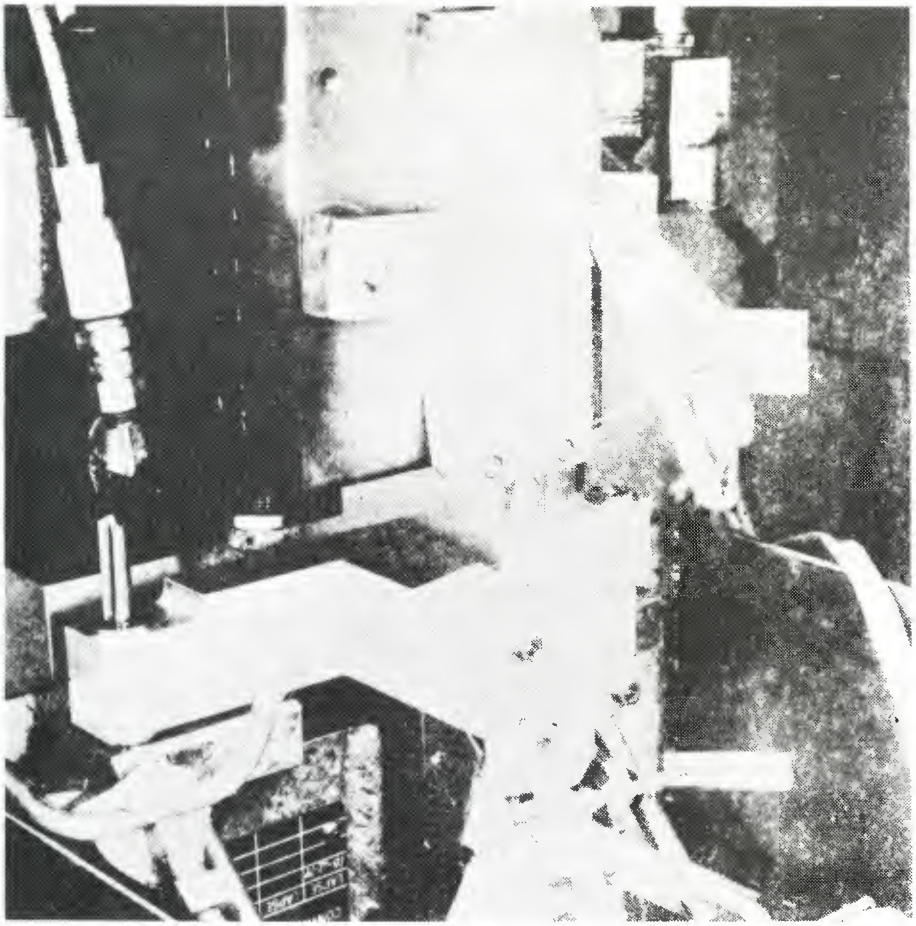


Figure 1 - EDM Tooling Set Up

BENEFITS

This project has resulted in the development of a machining process which is approximately 20 percent faster than the conventional process presently employed.

IMPLEMENTATION

Due to a stretchout of production for the T700 engine, implementation of the results of this project is considered uneconomical by the contractor involved. The technical report for this project has been widely distributed within the Government and to members of the aircraft industry.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Paul Rolston, US Army Materials and Mechanics Research Center, AV 955-5555 or Commercial (617) 923-5555.

Summary report was prepared by Alan Peltz, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 179 7291 and 180 7291 titled "Titanium Powder Metal Compressor Impeller" were completed by the US Army Aviation R&D Command in January 1982 at a cost of $306,000.

BACKGROUND

Centrifugal compressor impellers are typically produced by machining the flowpath and blades from oversized forgings. Impeller airfoils have complex shapes, high twist gradients, large camber and close spacing. Machining to net shape from oversized forgings results in a substantial loss of the forged material. Typically, 75 percent of the initial forging weight is machined as scrap. Labor costs associated with processing the forgings are approximately two-thirds of the total cost of the impeller.

By hot-isostatic-pressing powder metal (PM) to the near-net shape, material utilization is greatly increased. By chemical milling the acro-dynamic surfaces to final tolerances, the labor costs associated with finishing operations inherent in conventional forging techniques are essentially eliminated.

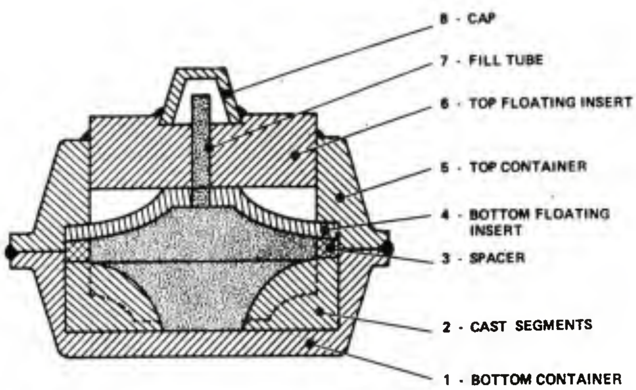
SUMMARY

The overall objective of the four year effort is to develop and validate the manufacturing process necessary for the fabrication of low-cost high-quality compressor impellers using powder metallurgy techniques. Development of this process, which is a co-funded effort with the Air Force Materials Laboratory, will provide fabrication processing for several components.

The FY79 project initiated a contract with the Garrett Air Research Manufacturing Company. Partial funding of the FY79 project limited the work accomplished to the design of tooling and associate tooling interface.

The FY80 project continued work on tooling to include tooling shape development. The objective of the contractual effort is to develop manufacturing technology for the production of integrally bladed impellers using titanium pre-alloyed powder and the fluid die powder metal consolidation process. The program is predicated on employing powder produced by using the Nuclear Metals, Inc. plasma rotating electrode process (PREP). This powder was selected for the fabrication of rotating engine parts since it is recognized that the PREP process theoretically is capable of yielding a titanium alloy product with an extremely low tungsten impurity content.

The Fluid Die (Figure 1), developed by Kelsey-Hayes, consists of a steel body of integral or build-up construction with an internal cavity configured to the desired final part contour after consolidation. The cavity is filled with metal powder, evacuated, sealed, and hot forged to achieve powder consolidation. The resulting PM near-net shape is extracted first by machining and then by chemical pickling of the steel envelope. The forged PM detail may be finished (Figure 2) to a final contour using chemical milling to remove the contaminated surface. The Fluid Die process has the potential for yielding titanium alloy centrifugal impellers with properties equivalent to those achieved by forging, but at reduced fabrication costs.



DETAIL	MATERIAL SHAPE
1	BAR OR TUBING AND PLATE
2	INVESTMENT CAST SEGMENTS WELDED INTO A RING
3	PLATE OR TUBING
4	PLATE
5	BAR OR TUBING
6	BAR OR PLATE
7	TUBING
8	BAR

Figure 1 - Fluid Die - Schematic

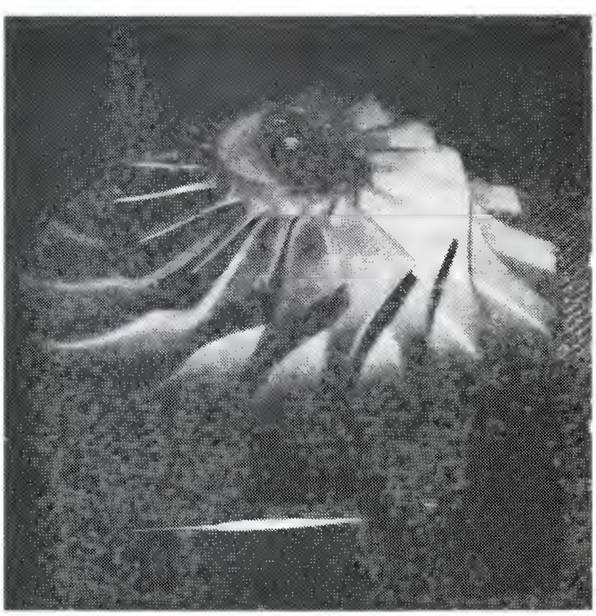


Figure 2 - First Iteration Ti-6Al-4V Titanium Alloy Impeller (S/N-4C1)

The first iteration (Lots A and B) press consolidation of Fluid Dies filled with three alloy powders (Ti 6-4, Ti 6-24-2, Ti 6-2-4-6) took place at Kelsey-Hayes Whitestown Plant. Eleven samples were consolidated. The first two samples were used to adjust the press stroke. These two setup samples were sectioned and examined microscopically. Densities were determined using the water immersion technique. In addition, one sample of each alloy was inspected ultrasonically. These impellers will be sectioned to correlate inspection results with microscopic observations. Six impellers were inspected using an optical comparator to obtain Z-line maps showing outlines of the hub contours. These maps for hub geometry and other optical comparator inspection results for the airfoils will be the data used to redesign die segments in preparation for future consolidations.

Future work on this effort includes: final rotor fabrication, hardware evaluation, spin testing, engine test substantiation, cast tooling demonstration, test hardware fabrication, material design data generation, final manufacturing specification, and preparation and delivery of final technical reports.

BENEFITS

These projects, in addition to the two follow-on projects, will result in a new method for manufacturing centrifugal compressor impellers. The powder metallurgy consolidation method will increase material utilization and reduce machining costs compared to current forging methods. In the size class pertinent to the auxiliary power unit, it is estimated the resulting manufacturing process will reduce the buy cost by approximately $1300 per engine compared to a forged and machined impeller. The benefits of these two projects will occur upon completion of the FY81 and FY82 projects.

IMPLEMENTATION

Implementation of this project has been delayed pending the results of the follow-on MMT projects 1 81 7291 and 1 82 7291.

MORE INFORMATION

Additional information on this project is available from Mr. J. Lane, US Army Research and Technology Laboratories, AV 927-2771 or Commercial (804) 878-2771.

Summary report was prepared by James P. Bruen, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project T79 5094 titled "Alloy and Armor Steels Treated with Rare Earth Additives" was completed by the US Army Tank-Automotive Command in May 1982 at a cost of $48,000.

BACKGROUND

In design of armor steel, high strength, ductility, and toughness are desired. However, high strength steel tends to have low ductility and/or toughness, so a compromise design is required.

Considerable experimental evidence has shown the benefits of low sulfur content and "sulfide-inclusion-shape control" in certain types of wrought steel. By lowering the sulfur content from the range normally present (0.015 to 0.030 percent) to very low values (0.005 percent), ductility and toughness can be improved.

Rare-earth metals (such as cerium), zirconium, calcium-silicon, and rare-earth silicide additions have been used to achieve sulfide-inclusion-shape control. By reducing the plasticity of the sulfide material, the inclusions tend to remain spherical, resisting elongation during hot rolling operations. This improves fracture toughness, a desirable property for example in arctic gas-transmission pipelines. It also reduces the possibility of lamellar tearing, sometimes a problem with conventional steel plates.

SUMMARY

The main objective of this first phase was to explore the feasibility of obtaining commercially produced heavy steel plate with very low sulfur content and sulfide-inclusion-shape control for tank armor for use in Phases 2 and 3. The aim of the overall program is to determine whether benefits reported for other products can be translated to armor plate.

A detailed program was prepared by Battelle-Columbus Laboratories that served as the basis for discussions with several steel companies. It was hoped that a small heat of about 25 tons, specially treated for low sulfur content and sulfide-inclusion-shape control, could be produced for this program. However, this approach was not feasible. The companies with smaller furnaces were willing to provide ingots of the desired compositions, but they lacked appropriate rolling capabilities.

However, a useful program can be conducted that has some distinct advantages over the original one, involving a limited number of plate thicknesses. Therefore, Battelle recommends that two plate thicknesses be evaluated, as follows:

Steel	Plate Thickness, inches
Mn-Mo-B	1/2, 1 1/2
Ni-Cr-Mo	3, 5

It is recommended that the calcium-silicon treatment, rather than the rare-earth-metal treatment, be used to produce a very low sulfur content in addition to imparting sulfide-inclusion-shape control. A combination of both these qualities should be more effective in improving the ductility and toughness of tank-armor steel than would inclusion-shape control alone. In addition, the hardness of the armor can probably be increased while meeting the present toughness requirements.

A survey of seven steel producers was conducted. Battelle recommended that steel plate be purchased from a company which is a major armor producer. This company is strong in the plate steel market, has a good reputation, and manufactures much heavy plate for pressure vessels where stringent high quality is demanded.

In Phase 2, two plates of each thickness will be produced, one with the standard hardness and the other with a higher hardness, if feasible. The cost of this phase will be about $268,000, contingent on being able to purchase partial heats. Otherwise, the additional material, including shipping and storage is estimated to be $166,000.

Assuming Phase 2 is successful, Phase 3 will be conducted with two steel compositions and six or seven plate thicknesses. Probably two steel producers will furnish material, both supplying thick plates and one supplying thinner plates. Therefore, three heats will be required. A rough estimate of the cost of Phase 3 is $1,000,000, contingent upon Battelle being able to purchase only the needed portions of the three heats.

BENEFITS

A workable plan has been developed which will improve the performance of armor plate for the M1 Tank and all other combat vehicles. Completion of this effort should result in armor plate which will meet present ductility and toughness standards while increasing the hardness by at least 50 Brinnell over the value presently specified for a given plate thickness.

IMPLEMENTATION

The results of this project will be implemented in Phases 2 and 3.

MORE INFORMATION

Additional information may be obtained from Mr. Donald E. Phelps, TACOM, AV 786-6433 or Commercial (313) 573-6433.

Summary report was prepared by Alan H. Spindler, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 577 6200 titled "Small Caliber Ammunition Process Improvement Program" was completed by the US Army Armament Research and Development Command in March 1982 at a cost of $1,259,100.

BACKGROUND

The equipment for producing 5.56mm cartridge cups had become obsolete and was increasingly unable to produce at the quantities and qualities required for the SCAMP equipment. To correct this situation, two approaches were funded. One was an improved two-draw process and the second was a rotary indexing tool set method.

SUMMARY

The rotary indexing concept offered the potential of providing high tool rigidity while requiring only a single slide press. This objective was achieved in that the system was installed and developed to the extent that a 1 million cup "production" run was completed. Average cup quality exceeded the goals but a small percentage of cups produced by one tool station did not meet the target quality. A compressed checkout schedule precluded investigation of this deficiency. No major mechanical problems were present in the equipment; however, the rotary indexing mechanism is susceptible to damage in the event of any malfunction. The mechanisms for preventing this damage are marginal in performance and would most likely be unacceptable in their present configuration. This approach was abandoned in favor of the two-draw process.

The primary task associated with the two-draw process was the cup forming tool geometry. Punch loads throughout the cycle were monitored to provide base-line data for the subsequent multistation tool set.

Testing was completed and the design optimized. A one million piece test run produced cups of excellent quality with base thickness, outside diameter and wall thickness remaining within limits. Wall variation did occasionally exceed the limits; however, this variation would not affect subsequent processing of the cups into cartridge cases.

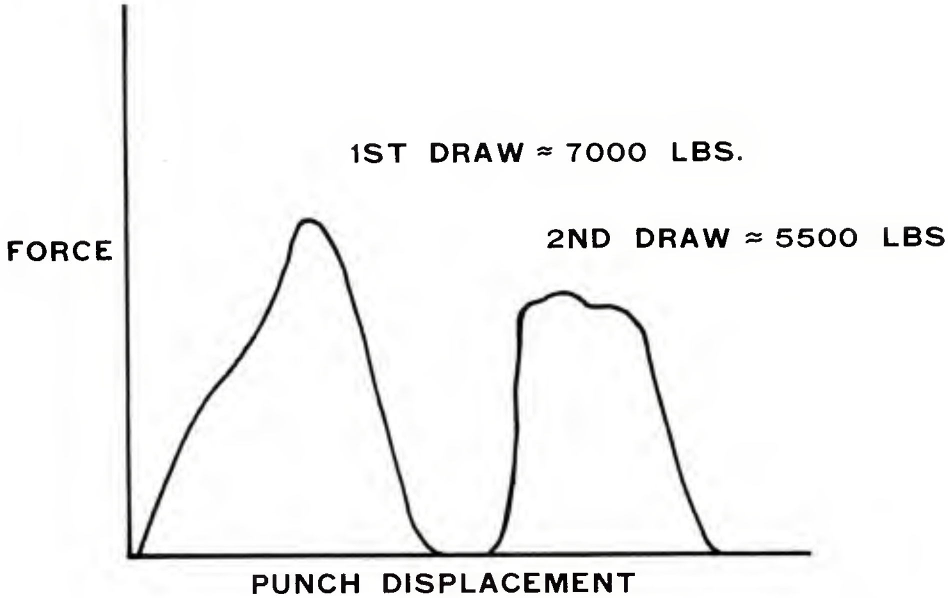


Figure 1 - Typical 2 Draw Load Diagrams

BENEFITS

The primary benefit of this program was the development of a new, modern type of cupping equipment. Since systems procured to the new tech data package will be capable of producing identical cups, an increased competition among the three producers should lower the unit cost.

IMPLEMENTATION

Three systems were procured under facilities contract 579 3002 and one each installed at Anaconda, Olin and Revere.

MORE INFORMATION

Additional information may be obtained from Mr. Bohdan Z. Hajduczok, ARRADCOM, AV 880-2712 or Commercial (201) 328-5752.

Summary report was prepared by Hal Weidner, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 679 7726 titled "Application of Cold and Warm Rotary Forging" was completed by Watervliet Arsenal in September 1982 at a cost of $108,000.

BACKGROUND

Hot forging capabilities of the rotary forging process are well recognized and the major forging parameters are well-defined. However, cold forging (forging at room temperature) and warm forging (forging at temperatures well below the normal hot-working range) of large-caliber gun tubes are, as yet, unexplored.

Cold and warm rotary forging processes offer savings due to the reduced needs for energy and equipment, and are capable of producing finished bores. Additional cost savings would result due to the consequent reduction in machining. The previous years' efforts centered on the optimization of hot forging parameters for the rotary forging process. These studies resulted in computer programs which predict stresses, loads, power, metal flow, and temperature distributions during the forging process.

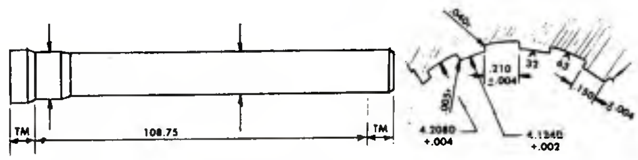
SUMMARY

This project was the final phase of a three year effort, funded in fiscal years 77, 78, and 79. At the outset of this effort, ring tests were conducted to determine the friction factors and flow stresses of gun steel at warm and cold forging temperatures. Mechanical properties of the test materials were taken to determine what the temper embrittlement behavior of gun steel would be at warm forging temperatures; and, in addition, the previously mentioned hot forge computer programs were expanded to include warm and cold forging applications.

The 106mm Recoil Rifle, was used as a test vehicle for the cold forging trials for thin-wall tubes. Seamless tubing was purchased and machined to the preform configuration to allow for 10, 15 and 20 percent reductions during forging. Eight 106mm Recoil Rifles then were cold forged to the finished bore configuration.

Originally, it was felt that warm forging to close tolerances was one method that could eliminate the rough machining required on the hot forged tubes. However, maintaining a uniform temperature on the larger forgings proved impossible with the existing equipment. Therefore, two preforms for the 105mm M68 barrel were initially hot forged to a modified configuration, to be used as blanks in cold forging the final 105mm M68 configuration. The dimensions of the preform blanks allowed for 10 percent and 20 percent forging reductions.

A summary of the dimensional results of the cold forged 106mm Recoil Rifles is given in Figure 1. As seen from the data, cold forging of thin-wall tubes with a finished rifling can be accomplished. A cross section of the rifling is shown in Figure 2.



No.	O.D.	RIFLING DIA. Bore Groove	Land	Ovality	Groove Width	Rifling Twist 1/83.26"	OD Chamber	Forging Cycle (Min.)	Wall Variation	Red.		Note
1	----------	-Used for	machine	set-up----	----------	----------	----------	----------	----------	----------	----------	
2	5.204	OK	OK	.0005	.206	- .40	6.030	10	.008	10%		
3	5.204	OK	OK	.0005	.206	- .40	6.030	10	.012	10%		
4	5.128	OK	OK	.0005	.206	- .40	-	10	.013	15%		Breech not forged machine malfunction
5	5.234	OK	OK	.0005	.206	-..40	6.030	10	.010	15%		
6	5.461	OK	OK	.0005	.206	- .40	6.119	10	.012	15%		
7	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	Tape malfunction
8	5.422	OK	OK	.0005	.206	- .40	-	10	.010	20%		Breech not forged machine malfunction

Figure 1 - 106MM Recoil Rifle

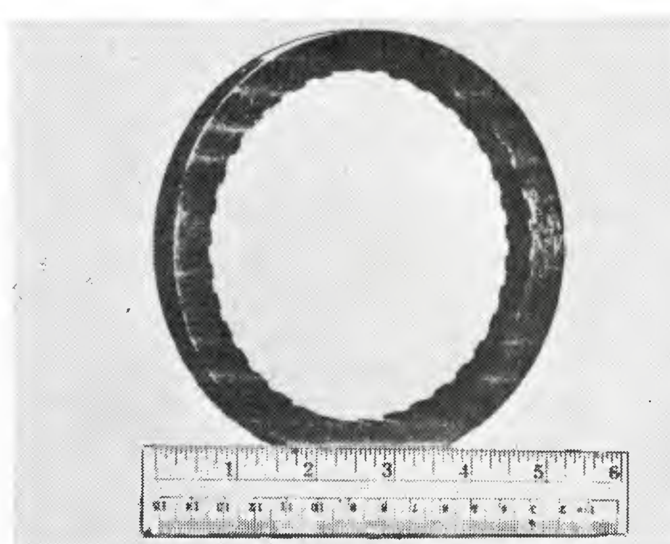


Figure 2 - Cross-Section of Rifling Configuration In Cold Forged 106MM Recoil Rifle

During the first 105mm M68 cold forging trial, a machine malfunction was experienced which terminated the forging cycle on this preform. The second preform, designed for a uniform 20 percent reduction, was then cold forged successfully. This first successful cold forging of a 105mm M68 indicates the feasibility of using this technique on thick-wall tubes and could possibly eliminate boring and other rough machining operations prior to autofrettage.

BENEFITS

The conventional machining of a 106mm Recoil Rifle takes 19.40 hours. With cold rotary forging of the same tube, machining would be reduced to 12.80 hours, providing an effective labor savings of 34 percent. The initial results with the 105mm M68 were insufficient to determine what economic benefits could be derived.

IMPLEMENTATION

The 106mm Recoil Rifle is no longer manufactured at Watervliet Arsenal and will not be implemented at this time. Implementation of the 105mm M68 cold forging technique is not recommended until further, more definitive results are obtained.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Leonard Liuzzi, Benet Weapons Laboratory, Watervliet Arsenal, AV 974-5827 or Commercial (518) 266-5827.

Summary report was prepared by Ken Bezaury, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 677 7727 and 679 7727 titled "Recycling of Scrap Gun Tubes by Rotary Forging" were completed by Watervliet Arsenal in September 1982 at a cost of $461,000.

BACKGROUND

Cannon tubes are now taken out of service and scrapped after reaching their fatigue limit or after erosion limits the accuracy of the weapon. A scrapped cannon tube is generally sold for less than one-eighth of the original material's purchase price. This represents not only a large monetary loss, but also a loss of critical material in the form of alloy steel of the exact composition required for producing other forgings.

With the advent of the rotary forge system at Watervliet Arsenal, a number of suggestions were made to expand the utilization of the rotary forge. Among these suggestions was one to recycle scrap tubes through the forge rather than to use them as scrap for remelting. Since the suggestion appeared to have merit and potential for considerable savings, funding was obtained through the Manufacturing Technology Program.

SUMMARY

The project was a two-year effort divided into two phases. The first phase was aimed at determining the quantity of scrap tubes available for recycling, the mix (various models), development of a computer program for optimizing the yield from each model, and an inspection procedure to determine the extent of firing damage. The second phase was the implementation of results through a series of forging trials.

The first step in the recycling program was to determine tube models and available quantities for recycling. Next, a computer program was written to establish an optimum mix of new tubes which could be produced from the available models of scrap tubes. Based on the computer program, scrap tubes were brought in from the field and prepared for recycling. Prepared tubes were forged, heat treated, and tested for mechanical properties.

The recycling of several tubes helped establish data for such aspects of recycling as machining preparation required, heat treat parameters to be used, and a method to determine and eliminate tubes which would be poor candidates for recycling.

The overall results proved that scrap tubes can be made into acceptable forgings that meet dimensional drawing requirements. However, in analyzing these results, it was found that the older scrap tubes produced by air melting practices resulted in very few new tubes with acceptable mechanical properties; while those tubes originally produced by newer melting practices such as vacuum degassing, vacuum deoxidizing, and electro slag refining resulted in nearly 100% acceptance of tubes with acceptable mechanical properties.

BENEFITS

A computer program was developed which, based on tube dimensions, generates an optimum mix of new tubes that can be produced and the required preform dimensions. For an example, see Figure 1.

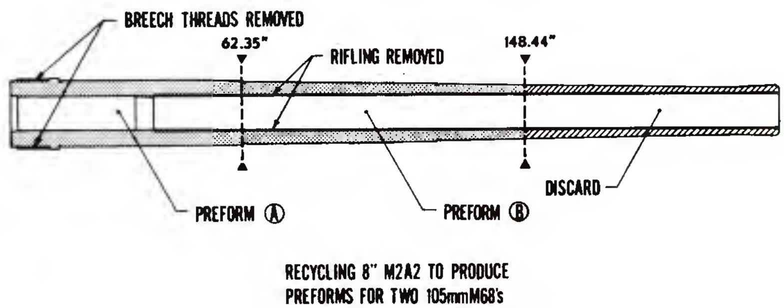


Figure 1 - Typical Machining Required For Rotary Forge Tube Recycling

A detailed economic analysis shows that $1267 can be saved by using scrap material to generate a 105mm M68 preform. In making a 155mm M185, $2,367 can be saved.

IMPLEMENTATION

The rotary forge recycling of spent tubes was implemented at Watervliet Arsenal, after acceptance by the Product Assurance Directorate, in April 1980.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Charles Calderone of Benet Weapons Laboratory, Watervliet Arsenal, AV 974-4179 or Commercial (518) 266-4179.

Summary report was prepared by Ken Bezaury, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 677 7943 and 678 7943 titled "Analysis for Modernization of Industrial Operations" were completed by the US Army Armament Materiel Readiness Command in June 1982 at a cost of $1,025,000.

BACKGROUND

Competition for available funding within the Army over the past several decades has resulted in the neglect of its industrial base. The Rock Island Arsenal (RIA) is currently performing its mission with old and obsolete equipment and buildings deteriorated by age and extensive industrial use. An inefficient manufacturing layout has evolved as a result of fragmented construction projects. These conditions resulted in less than required productivity and a substantial delay in achieving mobilization capacity. The RIA manufactures artillery components, recoil mechanisms, gun mounts, equilibrators, gun carriages, loaders, grenade launchers, aircraft weapon subsystems and small arms. This effort was undertaken to establish a master plan to modernize and improve Rock Island Arsenal's manufacturing operations. A prior MMT effort completed an interior electrical distribution system evaluation and Mylar plant layouts showing current production equipment locations.

SUMMARY

The objective of this effort was to reduce the cost of manufacturing at RIA and to improve the capability of RIA to respond to surge and mobilization requirements. An analysis was made of the manufacturing facilities, equipment and services at RIA. Management consultants established a plan for modernization of manufacturing equipment and facilities. A second group of consultants performed a detailed analysis of machine tool replacement to the state-of-the-art in metal removal operations. In addition, the manufacturing operations for forging, heat treating, casting, welding, surface treating and assembly were addressed with individual analyses by other consultants and the RIA staff.

The Renovation of Armament Manufacturing (REARM) program at RIA is a direct result of this MMT effort and includes major construction and production equipment efforts. The Military Construction Army (MCA) effort will demolish old buildings and build new buildings. The equipment effort will purchase machine tools and other industrial plant equipment. An economic analysis was prepared for Project REARM as an entity. Four options were evaluated and compared. The status quo option proposed essentially doing nothing and allowing the RIA to continue to deteriorate. The required mission would be performed by extensive contracting out. The second option proposed

adding more people on multiple shifts with limited contracting. The third option proposed no new construction but a much more extensive equipment acquisition program. The fourth option, the current REARM program, was a combination of new construction, process consolidation and equipment acquisition. The analysis was based on the RIA peacetime production requirements. Cost savings which could be realized during mobilization were not considered.

The RIA-REARM program plan required coordination between the equipment acquisition and the building construction. The RIA REARM program plan was modularized so that equipment to be installed into a new building was scheduled for acquisition in the same or a prior fiscal year as the building. Thus, the new facilities can be operational as each module is completed. The process flow of a typical component through the manufacturing operations before and after the REARM program is illustrated in Figure 1.

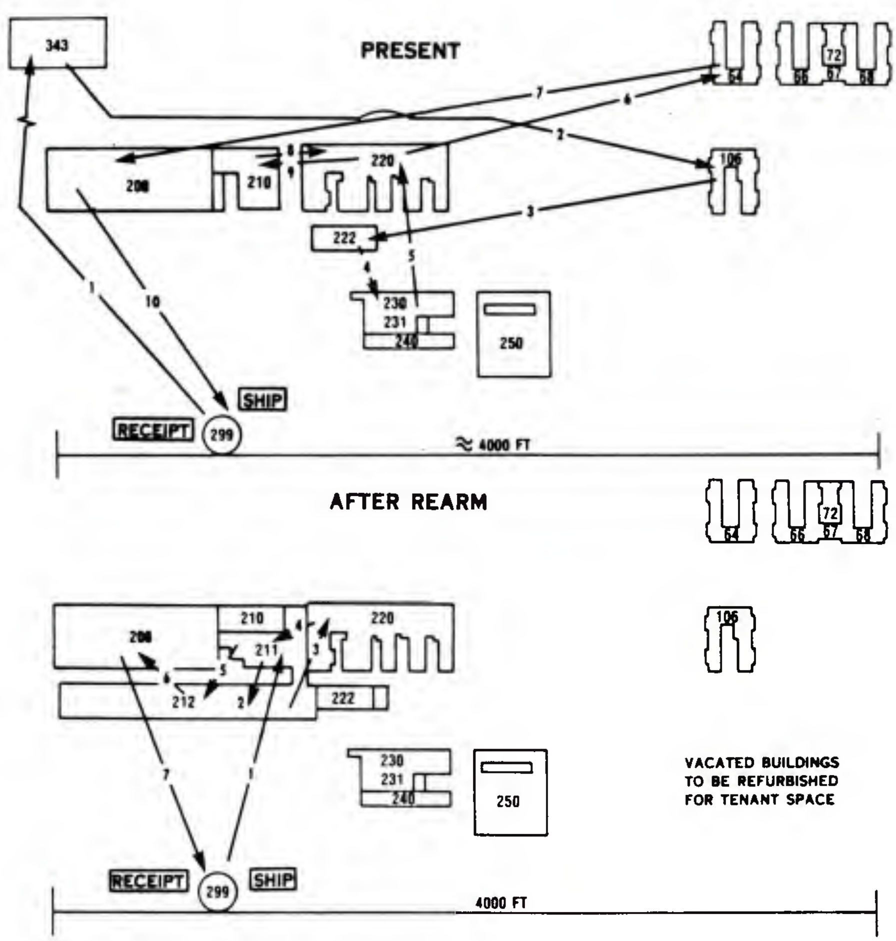


Figure 1 - Typical Process Flow Support Bracket, M140 PN 8449308
Before and After REARM

BENEFITS

Two major benefits are economic peacetime production and retained mobilization capacity. The economic analysis indicates that REARM was cost effective by $18 million in uniform annual savings over the closest of the three other alternatives. The following types of savings and cost adjustments were estimated and included in the economic analysis:

(1) Reduction in scrap costs by one-half, applicable to increased use of Numerical Control (NC) machines.

(2) Increase in tooling costs by 4 percent applicable to NC machines.

(3) Decrease in rent charges including utilities and overheat.

(4) Reduction in subcontracted work.

(5) Reduction in war reserve inventory carrying cost of 2 percent per month starting at the completion of the project.

IMPLEMENTATION

The result of this effort was an all inclusive master plan based upon technology upgrade. The implementation of this master plan is dependent upon the full funding of the RIA-REARM program.

MORE INFORMATION

Additional information on this effort can be obtained from the REARM Program Manager, Mr. Steve Robinson, Rock Island Arsenal, AV 793-5804 or Commercial (309) 794-5804.

Summary Report was prepared by Steve McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 679 7990 titled, "Improved Fabrication and Repair of Anodes," was completed by Watervliet Arsenal in June 1981 at a cost of $234,000.

BACKGROUND

A lead plating facility for the manufacture of anodes is necessary to meet the Watervliet Arsenal cannon tube chrome plating requirements. Dependence upon contractor supplied melted-on lead clad anodes has proven unacceptable from a cost and lead-time standpoint and lacks the quality required for chrome deposit. A facility is required with the capability to repair specific portions of damaged anodes as well as producing new full length anodes.

SUMMARY

This project is the first of a multi-year effort to establish a facility to lead plate anodes of varying lengths and diameters as well as to repair portions of damaged anodes. The homogeneous deposition of lead on copper cores of lengths up to 35 feet is a difficult and unusual task. Available lead plating solutions cannot be used without considerable modification due to the higher deposition rates and longer plating times required. A plating system was modified to include a micro-processor that will have the capability of monitoring and controlling the solution flow, solution pH and depletion of additives. An analysis was conducted with plating solutions modified with various compounds to optimize control of grain size and solutions that act as buffers and pH controllers.

The design of the lead plating facility was completed and all drawings and layouts have been finalized. A pictorial view of the lead plating facility is shown in Figure 1. The section of the main plating pit that will accommodate this system was cleared of unnecessary equipment and piping. The anode was fabricated and the lead sleeves, when stacked, will function as a lead tank. Assembly of the plating facility is under way. The polargraph and micro-processor have been temporarily installed in the laboratory and initial check-out has been conducted.

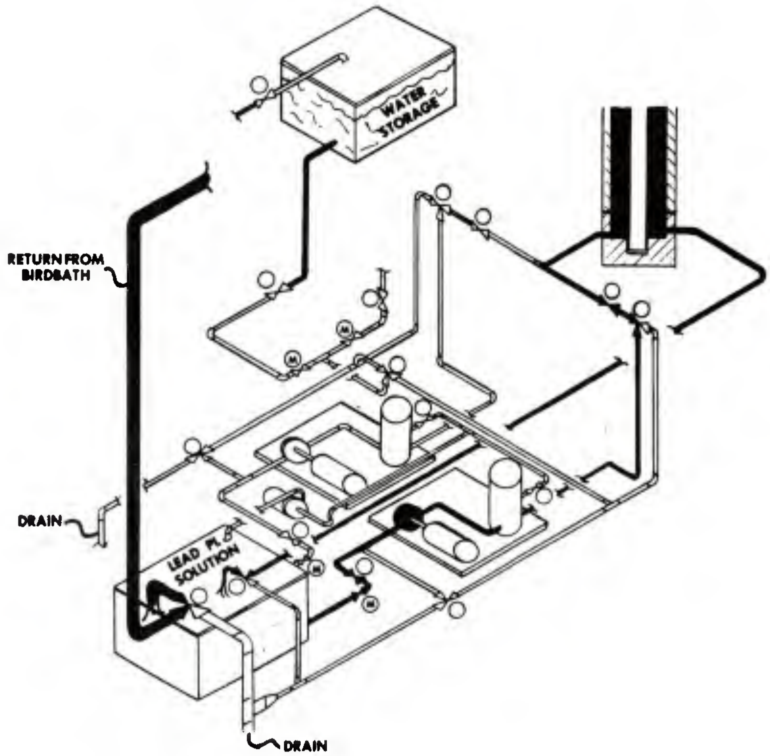


Figure 1 - Lead plating facility

BENEFITS

The establishment of an in-house capability will eliminate serious disadvantages associated with the current melt-burning deposition used by the outside contractor. The reduction of lead-time in the preparation of anodes and the ability to repair anodes that would otherwise be scrapped will result in significant cost savings.

IMPLEMENTATION

This was the completion of the first year of a multi-year effort; therefore, the results of this portion of the effort are not ready for implementation.

MORE INFORMATION

Additional information may be obtained from Mr. T. Pochily, Watervliet Arsenal, AV 974-5717 or Commercial (518) 266-5717.

Summary report was prepared by Bob Hellem, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 679 8004 and 680 8004 titled "Co-Deposition of Solid Lubricants During Anodizing" were completed by the US Army Armament Research and Development Command in December 1981 at costs of $120,000 and $121,000, respectively.

BACKGROUND

Numerous military applications involve aluminum alloys to take advantage of their high strength-to-weight ratios. These alloys need anodized coatings for corrosion resistance, wear resistance and non-reflective surfaces. For example, the aluminum alloy 7075-T6 upper and lower receivers for the M16A1 rifle are hardcoat anodized in a low temperature sulfuric acid process (MIL-A-8625, Type III). However, under sliding contact of the anodized surfaces, seizing or galling occurs. Temporary solutions to this problem can be made by applying solid film lubricants to the mating surfaces by spraying. But, since this is only temporary, galling quickly reoccurs when the solid film breaks down or is not adherent to the anodized surface.

SUMMARY

The objective of this effort was to establish a process which involves deposition (electrophoretic) of charged lubricant particles, e.g., Teflon, molybdenum disulfide, etc., during hardcoat anodizing. These particles would become an integral part of coating and differ from conventionally applied solid film lubricants which lie on top of the coating and adhere by mechanical bonds. Thus, this coating would be permanently lubricious and resolve the problems associated with galling and seizing.

The structure and properties of anodic films on aluminum are known to be highly dependent upon the alloy type. Although a variety of alloys were evaluated, emphasis was placed upon aluminum alloy 7075-T6 thus conforming to the alloy utilized in the M16A1 receivers.

Reagent grade basic solutions of sodium aluminate and sodium silicate were utilized in this study. Molybdenum disulfide, polyethylene or Teflon when added to these solutions remain at the top of the bath rather than as a suspension. These lubricant particles become an integral part of the

coating. Air agitation and stirring suspends the particles somewhat but when the surface tension of the aqueous solution was changed by the addition of Triton X-100 a complete suspension of the lubricious particles was obtained with basic solutions. Also utilized in this effort were acidic solutions of sulfuric acid (9.3%), and sulfuric (7.5%) and oxalic acids (0.75%). Triton X-100 when added to either of these solutions also produced suspensions of lubricious particles. Triton X-100 is an excellent surfactant but is non-ionic and hence it is incapable of producing the negatively charged particles required for electrophoretic migration of the lubricious particles to the anode during anodization. With the acid solutions an anionic surfactant dodecyl sodium sulfate was utilized for particle suspension and electrophoretic migration.

A representation of three aluminum alloy (7075-T6) journals were anodized simultaneously in each of the solutions described previously with and without (used as standards) suspended lubricious particles.

The reactions in basic solutions were performed in a glass vessel which was thermostatted at $15^{o} \pm 1^{o}C$. Current densities of 0.08, 0.16 and 0.32 amp/cm^2 (utilizing a constant current power supply) were employed in all reactions with (0.05, 0.1, 0.5, 1.0 and 2.0 gms/l) and without lubricious particles of either Teflon, polyethylene or molybdenum disulfide.

The reactions in acid solutions were also performed in a glass vessel at temperatures varying between $-4^{o}C$ and $0^{o}C$ in sulfuric acid bath and between 9^{o} and $11^{o}C$ in sulfuric-oxalic acid baths with and without lubricious particles to a final voltage of 40V. Dry ice was utilized for temperature control.

The wear resistance of the deposits was determined using the Falex lubricant tester. The journal was rotated at 290 rpm between the two V-blocks (steel-simulating mating surfaces as found in the M16A1 rifle receiver) positioned in the jaws of a load applying mechanism. The load applied to the blocks was increased from zero to 22.7 kg for a 32 second period. At the end of that time, and each 30 second period thereafter, the load was increased by 22.7 kg until a total of 182 kg was applied. The load was then maintained at the 182 kg level for 20 minutes or until catastropic failure occured (i.e. seizure or fracture of the journal).

Coating morphology examinations were made by the scanning electron microscope. The analyses (including depth) of the anodic coatings were performed with x-ray diffraction and EDX (energy dispersive analysis of x-rays) techniques. Visual examinations of the coatings were also made.

The electrolytic anodizing bath was escalated in volume from laboratory to production sizes, e.g., 75 cm x 45cm x 45cm (30 in. x 18 in. x 18 in.). Upper receivers were hardcoat anodized in electrolytic baths containing molybdenum disulfide. After anodizing, the coated receivers were cold water rinsed, air dried, visually examined and placed in a desiccator for dry cycling.

The coated upper receivers were assembled in M16A1 rifles. The rifles with test and control upper receiver were dry cycled (simulated firings) and inspected for wear after a variety of cycles.

Equipment was designed and procedures developed for operating a low temperature, -4 to 0°C, hard coat anodizing process for the co-deposition of lubricious particles during hardcoat anodizing of aluminum.

Uniform hardcoat lubricious deposits were obtained with either Teflon, molybdenum disulfide or polyethylene. Color variations of the lubricious hardcoat were observed not only with the amounts of lubricious material added to the anodizing bath but with the material itself. Catastropic failures occurred (seizure and fracture) with uncoated and conventional hardcoat journals in only 4-15 seconds during Falex wear testing. Failures were also evident with those hardcoated journals containing Teflon and polyethylene, but after 15-32 seconds, all within the first applied load. Failures also occurred with the hardcoat journals containing MoS_2 but only after the second load was applied and in a timeframe ranging between 40-55 seconds depending upon the amounts of MoS_2 in the coating. However, successful results were also attained with the second load and continued up to the fifth load (122 seconds) where failures were immediately eminent. Lubricious hardcoated receivers utilizing the 2 g/l MoS_2 bath were as easy to dry cycle after one thousand cycles as they were after one cycle. Galling and seizing occurs after only 250 cycles with the control (conventional hardcoat) receivers between the alignment track and bolt carrier.

BENEFITS

a. A prototype, co-deposition of lubricious particles during hardcoat anodizing of aluminum, system has been developed which is capable of producing improved wear and corrosion resistance coatings for upper and lower receivers of M16A1 rifle.

b. Procedures for controlling selected solution compositions of lubricious particles have been established.

c. The data and information obtained in this program are very significant and useful for application in current and future small caliber gun systems (where aluminum is utilized) to provide superior wear and corrosion resistance.

d. The information obtained in this evaluation will be incorporated as a revision to MIL-A-8626, Type III. New specifications will allow for TDP and ECP incorporation in future procurement.

e. The application of solid film lubricious hardcoatings to M16A1 upper (and lower) receivers should show a cost savings of $643,000 over a 10-year period based upon salvaging worn receivers and extending the service life. Additional savings could be realized by extending the application to other weapon components.

IMPLEMENTATION

The co-depositied lubricious particles in anodized hardcoat process established in this projected effort will be recommended for production trials for federal and other production facilities. The methods and procedures established can be adapted for current and future small caliber gun (aluminum) systems.

MORE INFORMATION

To obtain more information contact the project officer, Mr. L. L. Gruss, ARRADCOM, AV 880-2395 or Commercial (201) 328-2395.

Summary report was prepared by Bob Hellem, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 679 8005 titled "Establishment of the Mechanical Plating Process" was completed by the US Armament Research and Development Command in June 1981 at a cost of $150,000.

BACKGROUND

In all electroplating processes, hydrogen is deposited along with the coating causing embrittlement problems for steel parts, especially for those parts where the hardness exceeds R_C40. Such problems are frequently encountered with zinc and cadmium electroplated steel fasteners. Hydrogen embrittlement relief cannot be obtained by baking at elevated temperatures for plated steel parts of hardness R_C50 and higher. In addition, electroplating of fastener threads results in non-uniform deposits. Electroplating baths require close chemical control and costly waste treatments, especially when cyanide is utilized.

SUMMARY

The objective of this project was to establish a mechanical plating production facility for processing armament components. The mechanical plating process that was investigated was one in which the chemicals are added in sequence to a tank without removal of the mill. First, the cleaner solution is added and tumbling is started. When that operation is complete, the solution is drained into another tank. In the next step, coppering solution is added and when the plating action is completed, the solution is poured into another holding tank. Water, glass beads, accelerator and metal powder are then added and the mill is rotated until plating is deposited on exposed part surfaces. All plating fluids and rinse solutions are recycled in this method. None of the solutions are discarded; therefore, chemicals and water are conserved which results in process cost savings. After prolonged usage, fluids and solutions are chemically rectified and waste materials are removed as sludge. Chromating rinses, that can be done after plating to increase corrosion resistance, must be treated to convert hevavelent chromium to the trivalent state before proper disposal.

The types of plating deposited by this process are zinc, cadmium, tin and 50/50 cadmium/tin, and 75/25 or 50/50 zinc/cadmium. Any of these metals can be applied in layers to provide a synergistic effect for lubricity, corrosion resistance and coating smoothness.

Plating thickness is determined by the amount of powder used. The dimensions of holes, recesses or grooves in the part to be plated determined the size of the glass beads used in the plating operation. Plating thicknesses commonly range from 0.2 mil to 3.0 mils. Corrosion resistance is a function of thickness with any of the plating types.

The results of this project indicate that coating thickness of mechanically plated items were fairly consistent throughout the part, including recesses, grooves, holes and roots of threads. Coatings on edges of parts and on crests of threads were thinner than on other areas. Conversely, electroplating produces thicker coatings in those areas while the coating in recesses, grooves and roots of threads are thinner. Adhesion of mechanically plated parts to ferrous substrates is excellent.

Tests on mechanically plated zinc parts revealed that thin (0.05-0.07 mm) coatings, without a supplementary chromate coating, failed to meet the specification requirement for corrosion resistance. Chromated parts generally passed the corrosion requirement for the absence of red rust, but white products (ie zinc oxide) of the zinc coating were apparent. Heavy zinc coating provides long term corrosion protection.

Cadmium and cadmium-tin mechanically plated parts can meet the salt spray test requirement and are superior in that test to zinc mechanically deposited coatings of similar coating thickness.

BENEFITS

The information obtained in this evaluation can be fully utilized since the increasing constraints on electroplating effluents make the electroplating process increasingly cost prohibitive. Mechanical plating on steel parts above R_C40 hardness has shown no evidence of hydrogen embrittlement of the substrate and demonstrates its usage for structural and other critical components. The "closed-loop" process used for mechanical plating conserves water and chemicals since all are reusable after the deposition process. On small parts such as nuts, bolts, washers, etc., the mechanical plating process has been demonstrated to be more cost effective than electroplating.

IMPLEMENTATION

Evaluation of the mechanical plating process as described in this program will be documented in a final report and will be available to Government installations for plating rework of armaments and to contractors for use in weapon production.

Implementation of mechanically plated cadmium in lieu of electroplated cadmium on bolts used for the M39 Carriage for the M198, 155mm Howitzer has been initiated because of failures due to hydrogen embrittlement. ECP's are anticipated for parts on M109 studs, M110 spacers, M107 bolts, M45 rods and M140 brackets among others.

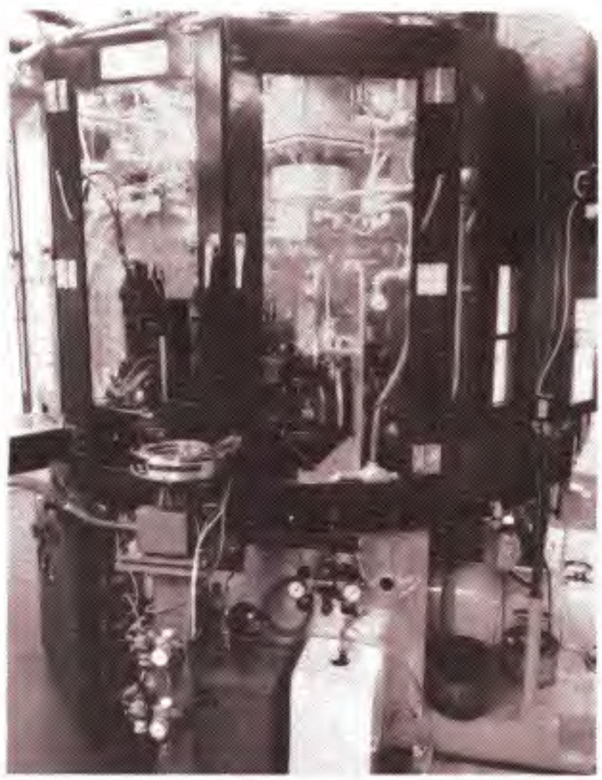
Proposed revisions in specification MIL C-81562A, "Coating, Cadmium, Tin-Cadmium and Zinc (Mechanically Deposited)" will be initiated by the Naval Air Engineering Center, Lakehurst, NJ., the standards organization responsible for its preparation and for its amendment.

MORE INFORMATION

To obtain more information, contact the project officer, Mr. W. T. Ebihara, ARRADCOM, AV 880-6553 or Commercial (201) 328-6553.

Summary report was prepared by Bob Hellem, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MUNITIONS



IOWA AAP DETONATOR LOADER

ABSTRACTS

Project Number	Project Title	Page
57T 3104, 576 3104	Copper Ampules for Fuse Power Supplies	MU-4

A high speed, semi-automatic production method was developed for the manufacture of copper ampules. The method was implemented by initial production facility projects and is now being used to produce thousands of ampules.

57T 4114-P06	Propellant and Explosive Waste Incineration	MU-20

This effort reviewed various types of incinerators for application to propellant and explosive waste disposal. Two acceptable incinerators were developed, a rotary kiln and a fluidized bed. Utilization of these incinerators will provide a safe waste disposal method with a significant reduction in pollutants. Two kilns are currently operating at Radford AAP and the fluidized bed was selected for depot use.

573 4114-P09 574 4114-P09	Treatment of Nitrobody Wastes from TNT Production	MU-25

This project explored suitable means of treating relatively dilute concentrations of nitrobody in TNT waste streams. The most economical method was found to be carbon regeneration, in which TNT laden carbon columns were backwashed with 28 bed volumes acetone. Implementation of this technology has reduced a pollution problem, met regulatory standards and decreased cost per hundred gallons from $7.43 to $3.48.

579 4285	TNT Equivalency Testing in Support of Safety Engineering for Ammunition Plants	MU-44

This project established TNT equivalencies for several materials frequently used in ammunition plants. These included the 155mm M483 projectile, M42 grenade tray, HMX, and Composition C-4. Utilization of the obtained pressure and impulse TNT equivalency values will assist safety engineers in installing adequate blast protection and will help eliminate costs associated with over-design.

580 4285	TNT Equivalency Testing for Safety Engineering	MU-47

This project established TNT equivalencies for several materials frequently used in ammunition plants. These included D1GL-RP propellant, JA-2 propellant, Cyclotol 70/30, RDX, and PBXC-203. The TNT equivalency ratings were determined from the blast pressure and impulse values measured. These ratings will assist engineers in designing adequate blast protection while avoiding the costly problem of over-design.

579 4288	Explosive Safe Separation and Sensitivity Criteria	MU-51

This project established safe separation distances of explosive end items and in-process materials and determined the sensitivity of explosives to primary and secondary impact at various stages in the manufacturing process. Tested explosives included 155mm M795 HE projectile, 155mm M549 HERA projectile, cyclotol, and BLU-63 AIB hemispheres. New safety criteria was written as a guideline for future construction and was also applied to existing load-assemble-pack facilities at Mississippi AAP, Milan AAP, Lone Star AAP, and Kansas AAP.

576 4301, 57T 4301, 577 4301	Acceptance Plan for Continuously Produced Multi-Base Cannon Propellant (CAMBL)	MU-54

This project devised methods of insuring high quality propellant without heavy dependence on ballistic firing. This was done by establishing relationships between gun performance and propellant properties, and relating those properties to the source material and process parameters. Test instrumentation and equipment was also developed. Cost savings of $90,000 per year have been achieved at RAAP by implementation of this effort.

		Page
578 4449	Process Improvement for Composition C-4	MU-69

This project demonstrated the feasibility of utilizing nominal Class 1/Class 5 RDX in the manufacture of Composition C-4, instead of the more costly standard Class 1/Class 5 RDX. No statistically different performances were observed in comparing the experimental and standard Composition C-4. Holston AAP is saving $55,000 per year by using this new composition.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 57T 3104 and 576 3104 titled "Copper Ampules for Fuse Power Supplies" were completed by the US Army Armament Materiel Readiness Command in October 1981 at a cost of $350K.

BACKGROUND

Much R&D has been conducted at Harry Diamond Labs and at several contractors on copper ampules. The emphasis of the work was on performance and reliability. The copper ampule design with spin and setback gives improved drop safety over the glass ampule.

In order to assure that the procurement cost for PS 115 power supplies was minimal, and handling safety was maximum, process engineering for semiautomatic, high speed manufacturing and testing was needed in making the production model of the copper ampule. An exploded view of the ampule is shown in Figure 1.

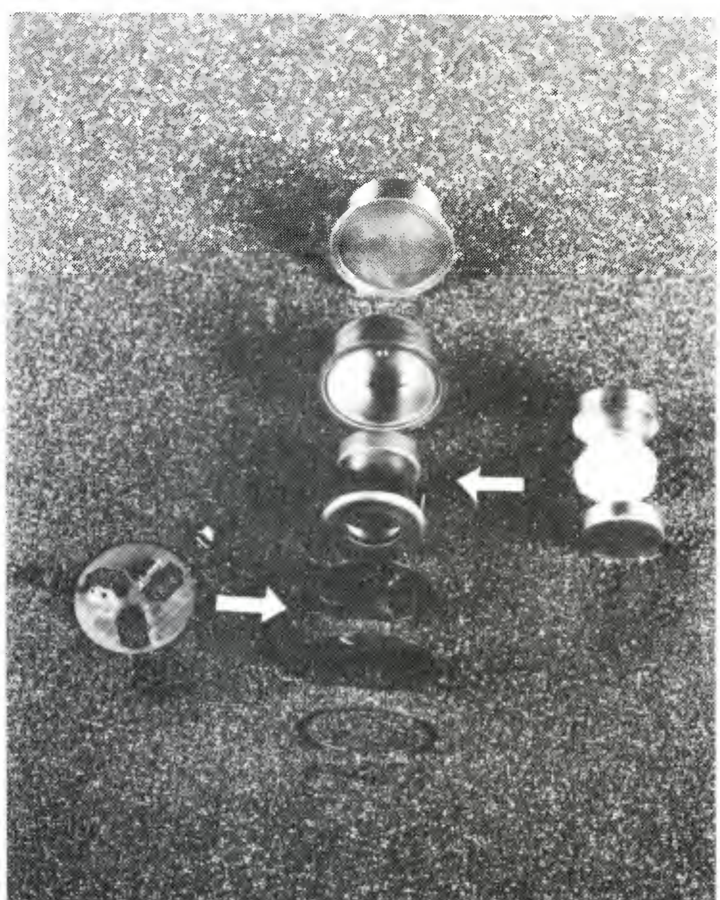


Figure 1 - Exploded View of a Copper Ampule

SUMMARY

The objective of this project was to design and build an ampule assembly machine and a cutter assembly machine. Union Carbide was contracted to perform this work.

The cutter assembly machine automatically die cuts the cutter plate and assembles the cutter blades to the plate. At the first stage of the machine, a Lourdes die press blanks the cutter plate from a continuous strip of copper and folds the blade tabs up. The next three operations place cutter blades. Each operation picks up one blade and places it on a specific pair of cutter plate tabs. The blades are supplied to the machine from vibratory bowls by way of vibratory inline tracks. Following blade placement, the last stage is another Lourdes die press which crimps the blade tabs, bends a preliminary fold, completes the final fold to a specific angle on the blade tabs and blanks the outside diameter. The cutter assembly machine automatically inspects the assemblies for missing or improperly positioned blades.

The ampule assembly machine automatically assembles the components of the ampule by combining cartridge assembly, weight and ampule can together with cutter assembly, diaphragm, weld ring, electrolyte and bromide.

The ampule assembly machine system consists of two identical, 24 station indexing dial assembly machines. The machines are controlled by a pair of common Allen Bradley programmable controllers. Non-liquid parts are supplied to the machine, as required, from feeder bowls. The ampule assembly machine is supplied with cartridge assembly and weights inserted into an ampule can via a parts conveyor. Pick up arms place the unit into a table nest in the proper sequential order. An injection of methylene bromide is put into the cartridge assembly. This is followed by an injection of fluoboric acid. A cutter assembly is placed into the can and a single diaphragm is placed upon the cutter assembly. A weld ring is placed upon the diaphragm. The ring and diaphragm are TIG welded to the can. Both the diaphragm and weld ring are supplied to the machine through cylindrical magazines. From the magazine the parts are picked and placed onto the balance of the assembly in the machine nest.

All assembly operations performed are verified by probing (electro-mechanical gaging) at subsequent stations. The control logic also verifies proper operation at various steps and shift register control cancels any further operations to any component failing verification. Incomplete assemblies are automatically rejected. Acceptable assemblies are 100% inspected before continuing their assembly operations.

BENEFITS

This project provided a means and method to fabricate copper ampules which gives a significant improvement in drop safety. An improved understanding of TIG welding principles for thin copper welding was gained.

IMPLEMENTATION

This project was implemented in the Initial Production Facilities Projects 576 3096 and 577 3096. Thousands of ampules are being fabricated for the PS-115, the PS-127, and the PS-416 power supplies.

MORE INFORMATION

Additional information on this effort may be obtained by contacting Mr. Andrew Sabonis, Jr., HDL, AV 290-3114 or Commercial (202) 394-3114. The contract number is DAAG39-77-C-0011.

Summary report was prepared by Dan Richardson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 574 4000 titled "Automated M55 Detonator Production Equipment" was completed by the US Army Armament Research and Development Command in January 1980 at a cost of $549,000.

BACKGROUND

With the advent of Improved Conventional Munitions, the requirement for non-electric detonators increased to 100M/month at mobilization and 100M/year in peacetime. Current detonator equipment is World War II vintage which requires large facility space and is highly labor intensive. These projects were to conceive, design and fabricate automated equipment for the manufacture and inspection of non-electric detonators, and also to develop a primer mix (PA-130) with enhanced flowability characteristics to replace NOL-130.

SUMMARY

The conceptual proof models for metering, dispensing and consolidating explosive powders, for crimping and sealing detonators, and for packing detonators were evaluated as follows: MRC's detonator sealing concept utilizes three independent rotary turrets for inserting closure discs, crimping detonators and lacquering the crimped areas. Consequently, it was necessary that the bench model duplicated these three operations as well as input/output functions. Since the individual turrets are independent of one another, a non-integrated bench model was fabricated.

A machine base with drive, three functional turrets, an input turret and an egress station were constructed. The input turret and egress station were assembled to the machine base and the resulting assembly was used with each of the functional turrets. In Figure 1 the input turret and egress station are shown working in conjunction with the closure insert turret.

In a production machine, each of the functional turrets will utilize 48 stations which revolve at 25 RPM to achieve the desired production rate of 1200 parts per minute. The 48 stations would be arrayed in 24 snap-in modules (i.e., two stations per module) since the use of dual station modules is more cost effective than single station modules. For the sake of economy, one module was used on each of the bench model turrets and only one of the two module stations was tooled.

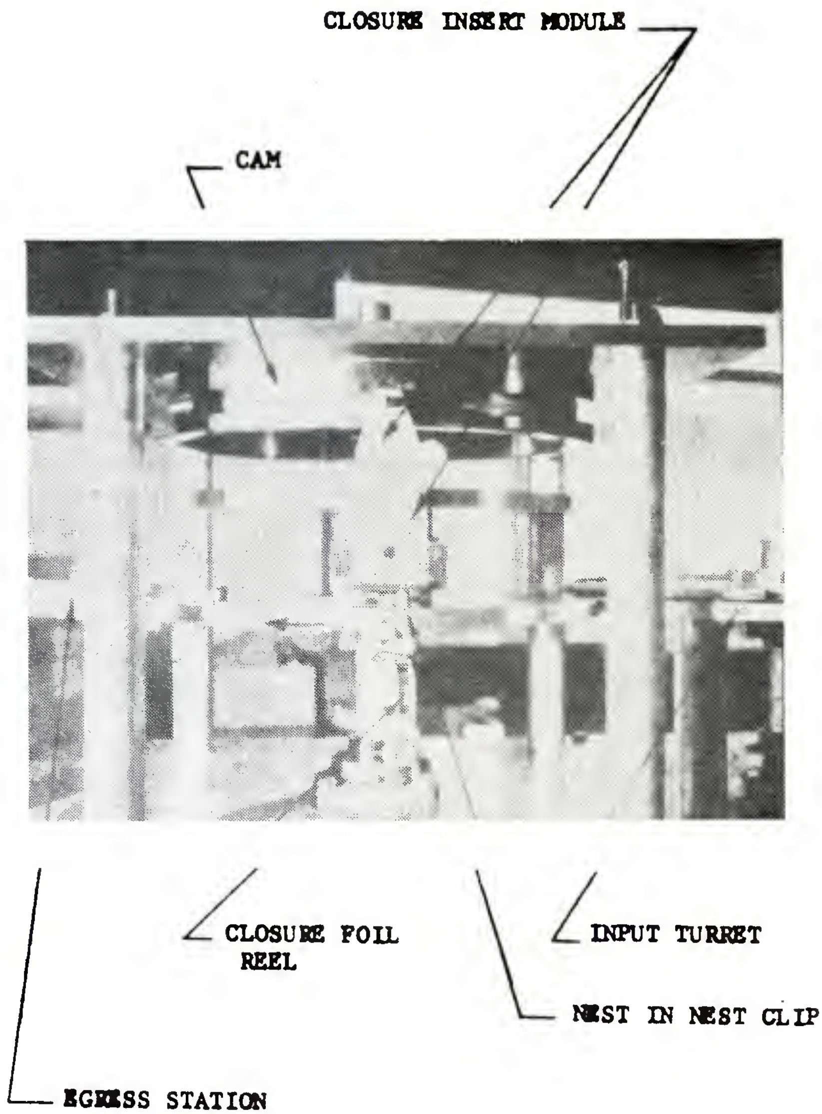


Figure 1 - Closure Insert Turret
Frontal View of Blanking Operation

BENEFITS

a. The concept for metering dispensing, crimping and sealing were successfully evaluated.

b. The Scope of Work of a pilot line for loading and sealing of detonators was started.

IMPLEMENTATION

The results of this project will be used and applied in the follow-on projects.

Technical difficulties encountered at Lone Star AAP resulted in unsuccessful blending of a production quantity of PA-130. Effort on this task continued with FY79 funding.

MORE INFORMATION

Additional information may be obtained from Mr. Paul Monteleone, ARRADCOM, AV 880-5705 or Commercial (201) 328-5705.

Summary report was prepared by Wally Graham, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 577 4000 and 578 4000 titled "Automated Detonator Production Equipment" was completed by the US Army Armament Research and Development Command in January 1981 at a cost of $960,100 and $1,222,800, respectively.

BACKGROUND

The purpose of this project was to conceive, design, fabricate, and evaluate techniques and equipment for the fabrication, inspection, and packing of M55 stab detonators; and integrating said equipment into a fully automated, cost effective system. This effort has been funded in prior years starting in FY71.

SUMMARY

An automatic inspection module to inspect detonator cups was initiated. Feasibility models for the automatic optical inspection of assemble detonators were constructed. Experiments to develop quick drying lacquers were conducted. RAM analyses of the multi-tool Iowa loader were performed. Iowa AAP performed debugging operations on the multi-tool loader and built an automatic lacquer dispensing system. Also, an improved aspirator system was designed and built.

Construction of the module for automatic inspection of detonator cups was completed and successfully tested; concepts and requirements for an automatic packout module were established; material handling system concepts were established; RAM analysis of the multi-tool loader was updated and refined; and parameters for ultrasonic sealing of detonators were established.

Lone Star AAP loaded and lacquered 4500 detonators with various lacquer formulations for testing at ARRADCOM and provided general program support; Iowa AAP designed, fabricated, and installed improvements on the multi-tool loader. See Figure 1.

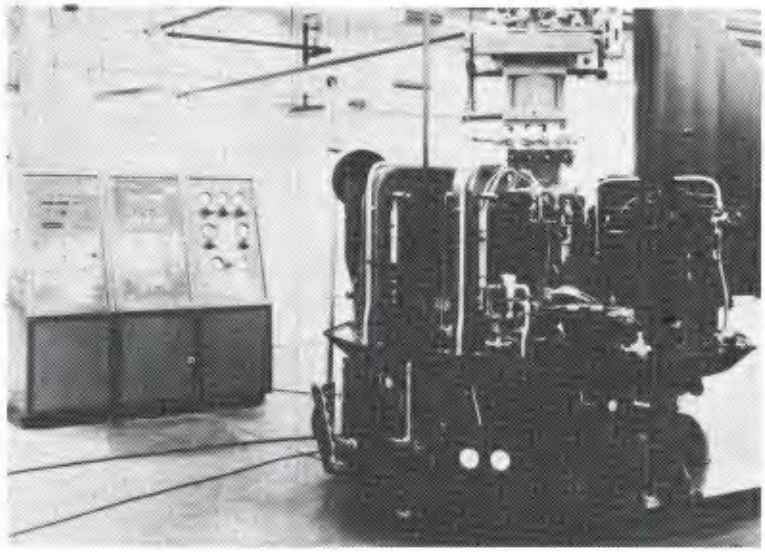


Figure 1 - Multi-Tool Loader

BENEFITS

a. The equipment developed under this project will replace and/or supplement the present costly manual - mechanical production systems so that the increased quantities of M55 detonators required for ICM production can be met. When the total project is completed and integrated into a complete system, it will result in a direct benefit of $10 million per year.

b. The areas of technology advanced by this project are:

(1) Rapid and accurate parts inspection.

(2) Rapid and accurate assembly inspection with reduced operator exposure to sensitive materials.

(3) Increased assembly production per machine.

IMPLEMENTATION

The results of this project will be used and applied in the accomplishments of follow on projects.

MORE INFORMATION

Additional information may be obtained from Mr. Paul Monteleone, ARRADCOM, AV 880-5705 or Commercial (201) 328-5705.

Summary report was prepared by Wally Graham, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 580 4033 titled "Caustic Recovery From Sodium Nitrate Sludge" was completed in July 1982 by the US Army Armament Research and Development Command at a cost of $153,000.

BACKGROUND

Currently, RDX and HMX are produced at Holston AAP using hexamine, ammonium nitrate/nitric acid, acetic acid, and acetic anhydride as raw materials. After production and separation of the explosive products, the remaining spent acid solution is processed to recover the acetic acid and small amounts of explosives. The spent acid is neutralized with sodium hydroxide, the sludge is concentrated by evaporation, water is added to cool and precipitate out the explosives, and, finally, steam is used to strip the remaining acetic acid from the sludge. The sludge is mostly sodium nitrate and ammonium nitrate contaminated with small amounts of explosives. This sludge is treated with additional sodium hydroxide to destroy the explosive contaminants. The recovered sodium nitrate is currently sold on the market at a loss. The remaining mother liquor is stored in lagoons and becomes a growing disposal problem.

Therefore, three alternatives to the present process were proposed to produce a different type of waste sludge which could be either totally destroyed or treated to yield a marketable product.

SUMMARY

The objective of this project was to evaluate alternative means for handling spent acid sludge. The technique was to replace the sodium hydroxide neutralization of excess nitric acid process with another neutralization agent which would yield a more valuable and easily saleable end product than sodium nitrate. Three such alternatives appeared feasible and economically attractive. They were:

°Neutralize excess nitric acid with ammonia. Hydrogenate the resultant ammonium nitrate sludge to destroy dimethyl nitrosamine and recover ammonium nitrate.

°Neutralize excess nitric acid with lime. Incinerate the resultant lime sludge to destroy explosives and nitrates and to recover the calcined lime for reuse.

°Neutralize excess nitric acid with ammonia. Incinerate the ammonium nitrate sludge formed.

Technical and economic feasibility studies of these techniques were performed at ARRADCOM and corroborated by Hayes, Seay, Mattern and Mattern (Battelle Labs) under contract. The most economically attractive technique was (a) neutralization with ammonia followed by purification by means of catalytic hydrogenation and disposal of the purified ammonium nitrate solution by sale as liquid fertilizer, a product in worldwide demand and approximately 5 times more valuable than sodium nitrate. A diagram of the ammonia neutralization process is shown in Figure 1.

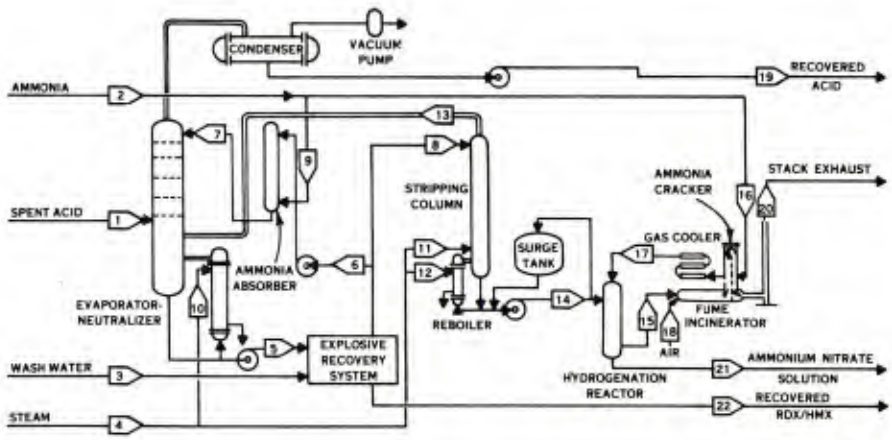


Figure 1 - Flowsheet and Material Balance - Alternative 1

The major technical uncertainty was the ability of the hydrogenation process to reduce the impurities in the recovered ammonium nitrate solution. However, independent experimental work indicated that hydrogenation of a spent acid sludge yields an aqueous solution of ammonium nitrate that is practically free of explosives, carcinogenic and odorous materials.

The use of incineration for disposal of the spent acid sludge also appeared a viable concept. Either an ammonia neutralized sludge or a lime neutralized sludge can be easily incinerated but a large capital investment for the incineration system is required. Moreover, fuel costs for an incinerator ranged from 2 to 3 percent of total operating cost (if low cost natural gas is used) to 9 to 14 percent (if fuel oil is used). The analysis conducted was based on the use of fuel oil since this appeared more realistic.

Laboratory scale studies of the thermal decomposition of waste acetic acid sludges and the corrosion effects of acetic acid sludge processing on various engineering materials were conducted under contract with Hazards Research Corporation.

A muffle furnace and a pipe furnace were used to incinerate the sludges. The results indicated that incineration of calcium nitrate and ammonium nitrate sludges was feasible. Calcium nitrate decomposition yielded nitrogen dioxide as the principal off gas with some carbon dioxide and a negligible amount of nitrous oxide formed. Ammonium nitrate decomposition yielded only moderately low levels (ppm) of noxious gases that could be eliminated by appropriate scrubbing. Suitable engineering materials which should be used in equipment for the processing of waste acetic acid recovery plant sludges were fire clay, Duriron D and Stainless Steel 309.

Incineration of the sludge was a viable concept but it required a large capital investment. Therefore, catalytic hydrogenation of ammonium nitrate sludge followed by resale of the purified solution was determined as the most economical alternative for processing of waste acetic acid recovery plant sludges.

BENEFITS

A technique was developed to utilize ammonium to neutralize the spent acid followed by catalytic hydrogenation of the resultant ammonium nitrate sludge and, finally, resale of the water solution.

IMPLEMENTATION

The alternative process developed for treating spent acid in this project will be continued under MMT Project 582 4511. Emphasis will be on developing a procedure for catalytically hydrogenating the ammonium nitrate sludge.

MORE INFORMATION

Additional information can be obtained from Mr. G. Eng, ARRADCOM, AV 880-2160, or Commercial (201) 328-2160.

Summary Report was prepared by Pete Martin, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 575 4050 titled "Automated Loading of Propellant Flash Reducers" was completed by the US Army Armament Research and Development Command in January 1981 at a cost of $985,000.

BACKGROUND

The purpose of this project is to automate the loading operations of the 155mm and 8-inch propellant flash reducers. The present method utilizes manual loading operations which are time consuming and hazardous to the operators.

SUMMARY

The fabrication, test, and installation of a prototype loading module was undertaken by FMC Corporation utilizing the technical data generated by the 574 4050 study. As developed and built, the loading module consists primarily of a ten foot diameter carousel which carries manually attached cloth flash reducer bags to interfaced loading stations for ingredient filling and closure sewing. The ingredients and loaded bag are accurately weighed.

The module uses a ten foot diameter carousel with 32 sets of funnels and clamps. For demonstration test, the carousel rotation speed was slightly greater than one-half revolution per minute, requiring each of two operators to insert bags on the carousel at the rate of approximately nine bags per minute.

The clamped empty flash reducer bag with funnel spout inserted in the filler opening is carried to the Hi-Speed X-170 netweigher where black powder, if required, is metered into the funnel.

The continuously moving carousel (Figure 1) carries the flash reducer bag to the Mateer-Burt volumetric filler to receive the required quantity of potassium sulfate (or other inert salt). An intermittently driven screw delivers, by volume, a measured quantity of inert salt into a carousel funnel on demand.

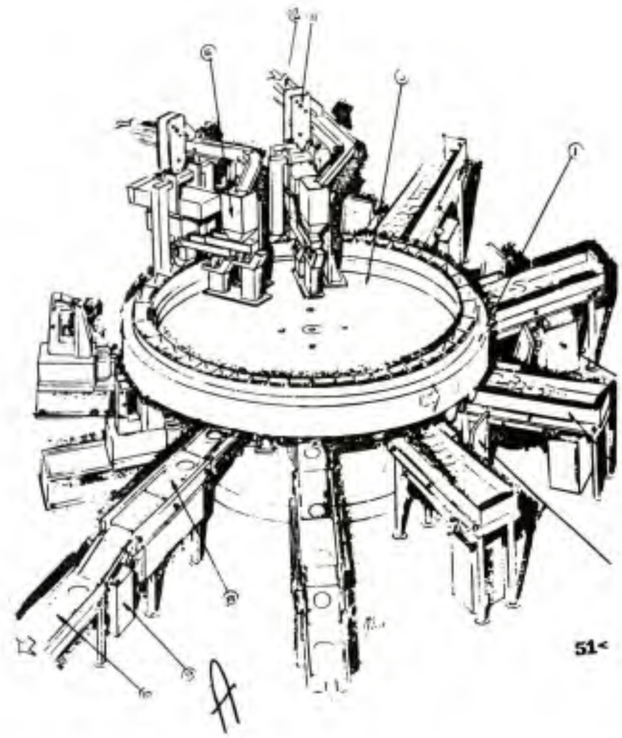


Figure 1 - Loading Module

The flash reducer is carried from the filler area past a saw-tooth section of cam guide rail which causes a jolting action to be transmitted to the funnel to assure passage of all of the fill ingredients through the funnel spout and into the flash reducer bag, then over an air piston actuated lifter which is raised under the bag, lifting, then lowering it to assist the flow of the fill material away from the closure sewing area.

The funnels are automatically raised out of the filler opening of the bag and the clamps are automatically spread to flatten the cloth for presentation to a modified Singer double-needle chainstitch sewing machine. As the bag approaches the sewing machine, a guide assists movement of the bag to prevent hangups and a timing belt drive engages to start the sewing machine to sew shut the fill opening.

The moving carousel now carries the bag to an inspector who checks for visible defects.

After the bag is carried past the inspector, a camming action of the carousel causes the clamps to be withdrawn allowing the filled and closed flash reducer bag to drop onto a take-away elevating conveyor for delivery to a Hi-Speed T-59 checkweigher scale.

A checkweigher weighs each flash reducer individually and determines if the loaded flash reducer is within limits. The checkweigher then diverts the flash reducer to separate accept or reject finished product collection points.

After the finished flash reducer is released, the carousel rotation causes the funnels to lower to the proper level for bag insertion and presents them for repetition of the loading cycle.

BENEFITS

This project provided prototype equipment for automatically loading both the 155mm and 8-inch propellant charge flash reducers. The advantages to be derived will be increased production and reduced item costs, reduction in operating personnel, improved operational safety and increased production reliability.

IMPLEMENTATION

The prototype loading module was shipped to Indiana Army Ammunition Plant. Following delivery to Indiana Army Ammunition Plant, an investigation into other feasible applications indicated the possibility of using the module in loading flash reducers for the M119A2 charge. This has been implemented.

MORE INFORMATION

Additional information on this project can be obtained from Mr. D. S. Davis, ARRADCOM, AV 880-5727 or Commercial (201) 328-5727.

Summary report was prepared by Wally Graham, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 576 4105 and 577 4105 titled "Automated Increment Loading and Assembly of Propellant Charges with Center Core Igniters" were completed by the US Army Armament Research and Development Command in July 1980 at a cost of $685,000 and $1,359,000, respectively.

BACKGROUND

The purpose of this project was to automate the load and assemble operations for propelling charges with center core igniters by providing new prototype manufacturing equipment. The current methods used to load and assemble the 155mm and 8-inch propelling charges are manual and very labor intensive.

SUMMARY

The prototype loading module, Figure 1, consists of a heavy steel tubing frame which supports upper and lower tooled tracks of 8 and 12 stations, respectively. The two tracks are driven by a common air motor. The upper level, containing 4 scales, handles the function of dispensing, weighing and checkweighing the propelling charge, totally automatic. The lower level, which utilizes one scale for mandrel and bag tare weight (off the module), moves the charge bag through the processes of filling, vibration/compaction, and sewing the bag closed.

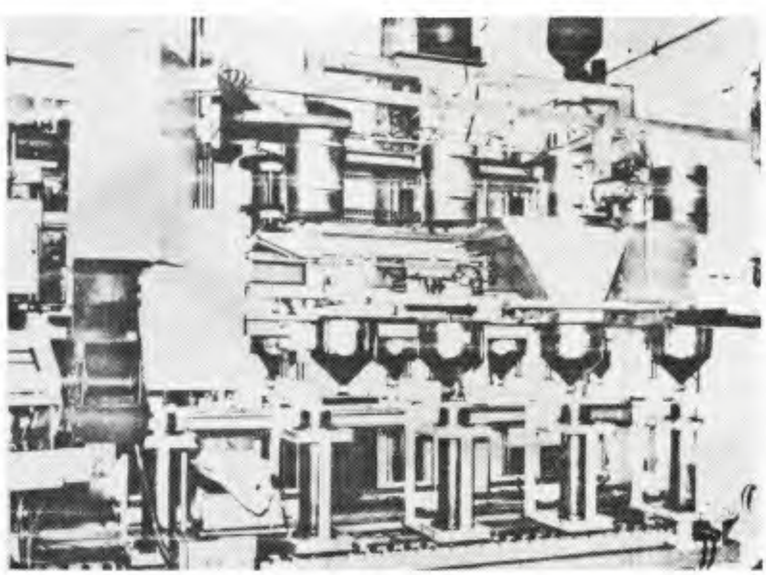


Figure 1 - Load Module (Center Core Prop Charge)

Basic design of the assemble module is similar to the loading module. The frame is constructed of heavy steel tubing which supports two tooled tracks of 8 and 6 stations each and driven by a common air motor. Overall control of the module and communication with a future central control room is by a Programmable Logic Controller (PLC) housed in an air purged cabinet. The cabinet also contains the air-electrical interface elements (solenoids and air operated switches) and a scale electronic unit. Application of "scale intrinsic safety" was successfully achieved utilizing Zener Barriers.

The first track of the assembly module handles the function of assembling Igniter assemblies to Increment Loading Assemblies and removing mandrels. A station is provided for tack sewing the Igniter Assemblies to the Increment Loading Assemblies through use of an auxiliary sewing machine. Another station is provided for the manual inversion of the Base Igniter Cap. Off the machine is a conveyor system for supplying Igniter Assemblies and the removal of mandrels. Built into the conveyor system is a scale for 100% weighing of Igniter Assemblies.

On the second track, the charge moves through the process for manual assembly of Flash Reducers to Increment Loading Assemblies (plus Igniter Assemblies). An auxiliary scale is used for weighing Flash Reducers 100% (accept or reject). Also, Increment Loading Assembly No. 9 is manually assembled to the two-increment-8-Inch charge and then the related Flash Reducer is placed on top of Increment No. 9. The second track is also used for manual tying the Tying Straps and for final ejection of the assembled charge (minus lacing jacket) into an elevating conveyor to await packing and shipping.

BENEFITS

Completion of this project has provided the technology for the equipping of a new facility being constructed at the Indiana Army Ammunition Plant (INAAP). The equipment has been designed to fit into the new facility and will do so provided a proposed product change in the product requirement can be made.

IMPLEMENTATION

The load and assemble modules were installed at the Crane Army Ammunition Activity (CAAA), Crane, Indiana for the purpose of producing charges and for obtaining reliability, availability and maintainability data. The project proved technically unsuccessful and unable to meet the product requirements. The equipment is now in storage at Indiana AAP.

MORE INFORMATION

Additional information on this project can be obtained from Mr. C. Cornali, ARRADCOM, AV 880-4162 or Commercial (201) 328-4162.

Summary report was prepared by Wally Graham, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 57T 4114 Subtask P06 titled "Propellant and Explosive Waste Incineration" was completed by the US Army Armament Research and Development Command in November 1979 at a cost of $35,000.

BACKGROUND

Project 5XX 4114 was a continuing program to provide an integrated plan of action on pollution abatement in connection with manufacturing, loading, assemblying, and packing of propellants and explosives. Due to the immense scope of this project, it was divided into three subprojects under the direction of Picatinny (P), Frankford (F), and Edgewood Arsenals (E) with multiple tasks under each.

The purpose of this particular subtask was to technically review various types of incinerators for application to propellant and explosive waste disposal. Picatinny Arsenal was to evaluate the vertical induced draft and the fluidized bed incinerators. Radford AAP was to procure and evaluate a rotary kiln incinerator. Previous work, upon which this subtask is based, was done under 573 4114, 574 4114, 575 4114, and 576 4114.

SUMMARY

Previous work utilizing the vertical induced draft incinerator, with a single-acting diaphragm pump in the feed system, conducted at Picatinny Arsenal demonstrated this method's feasibility. Nominal flow rates of 12.75% concentration of explosives were used to yield the design rate of 113.4 kg/hr (250 lbs/hr) explosive. Prior to incineration, TNT, Composition B, and HMX were ground successfully to a uniform particle size using a ball-mill grinder.

Fluidized bed incineration studies using a propellant and explosive slurry feed system were conducted at Picatinny Arsenal also. These studies determined that the incineration of 15 to 25% by weight slurries of TNT could be burned successfully at feed rates of 80 to 145 kg/hr (177 to 320 lbs/hr) TNT. The low emission values from this burn, using a nickle oxide catalyst, were attributed to the high combustion efficiency of the fluid bed design. Slurries of Composition B, HMX, RDX, ammonium nitrate, nitric acid, and single-base propellant were incinerated successfully also at a 10% (by weight) concentration of explosive.

Rotary kiln incinerator tests were conducted successfully at Radford AAP utilizing HMX ratios (HMX:water) of 8:1, 5:1, and 3:1. Several different temperatures, incinerator drum speeds, and feed rates were employed to optimize the burn. During these runs, however, no attempt was made to optimize air flow or scrubbing conditions and the NO_x in the exhaust gas ranged from 123 to 266 ppm. Other compounds burned successfully included TNT, Composition A5, Composition B, nitroglycerin, and single and double based propellants. A schematic of the rotary kiln incinerator is shown in Figure 1.

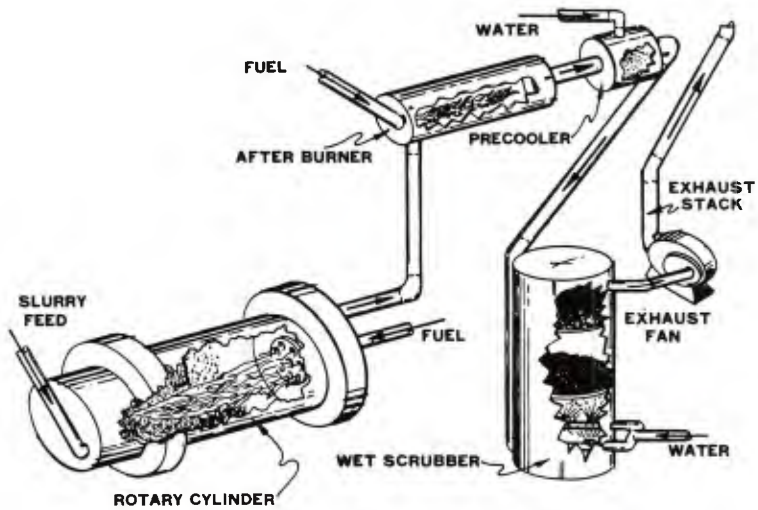


Figure 1 - Rotary Kiln Schematic

BENEFITS

This task developed two acceptable incinerators, rotary kiln and fluidized bed, to replace open air burning. Utilization of these incinerators will therefore provide for a safe method of propellant and explosive waste disposal with a significant reduction in pollutants.

IMPLEMENTATION

As a result of this effort, two 249.4 kg/hr (550 lb/hr) rotary kiln incinerators were installed and are operating at Radford AAP. Also, the fluidized bed incinerator concept was selected for the depot disposal system and further work on this system is now in progress at TRW Corp.

MORE INFORMATION

To obtain additional information, contact the project manager, Mr. Joe Santos, AV 880-4284 or Commercial (201) 328-4284.

Summary report was prepared by Mike Achord, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 573 4114, 574 4114, 575 4114 and 576 4114 Subtask P07 titled "Elimination of Nitrate Wastes" were completed by the US Army Armament Research and Development Command in September 1976 at costs of $354,600, $189,200, $34,000 and $100,000, respectively.

BACKGROUND

Project 5XX 4114 was a continuing program to provide an integrated plan of action on pollution abatement in connection with manufacturing, loading, assemblying, and packing of propellants and explosives. Due to the immense scope of this project, it was divided into three sub-projects under the direction of Picatinny (P), Frankford (F) and Edgewood Arsenals (E) with multiple tasks under each. The purpose of this particular subtask was to remove inorganic nitrates from waste streams at munitions facilities by establishing and evaluating pilot scale units.

The present state-of-the-art for nitrate abatement can be applied almost entirely to the treatment of sanitary or domestic type wastes where the average nitrate concentration is in the range of 20-80 mg/l. The concentrations of nitrate in typical munition plant waste-waters are 10 to 50 times greater. A comprehensive review of the available nitrate abatement techniques revealed that few investigations dealt with the treatment of high nitrate containing waste and prompted a decision to establish the applicability of biodenitrification, ion exchange and reverse osmosis for the intended purpose. The choice of these methods was based upon their favorably reported removal efficiencies at lower nitrate concentrations, the volume of recorded data for this application, and their capital and operating costs.

SUMMARY

Of the three techniques investigated, only biodenitrification was deemed suitable for application. The use of reverse osmosis was deemed unsuitable because of the deterioration of the membranes examined, cellulose acetate and sulfonated polyphenylene oxide, due to the pH of the wastewater. The use of counter-current ion exchange was considered to be uneconomical because of the cost of column regeneration. Biodenitrification is a biological process that occurs in the absence of oxygen. The microorganisms in water utilize the oxygen contained in the soluble nitrate (NO_3^-) together with an electron donor source (organic nutrient) to reduce the nitrate to primarily elemental nitrogen. Two approaches investigated utilizing this concept were the suspended growth reactor (slurry type) and the biological filter system (packed-bed type).

An 18.93 kiloliter (kL) per day pilot plant at Radford AAP was used to evaluate the biodenitrification (slurry type) process on the nitrocellulose manufacturing area wastewater. These studies revealed that with an average influent nitrate concentration of 550 mg/L, the detention time could be reduced to 18 hours with a nitrate removal efficiency of greater than 90% while maintaining an average efficiency of 85%. The suspended solids concentration and the volatile suspended solids concentration averaged 2g/L and 0.5g/L, respectively. No further reductions in time were possible because the maximum output of the influent pumps was attained. The maximum capacity of the unit was 2g/L as NO_3^- while maintaining a greater than 95% reduction in nitrate. A process flow diagram is shown in Figure 1.

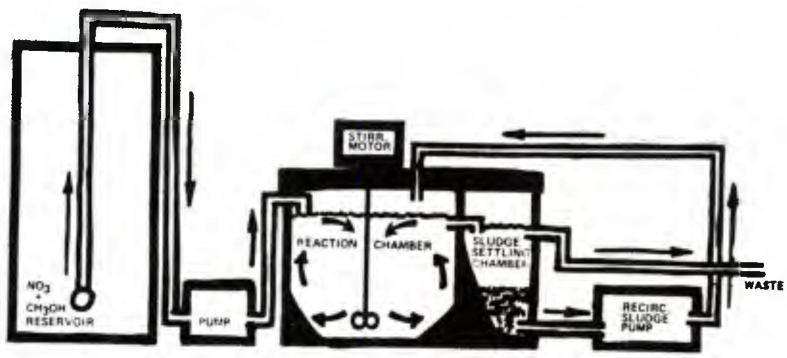


Figure 1 - Suspended-sludge denitrification unit

Packed-bed filter type investigations were conducted at Badger AAP using ethanol as the organic nutrient. Three types of packing were investigated (coarse gravel, PEA gravel and sand) and all yielded efficiencies of greater than 90%. Additional operational parameters determined were that additional amount of ethanol did not enhance the efficiency and the optimum temperature was 26.7°C. As to the inhibitory effects of nitroglycerin (NG), it was found that concentrations of 800-900 ppm have a strong adverse effect on the biodenitrification activity. Upon removal of the NG from the influent, the biodenitrification activity recovered only slightly to 50% but never exceeded that efficiency even after an extended period of time. A process flow diagram is shown in Figure 2.

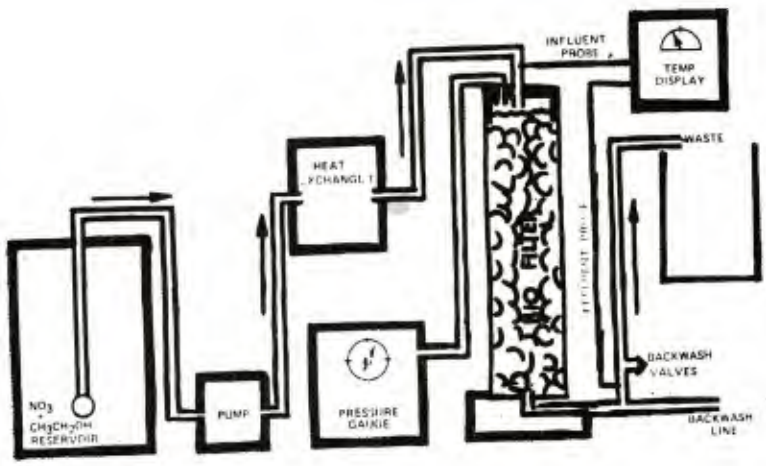


Figure 2 - Biological denitrification filter unit

BENEFITS

This subtask provides the technology and design criteria for facilities to abate nitrate pollution.

IMPLEMENTATION

The results of this subtask were not implemented because all of the techniques were considered to be uneconomical at the present time.

MORE INFORMATION

To obtain additional information, contact the Program Manager, Mr. John Canavan, AV 880-4284 or Commercial (201) 328-4284.

Summary report was prepared by Mike Achord, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 573 4114 and 574 4114 Subtask P09 titled "Treatment of Nitrobody Wastes from TNT Production" were completed by the US Army Armament Research and Development Command in November 1977 at costs of $183,400 and $149,200, respectively.

BACKGROUND

Project 5XX 4114 was a continuing program to provide an integrated plan of action on pollution abatement in connection with manufacturing, loading, assemblying, and packing of propellants and explosives. Due to the immense scope of this project, it was divided into three sub-projects under the direction of Picatinny (P), Frankford (F) and Edgewood Arsenals (E) with multiple tasks under each. The purpose of this particular subtask was to establish, by feasibility studies, suitable means for treating relatively dilute concentrations of nitrobody in TNT waste streams resulting from TNT finishing operations.

SUMMARY

The first area examined was the present method of carbon adsorption in which contaminated waste water is passed through an activated carbon adsorbent bed on which the TNT is absorbed. This saturated carbon is then destroyed by incineration which is economically unfeasible. Hence, regeneration studies were undertaken.

Of the two methods of regeneration examined, solvent and thermal, only solvent regeneration was found to be economical. Solvent regeneration studies revealed that TNT laden carbon columns, regenerated by backwashing with 28 bed volumes of acetone, was only 43% as effective in adsorbing TNT as was virgin carbon, methanol and toluene were even less effective at 33% and 31%, respectively. However, this technique was still regarded as being economically feasible even with the decreased adsorptive capacity of the columns.

Another area examined, on a pilot plant basis, was the use of photolysis and ozonolysis (separately or in combination) to treat the wastewaters. The pilot plant reactor is shown in Figure 1.

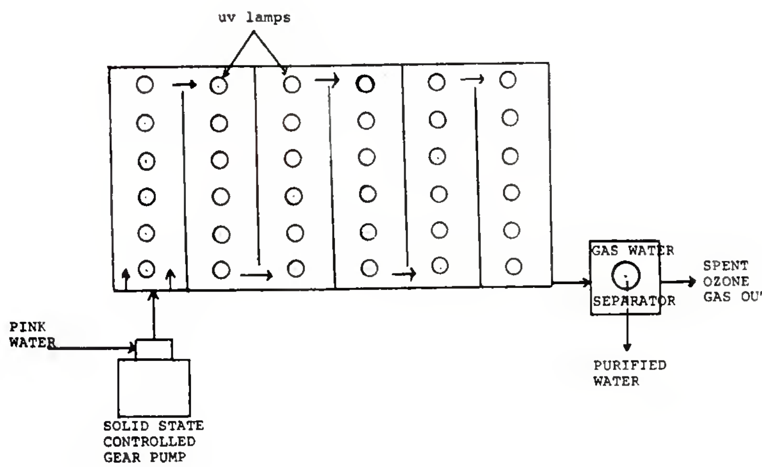


Figure 1 - Pilot Plant Reactor

The treatment of pink water by ozonolysis alone was demonstrated effective in 80% color removal on a 1-to-1 weight ratio of ozone: TNT and 93% color removal at a 1.5-to-1 ratio. This meant that either the aromatic compound present in pink water was destroyed or as a result of ozonolysis, a new compound was formed. Photolysis studies revealed that it was generally more efficient in degrading RDX than was ozonolysis. However, the combined use of UV and ozone showed a significant synergistic effect to the extent that their combined degradation rate was greater than the sum of the two individual degradation rates. The final effluent concentrations of TNT and RDX was less than 1mg/L.

BENEFITS

This task has developed and implemented the most cost effective technology to reduce a pollution problem and meet regulatory standards. Also, the use of carbon regeneration has lowered the cost of treating pink water from $7.43 per 1000 gallons to $3.48 per 1000 gallons.

IMPLEMENTATION

Carbon adsorption and regeneration is being used at Joliet, Iowa, and other AAP's.

MORE INFORMATION

To obtain additional information, contact the Program Manager, Mr. William Buckley, Jr., AV 880-4284 or Commercial (201) 328-4284.

Summary report was prepared by Mike Achord, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 581 4145 titled "Control Drying for Automated Propellant Manufacture" was completed in July 1982 by the US Army Armament Research and Development Command for a cost of $327,000.

BACKGROUND

The single-base propellant produced by the batch process was uniform in quality because of the cross blending of large quantities of propellant. The blending of propellant takes place at the end of the batch process. Time consuming acceptance tests consisted of laboratory analysis and ballistic tests.

The Continuous Automated Single Base Line (CASBL) was designed to manufacture more uniform and higher quality propellant than the batch process. The CASBL production was designed not to include an extensive cross blending operation, except for propellant produced within the same hour. The time required for laboratory analysis is excessive in comparison to the planned residence time for the propellant in the CASBL drying unit.

Good process control required the establishment of better control of moisture and volatiles content. This project was undertaken to establish instrumentation and controls so that the in-feed monitors and drying procedures would maintain uniform moisture and volatile levels. Prior efforts under Army MMT projects 57X 6557 and 576 4302 addressed some in-process and final acceptance criteria for propellant produced by continuous operations.

SUMMARY

The objective of this effort was to design, procure and evaluate a system for controlling the drying cycle for automated single-base propellant manufacture.

The CASBL process flow is indicated in Figure 1. Ether, alcohol and other chemicals are added during the dehydration, compounding and mixing operations. The air drying operation is the next to last operation.

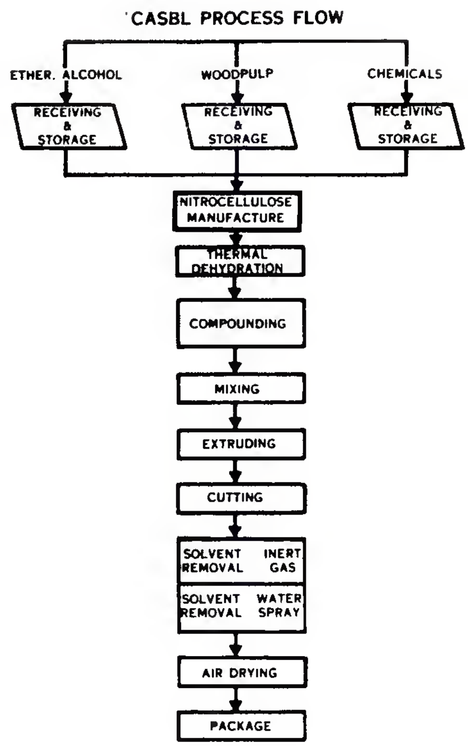


Figure 1 - Continuous Automated Single Base Line Process Flow

The approach was to review commercially available systems, procure and calibrate required instrumentation, modify selected production equipment and install and prove-out the in-feed and drying operation controls. The installation and prove-out of the instrumentation and controls will be completed under a follow-on MMT project 582 4145.

The engineering review and vendor survey determined that gas chromatographic (GC) systems would be preferred over infrared (IR) equipment for solvent recovery and water dry operations. The in-feed control instrumentation was procured and consisted of the GC system and 4 condensate flowmeters. The GC system included the on-line GC analyses of 11 liquid samples for ether, alcohol, water and on-line measurement of quantities of condensate from each solvent recovery condenser. A preliminary hazards assessment determined recommended safety improvements for the GC system.

The laboratory evaluation tested and calibrated one condensate flowmeter with a matched amplifier and totalizer. Process equipment was modified in one of the ten bays of CASBL. If all data analysis checks out well during CASBL prove-out, then the remaining bays will be modified.

Attempts to procure on-line air drying instrumentation were not successful. In addition, 12 off-line rapid moisture drying techniques or equipment were evaluated and none were considered adequate. An alternate off line testing technique, "closed bomb" test may be adequate. Data on relative quickness, relative force, and linear burning rate under varying conditions of temperature and pressure can be furnished by the "closed bomb" test.

BENEFITS

Improved process control will result from the ability to monitor the quality of the in-feed material. Other benefits are dependent on the results of the follow-on MMT effort and CASBL prove-out.

IMPLEMENTATION

This project is self-implementing at Radford Army Ammunition Plant. The procedures established under this project will be made operational in the CASBL production.

MORE INFORMATION

Additional information can be obtained from the project officer, Mr. C. McIntosh, ARRADCOM, AV 880-4123 or Commercial phone (201) 328-4123.

Summary report was prepared by Stephen A. McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 574 4169 titled "Establishment of an Improved Process to Manufacture Nitroguanidine" was completed by the US Army Armament Research and Development Command in July 1978 at a cost of $403,000.

BACKGROUND

Nitroguanidine (NQ) or picrite is a white crystalline powder that has been used by the US Army in propellant formulations since World War II. However, in 1968, the US Army was notified by the only continental source of supply, North American Cyanamid of Canada, Ltd, that manufacture of NQ would be discontinued. Consequently, to meet future requirements, studies were initiated to evaluate new methods of manufacture and to obtain data on plant design for a US military domestic manufacturing facility. Previous work, upon which this effort is a continuation, was conducted under Project 571 4169.

SUMMARY

The objective of this effort was to develop a safe, reliable and economical process which could be used as the basis for the design of a production sized facility. In order to accomplish this, two options were investigated. One option was to update the existing design for the British Aqueous Fusion (BAF) process. The other option was to complete the technical development of a process utilizing urea and ammonium nitrate (U/AN) as the raw materials. The second option had a significant economic advantage over the first option, but it was technically less developed. Therefore, a dual, simultaneous course of action was taken. The U/AN process development would be conducted on a pilot plant basis and the process engineering design would be updated. Then, at some later date, a decision would be made as to which process would be implemented.

The U/AN process, as shown in Figure 1, was investigated on a pilot plant basis at Hercules Co., Kenvil, NJ. This plant initially used silica gel as the reaction catalyst for the production of the intermediate, guanidine nitrate (GN); however, it was found to be unacceptable when exposed to feeds containing small amounts of water. Therefore, the use of a silica bead catalyst was adopted. Other problems experienced were poisoning of the catalyst due to diammonium phosphate which was used as a crystal habit modifier in ammonium nitrate, plugging of the reactor columns, and removal of the insoluble products. All of these problems were solved eventually, and the pilot facility was operated continuously for 2.5 months producing a total of 9102 kg (20,067 lbs) of GN.

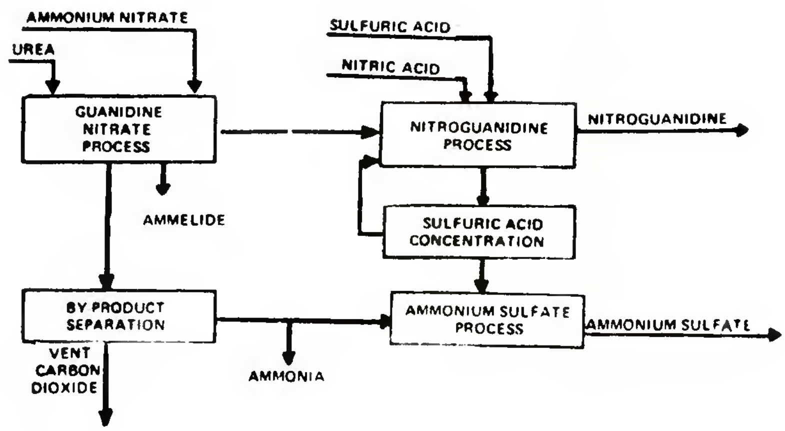


Figure 1 - Nitroguanidine Via Urea/Ammonium Nitrate Process

The GN produced by the U/AN process was converted to NQ by Cyanamid of Canada, Ltd using the standard method of dehydration with sulfuric acid. A total of 4263 kg (9400 lbs) of NQ was manufactured, meeting all applicable requirements. The NQ thus produced was then formulated into M30 triple-base propellant for ballistic evaluation. These tests demonstrated that the M30 propellant prepared with NQ, converted from the U/AN process derived GN, was ballistically equivalent to M30 propellant made with BAF process derived NQ. Also, there were no significant differences in the ignitability characteristics between the two types of propellant formulations.

Based on the successful piloting of the U/AN process and the ballistic evaluations of the propellant formulations, Picatinny Arsenal recommended the adoption of this process for a facility to be constructed at Sunflower AAP. However, the BAF process, as shown in Figure 2, was selected for facilitization at Sunflower AAP over the U/AN process because of its more advanced stage of development and the immediate need for a source of supply. The U/AN pilot plant equipment was, therefore, dismantled and stored unerected at Picatinny Arsenal.

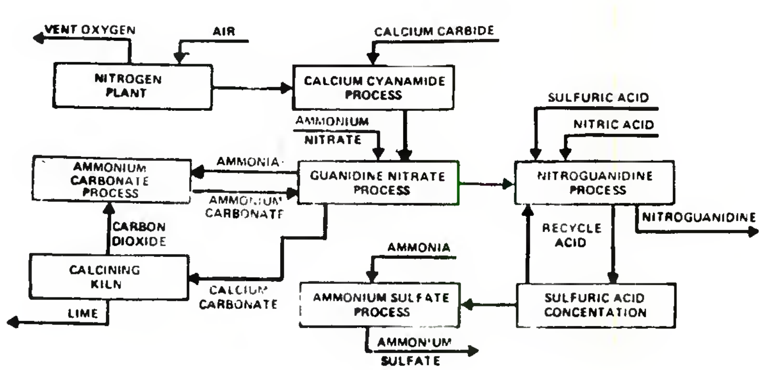


Figure 2 - Nitroguanidine Via British Aqueous Fusion Process

BENEFITS

One of the benefits derived from this project was a layaway pilot facility to provide a unit that can be readily reassembled and used as an operating training unit in the event that a production facility utilizing the U/AN technology would be needed. Also, an updated process engineering design for the BAF process was achieved.

IMPLEMENTATION

Implementation of this project was achieved through the publication of various reports dealing with the U/AN process parameters. Facilitization of this process was not accomplished because the BAF process was considered to be better suited for immediate use.

MORE INFORMATION

To obtain additional information, contact the project manager, Mr. C. Lewis, AV 880-3637 or Commercial (201) 328-3637.

Summary Report was prepared by Mike Achord, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 570 4202, 571 4202, and 572 4202 titled "Prototype Equipment for the Continuous Automated Production of Solvent-Type Multi-Base Cannon Propellant" were completed by the US Army Armament Command in August 1975 at a total cost of $3,220,000.

BACKGROUND

The batch method of manufacturing multibase propellant is of World War II vintage. It is considered hazardous and inefficient. It also requires large areas, numerous buildings, and multiple manual handling and transportation operations. To produce three million pounds of propellant requires approximately 400,000 manual handling and vehicular transportation steps. A schematic of this process is shown in Figure 1.

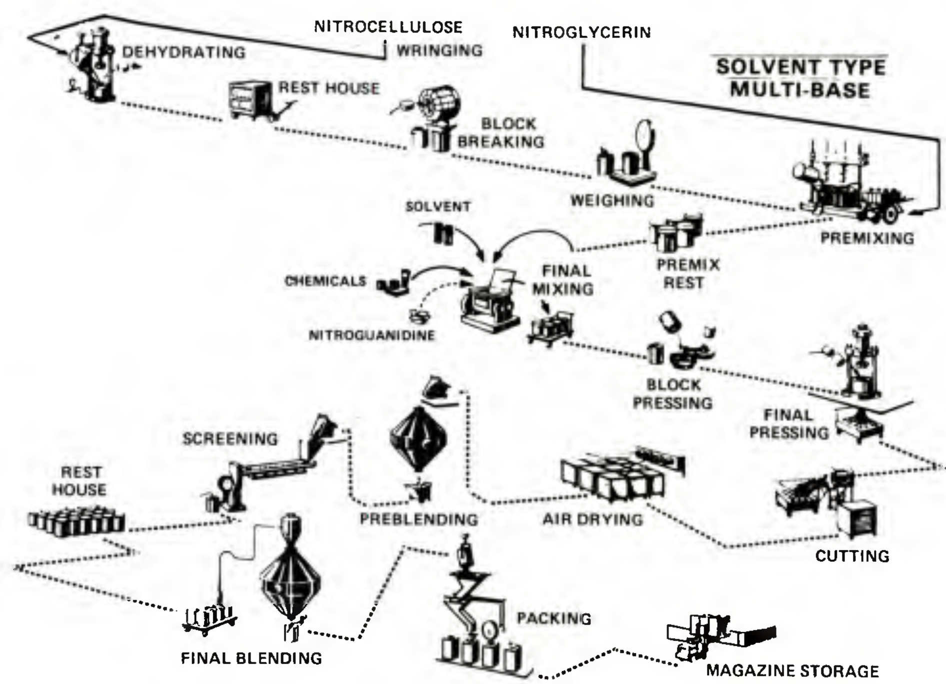


Figure 1 - Conventional Propellant Manufacture

SUMMARY

The objective of this series of projects was to establish and evaluate a continuous, automated prototype line capable of manufacturing multibase cannon propellant.

The approach was to carefully review the batch process for making cannon propellant and identify those operations which could be performed in a continuous manner. Equipment that could perform these operations was either procured or designed and fabricated. Experience and knowledge gained from a similar previous investigation of the continuous manufacture of single-base propellant was applied where possible. The initial investigations were performed on a bench scale. Information from these investigations was used to prepare the design criteria for the pilot prototype equipment. To avoid future scale up problems, this prototype equipment was sized to have a capability to meet production rates.

A pilot line pre-mixer, mixer, extruder, dryer, NG stripper column, and all of the feeder systems for solids and liquids were procured and installed along with the necessary control instrumentation. The pilot line thermal dehydrator, a conveyor system that connects the entire system, and a roll type cutter were designed. Inert runs followed by live runs were conducted on each piece of equipment. Since the conveyor system was not installed, the product from the different pieces of equipment was fed into buckets in a lazy susan type of device and manually transferred to the next operation. With the exception of one item, the performance of the equipment was satisfactory. Evaluation of the equipment in conjunction with the conveyor was scheduled for the following year.

BENEFITS

The project will provide the information needed to design a continuous and automated process line. Such a line will require less buildings, maintenance, and operating personnel. The exposure of operating personnel to hazardous materials will be reduced. The cost of producing cannon propellant will be reduced by approximately 40 per cent.

IMPLEMENTATION

The information developed by these projects were used to prepare design criteria for a production scale prototype line. The final implementation will occur in the construction of production facilities at Radford and Sunflower AAPs.

MORE INFORMATION

Additional information may be obtained by contacting the project officer, Mr. Leo P. Lempicki, ARRADCOM, AV 880-3637 or Commercial (201) 328-3637.

Summary report was prepared by Andy Kource, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 574 4215 titled, "Automating the Continuous TNT Production Facility Process Controls," was completed by the US Army Armament Research and Development Command in June 1980 at a cost of $324,000.

BACKGROUND

The most advanced technique for the manufacture of TNT at present is the continuous process system which is in operation at several Army Ammunition Plants. This system operates on a continuous basis from the initial nitration stage, through the dinitration and trinitation stages, and finally through the purification step. Process control operations consist of chemical laboratory tests on samples taken from different stages of the process. The tests are performed in a laboratory adjacent to the manufacturing lines. Since no real-time process control testing or automatic feedback exists in the present system, any corrective actions that may be necessary cannot be made until the test results are known. In a continuous system, this lapse of time between taking and analyzing a sample can allow the production of large amounts of product that do not meet specifications.

SUMMARY

The objective of this project was to establish in-line process control systems with a real-time analysis capability and automatic feedback control. Types of analysis required in TNT plants include nitric acid, sulfuric acid, nitrobody density, and composition flow rates, PH, and TNT set-points (freezing point). A flow scheme of principal process streams is shown in Figure 1.

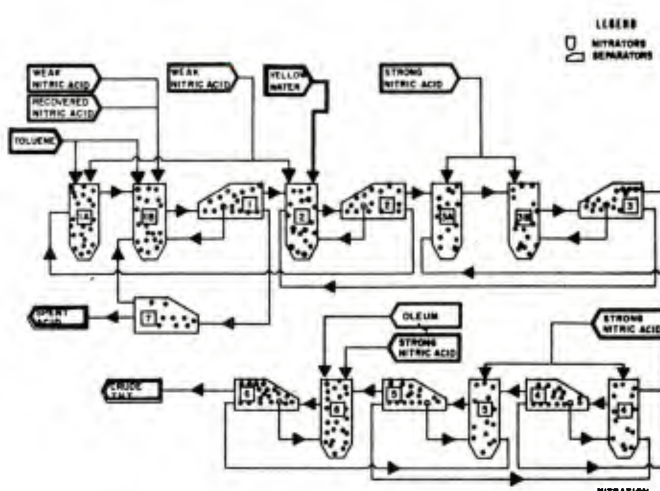


Figure 1 - TNT nitration flow scheme

Equipment was selected that would be suitable and compatible with TNT manufacturing. This equipment was to be capable of producing results equivalent to laboratory tests and versatile enough for manual, analog, or computer control. For applications where off-the-shelf equipment was not available, modifications were performed or prototypes were designed and fabricated.

The equipment was installed and evaluated for performance. Acceptance was dependent upon functionality, test accuracy, and demonstrated reliability. Several pieces required extensive evaluations to determine instrument error and reliability. Also, to establish acceptability of the instruments in TNT manufacture, the design criteria was subjected to a hazards analysis. The purpose of this analysis was to assess potential hazards in the design and correct any deficiencies to improve safety margins.

Assay results obtained from the instruments were compared with results obtained by using standard laboratory procedures. Regression analysis was performed on each set of data and correlation coefficients were calculated. In some cases, coefficients of 0.99 were obtained which indicated a strong correlation.

Accurate feed rate control requires that flow rate and density be measureable and adjustable for control of mass flow rates of acid to each vessel. Due to the corrosive nature of sulfuric and nitric acids, externally mounted gages on pipes were deemed to be the most desirable for production use. A Kay-Ray nuclear density gage was selected for this application. After its evaluation, it was concluded that it would be an excellent means for controlling flow rates, ie, acid strength control. It was also determined that eight gages would be needed for adequate process control of a continuous TNT manufacturing process such as described in Figure 1.

Three types of instruments were considered for measurement of process stream flow rates. Each used a different principal of measurement. One was a target type meter, the other an ultrasonic flowmeter, and the last, a magnetic flowmeter. The magnetic flowmeter was selected as the best candidate for process control. It measured flow by producing an emf that was proportional to the fluid velocity. It was durable, stable, and its accuracy had been proven acceptable in field testing.

The manufacture of TNT requires close control of sulfuric and nitric acids entering and departing each nitrator. An instrument that could analyze both sulfuric and nitric acid was needed. A complicating factor was that soluble nitrobodies were contained in these acid streams. These nitrobodies interfered with sample analyses and produced low results for nitric acid concentrations. An instrument suitable for on-line installation and capable of continuously monitoring the spent acid of each nitrator without interference from the nitrobodies was sought. The technique that showed promise towards meeting these requirements was liquid chromatography (LC).

The LC approach to acid analysis was found to be beneficial in determining acid concentration in the nitration vessels. This was demonstrated by operating one TNT manufacturing line for a one-week period using nitric/sulfuric data derived from an off-line LC unit. However, some electronic problems surfaced and the separation unit that had been designed to prevent nitrobodies from plugging the LC unit was found to have some design deficiencies. Both problems have to be corrected before this system can be placed on-line.

Ultraviolet (UV) spectrophotometry was investigated as an alternative method for on-line nitric acid analysis. Experiments were designed to analyze acid samples at 301 and 350 nm wavelength; however, it was found that nitrobodies in the acid interfered with the test analysis. Since nitrobodies are constantly present in the acid streams, the UV technique was rejected as a viable method for on-line process control.

The freezing point test is a vital control test in TNT manufacture. To assure that the final end product will meet the specifications for purity, frequent sampling and testing is required. Because of the labor costs involved, it was desirable to instrument a test method that would automatically sample and test the TNT during production. Laboratory studies were initiated to determine the best method adaptable to instrumental analysis for freezing point determination.

The automatic TNT freezing point analyzer that was designed, built, and evaluated did not adequately induce crystal nucleation in the TNT sample nor did it measure temperature to the required degree of accuracy. It was concluded that this prototype was not sufficiently developed for on-line operations.

BENEFITS

The results of this effort will reduce personnel exposure, reduce the time normally experienced in manual process control testing, and improved process control through automatic feedback of electrical signal outputs.

IMPLEMENTATION

Instruments successfully evaluated in this effort were installed in the restored TNT lines at Radford AAP to control acid feed rates, PH, and density. This was accomplished under Facility Project 575 5901, "Restoration of TNT Lines B & C."

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. C. McIntosh, HQ, ARRADCOM, AV 880-4123 or Commercial (201) 328-4123.

Summary report was prepared by Andy Kource, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 575 4240 titled "Investigation of Loading Amatex-20" was completed by the US Army Armament Research and Development Command in August 1978 at a cost of $3,270,000.

BACKGROUND

In a memorandum from DDR&E, dated 25 September 1969, titled "Joint Services Evaluation Plan for Preferred and Alternate Explosive Fills in Principal Munitions," the Army was directed to investigate alternate fills for "selected high use munitions" that would be commercially available in a national emergency. Amatex-20 was selected as the alternate fill for the 105mm M1, 155mm M107, and the 8 in. M106 projectiles. Previous FY74 work demonstrated that this explosive can be successfully loaded into 105mm projectiles on a pilot operation basis with the most successful composition being 40% TNT, 40% ammonium nitrate (AN) and 20% RDX.

SUMMARY

The major objectives of this effort were to investigate process-related Amatex-20 loading problems and to determine if Amatex-20 can be processed in equipment developed under the modernization program. In order to accomplish these objectives, an investigation into the loading of Amatex-20 utilizing conventional equipment was conducted along with a study of the capability of the modernized pilot line (continuous melter) at Picatinny Arsenal to handle Amatex-20. The information collected under this program would then result in the technology and data necessary for the load, assembly, and pack of Amatex-20 rounds.

Specification grade Amatex-20 flake was manufactured at Holston AAP using Composition A-7, TNT, and AN. Similar operating techniques in equipment with the same design as that employed for the incorporation of castable TNT/RDX and/or TNT/HMX compositions were used. The basic flow diagram is shown in Figure 1. From this work, it became apparent that the moisture content of AN was a critical parameter. If excessive moisture was present, either in the AN or in the Composition A-7/TNT mix, the resulting cast product would contain segregated AN in various areas. Therefore, it was found that the moisture content of AN should ideally be below 0.10% at the time of charging. In addition, the efflux viscosity was beyond specifications, but this problem could be corrected through rework. Hence, the requirements upon the process were humidity control, AN preheating, particle size restraints, and a more thorough mixing apparatus.

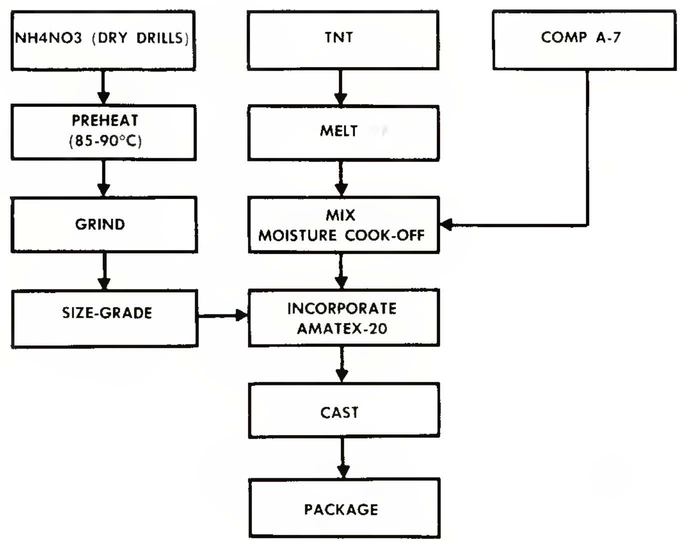


Figure 1 - AMATEX-20 Process Flow Diagram

An Amatex-20 batch loading line was set up at Iowa AAP and after initial debugging functioned successfully. Initially, 5000 rounds each of the 105mm M1, 155mm M107, and 8 in. M106 projectiles were loaded with Amatex-20 and shipped to Yuma, Panama, and Alaska for certification tests over three years. Subsequent ballistic testing of 3000 rounds produced two low order and out-of-bore downrange prematures, but investigations revealed that these were due to nose cracks in the metal part and not the Amatex-20. Shells loaded at Iowa AAP showed that new cavitation standards would be required because they did not meet current Composition B requirements.

Efforts conducted in the areas of packaging designs and adaptation to the modernized line were continued under the FY76 Manufacturing Methods and Technology project of the same title.

BENEFITS

Composition B is the Army preferred fill for artillery HE bursting projectiles with TNT as an approved alternate. However, in establishing mobilization explosive production facilities, additional TNT lines would be needed resulting in an unbalanced explosives base. This project provided the technology to use Amatex-20 to relieve such an imbalance.

IMPLEMENTATION

Implementation was deferred until completion of the FY76 effort.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. P. Skerchock, AV 880-4252 or Commercial (201) 328-4252.

Summary report was prepared by Mike Achord, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 576 4240 titled "Investigation of Loading Amatex-20" was completed by the US Army Armament Research and Development Command in August 1978 at a cost of $750,000.

BACKGROUND

This effort is a continuation of the studies to investigate process related Amatex-20 loading problems. Previous work conducted under Project 575 4240 demonstrated the use of conventional equipment for loading Amatex-20. In addition, preliminary investigations into the capability of the continuous melt-pour line at Picatinny Arsenal to handle Amatex-20 and packaging designs for Amatex-20 were conducted.

SUMMARY

The major objective of this effort was to determine if Amatex-20 could be processed in equipment developed under the modernization program. To accomplish this objective, the continuous melt-pour line at Picatinny Arsenal, Figure 1, was further studied in relation to the problems of hygroscopicity, pour characteristics, corrosiveness, and riser recovery associated with Amatex-20.

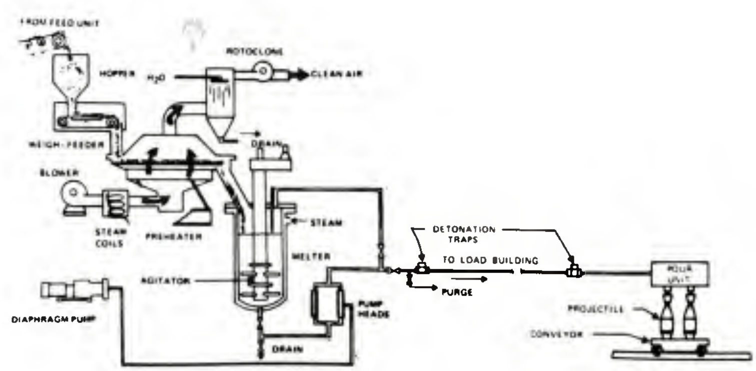


Figure 1 - Continuous Melt-Pour Line at Picatinny Arsenal

In relation to the problem of moisture content control due to the hygroscopicity of Amatex-20, a continuation of the packaging design studies, initiated during the FY75 effort, was undertaken. Efforts were directed towards limiting the moisture content of Amatex-20 to 0.2% during shipment or storage prior to use. Accelerated testing in a temperature/humidity chamber was conducted on several design packages. Results indicated that all of the experimental design packages were acceptable for use, with the most acceptable for short term storage being a modified Composition B design package.

Amatex-20 was successfully processed through the continuous melt-pour equipment including conveyor, weigh feeder, and melter at Picatinny Arsenal. However, prior to initiation of this process, parts containing copper or zinc had to be replaced. This was due to the chemical reaction of Amatex-20 with these metals; in the former case, it formed an explosive compound and in the latter, it caused corrosion. Additional problems encountered included the Pulsafeeder pump and the TNT/solids mixer. The pump was not suitable for molten Amatex-20 due to its different fluid characteristics. An alternate pump (air operated, double diaphragm) was evaluated but produced equally poor results. The TNT/solids mixer was inadequate because of a lack of proper control. Therefore, both concepts were terminated.

Design parameters were established for a dry mechanical crushing process to reduce the size of Amatex-20 risers for re-use. Crushing rates of 2000 pounds/hour were achieved. The resulting size for 85% of the material was between 0.25 and 1.5 inches with remaining fines being pelletized. All of the riser product was acceptable for re-use.

Conceptual production layouts from the FY75 effort were completed at Holston AAP. These included necessary system changes for the manufacture and/or processing of Amatex-20. Included were apparatus and site drawings, building arrangements, and cost estimates.

BENEFITS

The benefits of this project were not realized because of a special In-Process Review held on 23 February 1977 at the US Army Armament Research and Development Command which found that it was more cost effective to continue to use TNT as the approved alternate fill. Therefore, no further process development was undertaken.

IMPLEMENTATION

There will be no implementation as a result of this project; however, technical reports on the Amatex-20 technology are available at the US Army Armament Research and Development Command.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. P. Skerchock, AV 880-4252 or Commercial (201) 328-4252.

Summary report was prepared by Mike Achord, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 579 4285 titled "TNT Equivalency Testing in Support of Safety Engineering for Ammunition Plants" was completed by the US Army Armament Research and Development Command in June 1981 at a cost of $416,000.

BACKGROUND

The US Army has been involved in a continuing program to upgrade the safety standards of new and existing ammunition plants. In support of this program, design standards are developed for hardening protective structures to withstand the effects of the detonation of high explosives. Design and safety engineers require data pertinent to the maximum strength of a blast wave that may originate from any of the explosive or deflagratable materials present in a plant. Since blast parameters were not available from the literature on certain explosives and propellants, efforts were needed to establish TNT equivalencies of these materials. By utilizing this data, significant cost savings could be achieved by avoiding over-design of structures and safety of personnel improved by the installation of adequate blast protection. During the FY78 project, tests were conducted on bulk nitrocellulose, LX-14, composition A-3, and ball powder WC844.

SUMMARY

The purpose of this project was to generate peak pressure and positive impulse data from blast measurements on the 155MM M483 projectile, M42 grenade tray, HMX, and Composition C-4. The results were compared to the blast output of surface bursts of hemispherical TNT and the TNT equivalency of the material was calculated. The following summarize the results on some of the materials evaluated:

<u>155MM M483 Projectile and M42 Grenade Tray</u> - The M483 projectile is composed of eight layers of M42 grenades and three layers of M46 grenades for a total of 88 grenades (eight grenades to a layer). Each grenade contains 31 g (.068 lb) of composition A5 explosive for a total of 2.71 kg (5.98 lb) of explosive in each projectile. The grenades are pressed into the projectile one layer at a time until the full complement of 11 layers has been loaded. All 11 layers are not pressed at one station; therefore, the typical facility consists of several pressing stations with projectiles being conveyed from one station to another in various stages of completion. The explosives at each station are essentially in two configurations. In addition to M483 projectiles (either partially or completely loaded) there are trays of M42 and/or M46 grenades.

The explosive overpressure which would be generated by an accident in a cubicle, was calculated for each cubical configuration and their equivalent weights of hemispherical TNT totaled to achieve a design charge weight for that cubicle. The airblast output was evaluated for both the projectile, M483 (single rounds) and trays of M42 grenades (64 each) as shown in Figure 1.

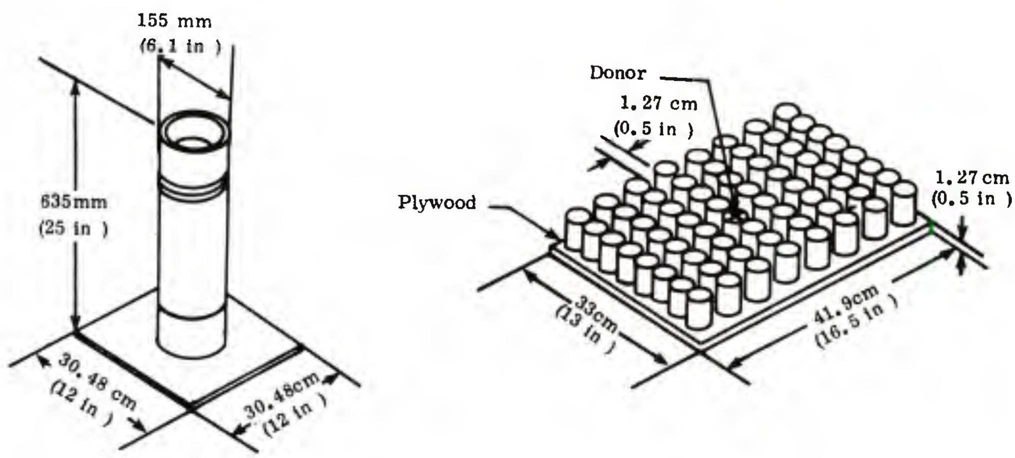


Figure 1 - M483 Projectile (left) and M42 Grenade Tray Configuration (right)

Single M483 projectiles were placed vertically with the nose pointed downward on a steel witness plate with dimensions of 30.5 by 30.5 by 1.91 cm (12 by 12 by 0.5 in). To enable the projectile to be held upright, a hole slightly smaller than the diameter of the round was cut in the witness plate to allow the nose cavity to protrude into the ground approximately 20.3 cm (8 in). Three bundles of 48 each 2.44 by 1.22 by 0.0127-m (8 ft by 4 ft by 1/2-in) cellulose fiber panels were placed at 90° and 45° from the test charge to gather fragmentation data from each of the three test charges fired. The projectile was primed after removing the M10 expulsion charge and removing the most centrally located grenade of the top layer and replacing it with an unfuzed M42 grenade. A J2 blasting cap was inserted in the fuze well cavity and initiated remotely.

A grenade tray constructed from 0.95-cm (3/8-in) plywood was filled with 64 M42 unfuzed grenades and placed on a steel witness plate. The grenade tray was primed by placing a J2 blasting cap in the most centrally located grenade and initiated remotely.

For the M438 projectile, the pressure TNT equivalency was generally equal to or greater than 100% at all scaled distances; whereas, impulse equivalency was greater than 100% at the near field distances and less than 100% beyond far field distances. The pressure values for the M42 tray test indicate that the TNT equivalency was less than 100% at the near field distances and greater than 100% beyond far field distances. Impulse values were less than 100% at all distances.

Cyclotetramethylenetetranitramine (HMX) - The HMX was received from Holston AAP wetted with isopropyl alcohol. The TNT equivalency tests were conducted with storage containers which are used at specific locations in a HMX manufacturing facility. These containers were the transfer container (Nutsche) and the cylindrical shipping container. The weight of HMX in these containers is 544.3 kg (1200 lb) and 90.7 kg (200 lb) respectively. These weights were scaled down for this test series to minimize material requirements as well as to assure compliance with the range charge weight limitation.

Each test charge was initiated with a conically shaped booster of composition C4 centered on top of the HMX in the simulated Nutsche container and shipping drum with a J2 blasting cap inserted at the apex and embedded to the center of the cone. The test charge for each configuration was placed on a 1010 carbon steel witness plate 1.27 cm (0.5 in) thick with the outside dimensions 5.08 cm (2 in) larger than the base of the test container dimensions.

The pressure equivalencies of HMX were greater than 100% at the near-field scaled distances and varied above and below 100% at the far-field scaled distances. Impulse equivalencies varied significantly above and below 100% at the near-field scaled distances and below 100% at the far-field scaled distances. Test results indicated that pressure and impulse values were dependent upon container geometry and scaled according to the cube root of the charge weight.

BENEFITS

This project provided TNT equivalency data which, when used with DARCOM R 385-100 and TM5-1300, enables the designer to design walls that will safely resist the blast effects of an accidental explosion of the materials tested. Considerable cost savings can be realized through the use of the data developed.

IMPLEMENTATION

The results published in technical reports were distributed to AAP's, Corps of Engineers, other design agencies, and various other safety echelons for use in conjunction with TM5-1300. The designer will be able to calculate loads on protective walls readily for the energetic material in question.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. J. Marsicovete, AV 880-3906 or Commercial (201) 328-3906.

Summary report was prepared by Pete Martin, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 580 4285 titled "TNT Equivalency Testing for Safety Engineering" was completed by the US Army Armament Research and Development Command in August 1982 at a cost of $407,600.

BACKGROUND

The US Army has been involved in a continuing program to upgrade the safety standards of new and existing ammunition plants. In support of this program, design standards are developed for hardening protective structures to withstand the effects of the detonation of high explosives. Design and safety engineers require data pertinent to the maximum strength of a blast wave that may originate from any of the explosive or deflagratable materials present in a plant. Since blast parameters were not available from the literature on certain explosives and propellants, efforts were needed to establish TNT equivalencies of these materials. By utilizing this data, significant cost savings could be achieved by avoiding over-design of structures and safety of personnel improved by the installation of adequate blast protection.

During the FY79 project, tests were conducted on the 155mm M483 projectile, M42 grenade tray, HMX, and Composition C-4. TNT equivalencies were determined from these data.

SUMMARY

The objective of this project was to obtain TNT equivalency ratings for selected high energy materials. This was accomplished by determining the peak pressure and positive impulse data from blast measurements and converting the data into TNT equivalency values.

Tests were conducted on D1GL-RP propellant (I5420, I5421, I5422), JA-2 propellant (L5460), Cyclotol 70/30, RDX, and PBXC-203. The tests resulted in the establishment of pressure and impulse curves from the materials detonated.

The TNT equivalency was then computed based on comparison with TNT hemispherical surface bursts. The following paragraphs summarize the results on some of the materials evaluated:

JA-2 (L5460) Propellant

This material was a multi-perforated, solventless high-force propellant composed of nitrocellulose, diethylene glycol dinitrate, nitroglycerin, akardite II, magnesium oxide, and graphite. This German composition, processing, and packaging was to be transposed into US mass production techniques. The propellant will be used in the 120mm round and was tested as a requirement for facility modification. JA-2 propellant was detonated in configurations simulating the cylindrical shipping drum and the dryer bed typical in a manufacturing facility.

Tests results indicate that pressure and impulse values were dependent upon geometric configuration and length and height to diameter of charge. The pressure and scaled impulse equivalencies were greater than 100 percent for the simulated shipping container in all charge weights at all scaled distances, except at 15.87 m/kg$^{1/3}$ (40.0 ft/lb$^{1/3}$). For the simulated dryer bed configuration, with a charge weight of 49.90 kg (110 lb), the detonation was complete. Pressure equivalencies were greater than 100 percent except at a scaled distance of 3.57 m/kg$^{1/3}$. Impulse equivalencies were greater than 100 percent except at the scaled distance of 15.87 m/kg$^{1/3}$ (40.0 ft/lb$^{1/3}$).

Cyclotol 70/30

Cyclotol 70/30, a high explosive with a nominal composition of 70 percent RDX and 30 percent TNT, was detonated in configurations representative of the hopper configuration at the end of the casting belt, the transfer box, and shipping container typical in a manufacturing facility.

The amounts of Cyclotol 70/30 in these configurations were 113.4 kg (250 lb), 635 (1400 lb), and 27.22 kg (60 lb), respectively. The large weight contained in the hopper and the transfer box configurations was scaled down for these tests. The explosive was tested in the dry form since it represented the more sensitive condition.

The results obtained indicated that the pressure equivalencies were greater than 100 percent at the near-field scaled distances 3.57 m/kg$^{1/3}$ (9.0 ft/lb$^{1/3}$) for all configurations, and varied above and below 100 percent at the far-field scaled distances $\geq$7.14 m/kg$^{1/3}$ (18.0 ft/lb$^{1/3}$). Impulse equivalencies varied for each test series and were greater than 100 percent for all configurations at scaled distances $<$ 3.57 m/kg$^{1/3}$ (9.0 ft/lb$^{1/3}$) and varied above and below 100 percent at scaled distances $\geq$ 3.57 m/kg$^{1/3}$ (9.0 ft/lb$^{1/3}$). Test results indicated that pressure and impulse values were dependent on geometry and scaled according to the cube root of the charge weight.

RDX

High explosive RDX was detonated in scaled down configurations representative of the transfer container (Nutsche) and the shipping container typical in a manufacturing facility.

The quantities of RDX tested were 22.68 kg (50 lb), 27.22 kg (60 lb), and 54.43 kg (120 lb). The typical charge placement is shown in Figure 1. Each test charge was initiated with a J2 blasting cap and a conically shaped booster of composition C4 high explosive. The C4 was centered on top of the RDX in the simulated Nutsche container and shipping drum and the blasting cap inserted at the apex and embedded in the center of the cone. Pressure transducers were mounted on the witness plate to measure blast pressures.

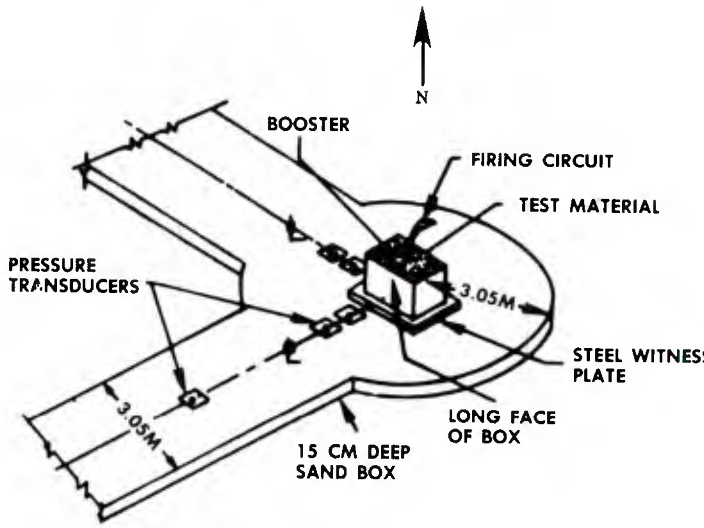


Figure 1 - Typical Charge Placement for Equivalency Tests

The test results indicated that pressure and impulse values were dependent upon geometry (transfer container versus shipping container) and, to within experimental error, scaled according to the cube root of the charge weight. These high equivalency results are consistent with tests performed on C4 and A3 which contain high percentages of RDX. It is recognized that charge shape has a significant effect on airblast parameters. Studies of cylinders, spheres, and hemispheres show the equivalency to be variable with scaled distance. Airblast measurements from spherical and hemispherical surface bursts of TNT are well documented in many other literature sources concerning airblast phenomenon. In comparing the RDX airblast measurements to TNT hemispherical data it should be noted that pressure and impulse changes are relatively insensitive to weight changes ($Z \approx 1/w^{1/3}$), however equivalent weights amplify the pressure (or impulse) differences.

BENEFITS

This project provided TNT equivalency data which, when used with DRMCR 385-100 and TM5-1300, enables the designer to design walls that will safely resist the blast effects of an accidental explosition of the materials tested. Considerable cost savings can be realized through the use of the data developed.

IMPLEMENTATION

The results published in technical reports were distributed to AAP's, Corps of Engineers, other design agencies, and various other safety echelons for use in conjunction with TM5-1300. The equivalency results using TNT as a basis can be converted readily to overpressures and impulses since the design data in the manual is based upon TNT curves. This enables the designer to calculate loads on protective walls readily for the energetic material in question.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. J. Marsicovete, AV 880-3906 or Commercial (201) 328-3906.

Summary report was prepared by Pete Martin, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 579 4288 titled "Explosive Safe Separation and Sensitivity Criteria" was completed by the US Army Armament Research Development Command in June 1981 at a cost of $637,500.

BACKGROUND

This project is a continuation of a multi-year effort to develop safety criteria that can be used as a basis for the design of all future explosive production facilities. At the present time, an Army-wide modernization program is underway to either upgrade existing or develop new explosive manufacturing and load-assemble-pack (LAP) facilities. This effort will enable the US Army to achieve increased production cost effectiveness along with improved safety as well as to provide manufacturing facilities for new weaponry with existing facilities. The prior year's effort in FY78 consisted of studies to determine safe separation of explosive end items such as 155mm M483 HE projectiles, nitroguanidine, and flaked TNT. The effort described here will emphasize studies in safe separation distances and sensitivity of explosives and projectiles.

SUMMARY

The objectives of this project were to establish the safe separation of explosive end items, in-process materials, and establish the sensitivity of explosives at various stages of the manufacturing process to primary and secondary fragment impact. Project accomplishments for this effort were numerous, and the following paragraphs provide examples of work accomplished on specific items and explosives.

A test program was implemented to determine the safe spacing of 155mm M795 HE projectiles under simulated loading plant conditions, so that the effects of a major unscheduled detonation on the assembly line would be limited to and not propagated beyond the immediate area and/or loading bay. Initially, the minimum non-propagation distance between adjacent projectiles was established by utilizing various donor-to-acceptor centerline distances.

Each test layout consisted of one donor and two acceptor projectiles arrayed in a straight line and raised off the ground to simulate the conveyor system's average height above the building floor as shown in Figure 1. The center specimen served as the donor while the projectiles at either side served as the acceptor specimens, thus producing two acceptor sets of test data results for each test donor detonated.

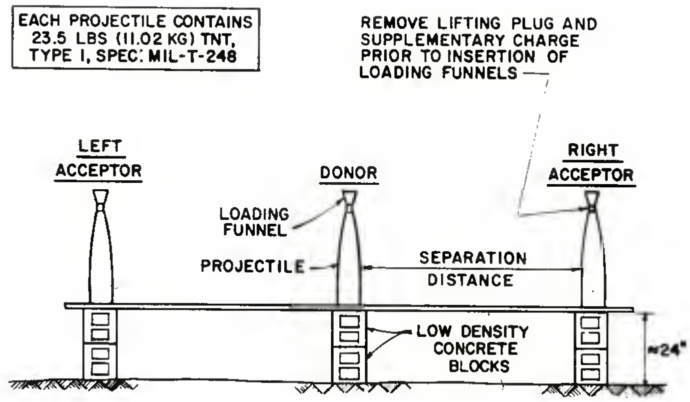


Figure 1 - Projectile Test Layout

The test array of three unfuzed 155mm M795 HE projectiles were arranged in a vertical (nose up), linear position, and mounted on a 2.54- by 15.24-centimeter (1.0- by 6.0-inch) pine board to simulate the conveyor system. The test projectiles were supported by low density concrete blocks (two under each donor and acceptor projectile) approximately 45.7 centimeters (18 inches) above the existing terrain to again fully simulate the LAP facility's conveyor system.

It was concluded from the results of the 155mm M795 HE projectile non-propagation tests that the safe separation distance between adjacent single projectiles with loaded casting funnels was 4.57 meters (15.0 feet). At this distance, the probability of the propagation of an explosive incident was 7.11 percent at the 95 percent confidence level.

The primary objective of the next project segment was to determine, by experimental testing, the safe non-propagation separation distance between various configurations of 155mm M549 HERA projectiles during transport between LAP operations on continuous feed conveyor systems. The data derived from this project segment would be utilized to establish criteria for unit spacing on conveyors, conveyor speeds, and production rates for the manufacture of 155mm M549 HERA projectiles.

The test program consisted of two portions, each utilizing an exploratory phase and an ensuing confirmatory phase to establish statistical confidence. The first portion utilized single 155mm M549 HERA projectiles in a line, raised above terrain level to simulate the conveyor system's stand-off distance. The second portion utilized pallets containing eight 155mm M549 HERA projectiles arranged in a 2 by 4 matrix, again in a line and raised above the terrain level to simulate the conveyor system's stand-off distance. This latter portion utilized loading funnels filled with Composition B inserted into each projectile.

The test results of the single projectile phase indicated that the unshielded safe separation distance between projectiles was 1.5 m (5.0 ft). If a shield, consisting of a single 7.6-cm (3.0-in) diameter aluminum (6061-T6) rod, was positioned vertically in a straight line halfway between the projectiles on a conveyor system in existing loading plants, the safe separation distance was 8.9 cm (3.5 in). For the palletized projectile tests, the safe separation distance between pallets was 3.1 m (10.0 ft), utilizing a shielding arrangement consisting of two 7.6-cm (3.0-in) diameter aluminum (6061-T6) bars on each end of the pallets aligned with the projectile's centerline.

The purpose of the final program segment was to obtain the safe separation criteria for in-plant activities involving bulk explosives and explosive-filled ordnance related to the manufacturing and assembly of BLU bomblets. The tests were carried out to simulate, as closely as possible, actual processing activities. They demonstrated that maintenance of specific separation distances can minimize property damage and reduce the probability of propagation resulting from a detonation.

The following test results were indicated: The transport of 27.3 kg cyclotol in cardboard containers required a safe separation of 5.5 m. If the cyclotol was in 3 mm thick 6061-T6 or 7075-T6 aluminum boxes, the safe separation distance exceeded 8.2 m. If the aluminum boxes were shielded with 9 mm of kevlar bonded to the containers, the safe separation was reduced to 7.3 m. The BLU-63 A/B hemispheres in pouring trays can be conveyed safely in intimate contact as long as the riser was limited to 2.0 kg of explosive.

BENEFITS

This project developed new safety criteria which was integrated into safety regulatory documents (DMCR-385-100) to permit construction of both functional and safe munitions manufacturing facilities. It will place safety requirements on a cost effectiveness basis without sacrificing safety, by the application of information derived from realistic testing, rather than engineering judgment.

IMPLEMENTATION

The safe separation distance data developed from this project was applied to the design on the LAP line at Mississippi AAP. The information was also applied to existing LAP lines at Milan AAP, Lone Star AAP, and Kansas AAP.

MORE INFORMATION

Additional information on this project is available from Mr. R. Rindner, ARRADCOM, AV 880-3828 or Commercial (201) 328-3828.

Summary report was prepared by Pete Martin, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY
PROJECT SUMMARY REPORT
(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 576 4301, 57T 4301, and 577 4301 titled, "Acceptance Plan for Continuously Produced Multi-Base Cannon Propellant (CAMBL)," was completed by the US Army Armament Research and Development Command in March 1981 at a cost of $1,028,000.

BACKGROUND

Current acceptance plans for multi-based cannon propellants are inadequate because they are based on ballistic firing with not enough thought given to controlling source materials and "in-process" variables.

This project is supplementary to, but independent from, Projects 573 4202 (design of CAMBL) and 579 2875 (Construction of CAMBL at Radford). It represents an effort to improve the accuracy and rapidity of assessment and insure desired quality by identifying and controlling all important source material and process parameters.

In addition to the previously mentioned projects, Project 575 4186 titled, "Acceptance of Propellant Produced Via the Continuous Process," addressed single base propellant produced from the Continuous Automated Single Base Propellant Line (CASBL).

SUMMARY

The purpose of this project is to minimize dependency on ballistic firing. This objective can be achieved by the following:

1. Establishing mathematical relationship between end item performance (in the gun) and propellant properties.

2. Translating (mathematically) these propellant properties into source material and process.

3. Designing and procuring prototype test instrumentation and equipment.

The first year's effort (FY 76 & 7T) involved the theoretical development of ballistic and process prototype (Dyna) models to determine properties of multi-base propellant which must be controlled to assure ballistic homogeneity and preclude the need for final blending.

The second year's effort (FY77) was primarily devoted to the verification of the model relationship by manufacturing propellant with process controls purposely varied. The samples from these runs were laboratory tested and finally ballistic gun firings were conducted. Figure 1, shown below, is the initial prototype Alpha-dynagun. Figure 2 is a photo of the second version completely built Beta-dynagun.

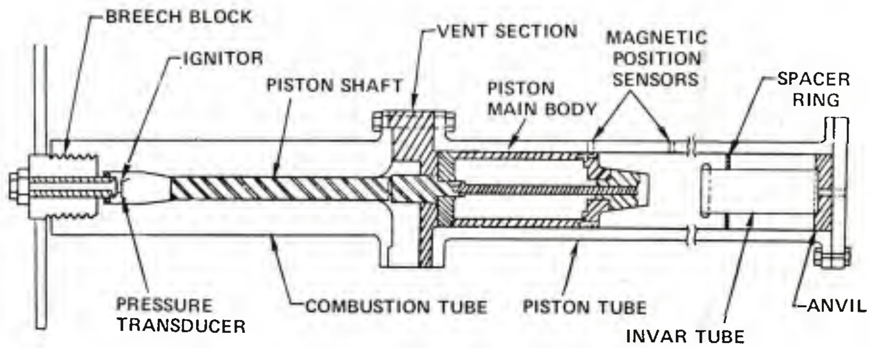


Figure 1 - Detail of Alpha-dynagun

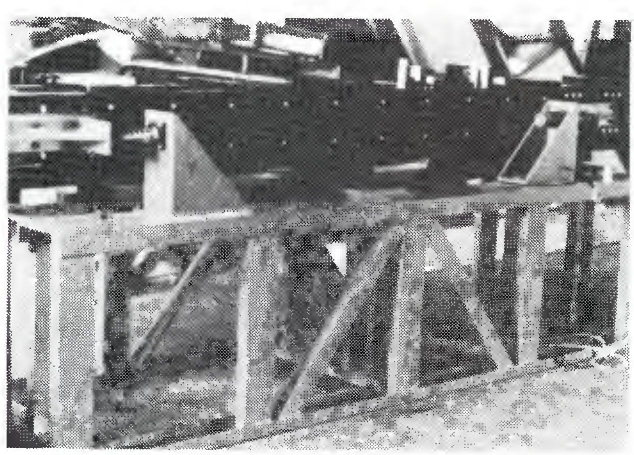


Figure 2 - Beta-dynagun

The results of this project produced the following additional information.

- o Additional testing techniques have been successfully developed for rapid determination and control of product parameters that influence the quality and measure the chemistry of finished product.

- o Computerized test techniques will allow rapid retrieval of test data for use in the continuous evaluation and control of propellant produced by the CAMBL.

- o Investigation revealed that the die pin sizes (perforation diameters), propellant densities, propellant plasticizer and NC content had significant influence on the quality of finished propellant.

BENEFITS

With successful completion of this program, cost savings at RAAP were achieved by changing the testing and quality assurance programs presently being used for the batch method of manufacture to the new techniques and QA Plan for the continuous process. The processing of 2.4 million pounds/month of M30 propellant has saved approximately $90,000 per year with a potential of other peacetime savings totaling $180,000. Mobilization savings have been estimated at $1,300,000 per year.

IMPLEMENTATION

Results of this study have been implemented by changes to the Tech Data Package.

MORE INFORMATION

To obtain more information, contact the project officer, Mr. G. Silvestro, ARRADCOM, AV 880-5486.

Summary report was prepared by T. Locke, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 578 4322 titled, "Design Criteria and Systems Characterization of Electronically Controlled Production Facilities," was completed by the US Army Armament Research and Development Command in August 1980 at a cost of $185,000.

BACKGROUND

Industrial electronic control systems are essential components of the munitions production base facilities. Production requirements are such that the facility life cycle includes active periods and extended periods (1 year to 10 years or more) of complete shutdown and inactivity. Modern Army facilities in an inactive status must be capable of reactivation to full production on 4 months notice. Industrial experience or data in the public domain on the degradation of industrial electronics, while stored or mothballed did not exist prior to this effort.

This effort was undertaken to establish guidelines for the reactivation of existing facilities, and to establish design criteria for future systems. There were no prior efforts of a similar nature.

SUMMARY

The objective of this effort was to establish a data base, guidelines and methodology to improve the Army's production readiness. This baseline of information will aid the procurement, prove out, and maintenance of electronic process control systems. The approach was to select a model facility, Joliet Army Ammunition Plant (JAAP) and establish a procedure for controlled deactivation and reactivation on a 6 month cycle. Production line #16 for TNT manufacture at JAAP was inactive from April 1978 except for a typical 2 week reactivation period every 6 months. A Test and Evaluation Plan was established detailing the procedures for: (1) starting the electronic process control systems (EPCS), (2) measuring parameter data to assess the operational integrity of the system, and (3) establishing proper shut down procedures for the EPCS.

Based on the successful reactivation cycles at JAAP, a similar program was planned for production lines at 8 other Army Ammunition Plants.

A Test and Evaluation plan detailing the methodology of assessing the operational integrity of EPCS was developed. The Test and Evaluation Plan was followed for five reactivations at JAAP. Data was recorded and analyzed on EPCS performance.

Failure analysis and replacement was completed on failed electronic components. The modes of failure of electronic control systems due to dormant storage are illustrated in Figure 1.

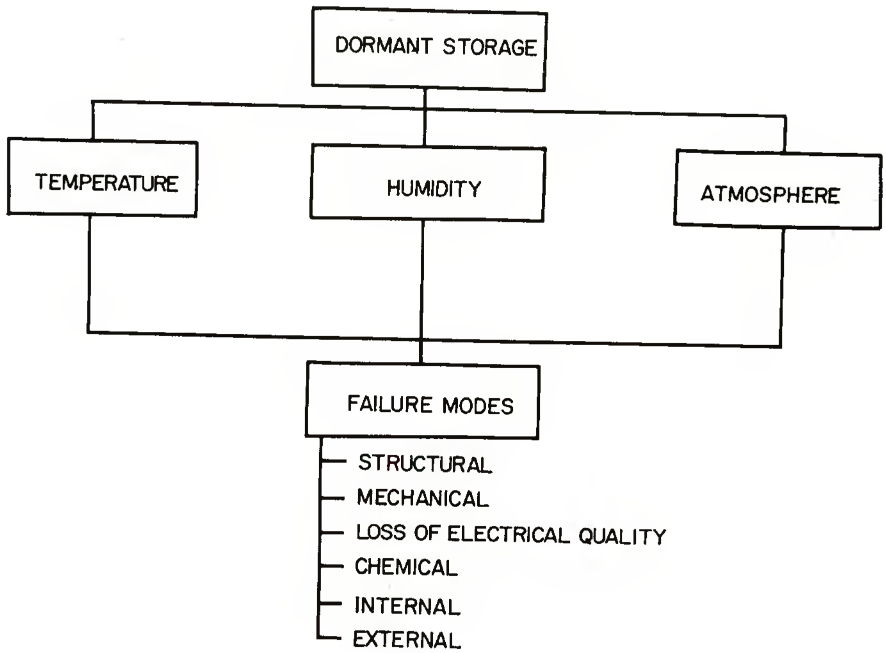


Figure 1 - Modes of Failure Due to Dormant Storage

A User Adapted Startup Manual was prepared in conjunction with the Human Factors Engineering Lab. The User Adapted Manual and a Testing and Calibration Manual were used by a third party to start-up the EPCS at JAAP. A methodology for cross referencing and indexing EPCS documentation was established. An example from the Test and Calibration Manual is illustrated in Figure 2.

BENEFITS

The results from this project have improved the readiness posture of line #16 at JAAP. The results from this project have also been applied to generate a methodology that is applicable to other Army Ammunition Plants.

IMPLEMENTATION

The results of this project were applied to MMT Project 579 4322. Work is now in progress to extend the methodology established under this project to appropriate production lines within the Army Industrial Base.

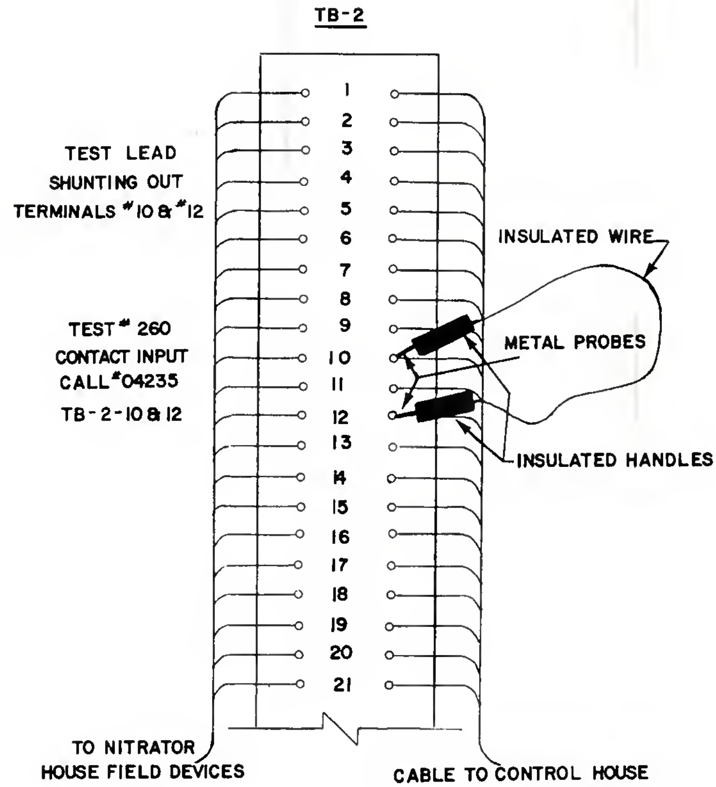


Figure 2 - Test and Calibration Example

MORE INFORMATION

Additional information can be obtained from the project officer, Mr. William Doremus, ARRADCOM, AV 880-3084 or Commercial (201) 328-3084.

Summary report was prepared by Stephen A. McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 579 4322 and 580 4322 titled "Design Criteria and Systems Characterization of Electronically Controlled Production Facilities" were completed by the US Army Armament Research and Develoment Command in July 1982 at a cost of $1,123,000.

BACKGROUND

Industrial electronic process control systems (EPCS) are essential components of the ammunition production base. The EPCS controls an automated production line and can consist of sensors, controllers, computers, interfaces, microprocessors and software. Production requirements are such that a facility life cycle includes active periods and periods of inactivity. The periods of complete shutdown or inactivity can extend from one year to 10 years or more. Modern Army facilities in an inactive status must be capable of reactivation to full production on four months' notice.

Industrial experience or data on the degradation of industrial electronics which have been stored or mothballed did not exist in the public domain prior to this effort. This effort was undertaken to establish guidelines for the reactivation of existing facilities and to establish design criteria for future systems.

SUMMARY

The objective of this effort was to establish a data base, guidelines and a methodology to improve the readiness of the Army's ammunition production base. This baseline of information will aid the procurement, prove out, and maintenance of electronic process control systems. Under the prior project, trinitrotoluene (TNT) production lines at Joliet and Volunteer AAP's were used as test sites. These 2 lines were deactivated or put into layaway after a baseline of health was established. After shut down, the lines were cycled at periodic intervals. Each cycle consisted of start-up, check-out, and shut-down. During each cycle, the EPCS was repaired, recalibrated and tested such that an acceptable baseline state of health was assured. As a result of the application of the methods established by the prior effort, these 2 TNT lines have experienced minimal start-up and repair times. The reactivation times for the EPCS for these 2 lines are well within the mobilization readiness requirement.

Based on the success with the 2 TNT lines, the effort was extended to other types of Army ammunition production facilities. The second sampling of facilities addressed the EPCS's used to control metal parts manufacture, the load assembly and pack operations, small caliber ammunition manufacture, and

other propellant and explosive operations. A result from this effort is the establishment of a generic methodology for the Layaway and Mobilization Plan (LAMP) of a EPSC which is illustrated in Figure 1.

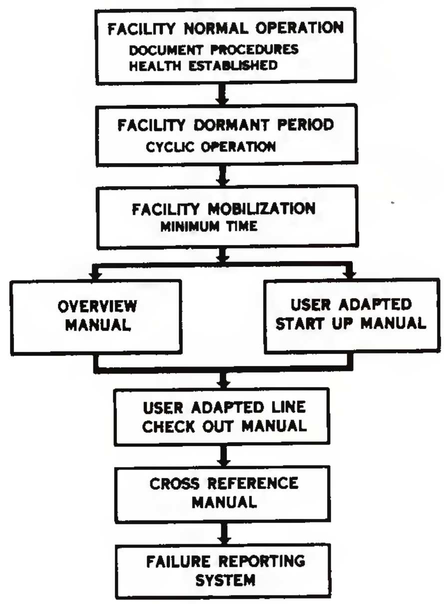


Figure 1 - Layaway and Mobilization Plan (LAMP) Electronic Proeess Control System

The LAMP methodology for an EPCS includes: baseline techniques, failure and defect reporting, user adapted step by step procedure, cross reference methods, documentation orientation and structure, skills registers, reliability assessments, and spare parts and environmental control. These methods were proven out using the Third Party Operability (TPO) concept which uses structured procedures and permits competent but unfamiliar personnel to utilize the EPCS in a relatively short time.

BENEFITS

The LAMP methodology can minimize mobilization times. The TPO concept as applied in the LAMP methods can minimize problems associated with personnel, contractors, documentation and other resources, and can improve normal operating efficiency. The methodology established by this effort allows for the employment of a common procedure among Army facilities. This common procedure appropriately applied could promote a Army corporate approach to readiness and could provide a Government overview of the EPCS's.

IMPLEMENTATION

The procedures established in this effort are being used to aid in the design of new systems and in the maintenance of existing systems. The requirements for new EPCS's are being designed under an OMNIBUS program to establish criteria for new production facilities. Existing Government owned systems are being addressed by layaway project 582 8242. The LAMP methodology is planned to be applied to 19 EPCS's which control 30 production lines at eight different Contractor Operated Army Ammunition Plants.

The Government Accounting Office has endorsed the application of the LAMP methodology to existing and planned EPCS's.

MORE INFORMATION

Additional information can be obtained from the project officer, Mr. William Doremus, ARRADCOM, AV 880-3835 or Commercial (201) 328-3084. Many documents have been prepared under this effort as indicated by the following list and will be summarized in the final technical report.

	TITLE	INPUT	DATE
1.	Maintenance of Electronic Process Control Systems Under Dormant Conditions	Saddlebrook, NJ	Feb 82
2.	Report on Study of Dormancy Effects on Reliability of Electronic Process Control Systems	Reliability Analysis Rome Air Dev. Center Griffiss AFB, NY	May 81
3.	User Adapted Start Up Procedure for DDC System at Joliet AAP	ARRADCOM Dover, NJ	Jan 80
4.	Documentation Index/Cross Reference Guide for DDC System at Joliet AAP for Use With User Adapted Start Up Manual	ARRADCOM Dover, NJ	Sept 80
5.	User Adapted Line Check-Out Manual for DDC System at Joliet AAP	ARRADCOM Dover, NJ	June 81
6.	Data Item Descriptions Index Technfcal Manual Systems Manual Users Manual Instruction Manuals System/Equipment Failure Analysis and Corrective Action Report	ARRADCOM Dover, NJ	May 82

Summary Report was prepared by Steve McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 577 4362 titled "Continuous Automated Post Cyclic Conditioning Facility for Large Caliber Composition B Loaded Projectiles" was completed by the US Army Armament Research and Development Command in March 1981 at a cost of $490,000.

BACKGROUND

The modernized LAP facilities require the capability to load munitions with either TNT or Comp B explosive. Therefore, it is necessary to develop production processes that effectively produce tight explosive fillers. This project will define procedures for loading TNT in the existing and newly developed high explosive loaded family of ammunition which includes 155mm M549, 155mm XM795 and the 8-inch M65D projectiles.

SUMMARY

The work necessary to accomplish the production parameters was as follows:

The projectile bodies or warheads were depalletized, the interiors vacuumed and inspected, and the thread protectors and funnels assembled. Two funnels were designed for loading the TNT filler in the warheads. All warheads and funnels were assembled and placed in the prototype tooling fixture mounted on the carrier and then conditioned to a temperature of $71 \pm 1^{o}C$ for 12 hours.

The metal parts were preheated in existing equipment. Approximately 300 pounds of TNT were used for each 155mm and 8-inch test. The explosive was inspected, melted, and feathered in a Copp kettle until a flake to molten ratio of 20 to 80 was achieved. The solid and molten material was conditioned to the required pour temperature by circulating hot water through the jacket of the kettle. When this material reached $80 \pm 1^{o}C$, the explosive was transferred to the variable volume pouring manifold through a rubber hose and four warheads were positioned beneath the manifold. When the maximum explosive level was reached in the jacketed variable volume pouring manifold, the warheads were simultaneously loaded with TNT (50 seconds for M549 and 80 seconds for M650). The required temperature of the explosive was maintained by circulating hot water through the jackets of the explosive pour nozzles and manifold, and the temperature was verified before loading the projectiles.

After temperature verification, the warheads and carriers were transferred directly into the cooling bay which has a capacity for two carriers and is equipped with universal steam thermal panels (See Figure 1) that prevent explosive solidification in the funnels and warhead necks. This allowed molten explosive to flow as the cast solidifies from the base up.

Figure 1 - Controlled cooling bay with universal steam thermal panels

Approximately 12 minutes were required to load the warheads, fill the cooling bay with water, and initiate the controlled cooling process. When the 5.5-hour M549 and 8-hour M650 processes were completed, the warhead carrier was removed from the cooling bay and the probing operations were performed. The warheads were then stored in a cool-down area (2.5 hours for the M549; 3 hours for the M650) to allow the molten explosive in the funnels to solidify. After the cool-down cycles were completed, the funnels were removed from the warheads.

The process equipment included a water circulating system which continuously circulated water about the warheads at a constant temperature. This solidified the explosive in the warheads at a uniform rate from the base up and provided a reproducible process cycle which enabled the probing to be performed under the same conditions at all times. The time at which the probing occurred was critical since the explosive in the warheads was becoming solidified while the TNT in the funnels was 70% to 80% molten. The molten explosive was required to fill the void in the cast made by the probes in removing the piping cavities from the cast TNT.

BENEFITS

Reduced L/A/P cost, improved cast quality, reduced processing time and elimination of base gaps between explosive and projectiles.

IMPLEMENTATION

a. Detailed drawing packages, process descriptions, process and equipment specifications developed under this project have been prepared in direct support of the:

(1) 155mm XM795 DTII TNT loading at Louisiana AAP.

(2) Initial Production Facility for LAP of the HE XM795 projectile.

(3) Equipment design for the 155mm M549/8 Inch M650 LAP facility.

b. The process controls, environmental conditions, controlled cooling process cycle and tooling designs are being incorporated in the TDP for the XM795.

(1) Controlled cooling processes have been successfully established for the 155mm M549 and XM795 and 8-Inch M650 projectiles.

(2) The XM795 process was implemented at Louisiana AAP for TNT loading of all DTII Projectiles.

MORE INFORMATION

Additional information on this project can be obtained from Mr. Curtis Anderson, ARRADCOM, AV 880-3162 or Commercial (301) 328-3162.

Summary report was prepared by Wally Graham, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 578 4447 titled "Nitroguanidine Process Control Analytical Systems" was completed by the US Army Armament Research and Development Command in September 1980 at a cost of $470,000.

BACKGROUND

The basic nitroguanidine manufacturing facility design was based upon the British Aqueous Fusion (BAF) process. Process materials flowed through the system only once. This caused inefficiencies and pollution problems. The basic process design was modified to include re-circulation and recovery systems. It was suspected that components in the recycle streams may cause interference with some of the commonly used analytical methods. Therefore, it became necessary to determine where to locate specific process control points and identify procedures and instrumentation for performing the analysis in a real-time mode where possible.

SUMMARY

The objective was to develop rapid methods for the analysis of cyanamide, guanidinium, carbonate, calcium, sulfur, total sulfate, and fluoride in the process streams of the nitroguanidine plant, with emphasis on instrumental methods which could be applied to on-line analysis. This report summarizes the results obtained from using polarography, ultraviolet absorption spectrophotometry, and ion chromatography interfaced with dedicated micro-processors for rapid handling of analytical data.

The complexity of the reaction systems in the continuous nitroguanidine process is shown in a simplified block diagram in Figure 1. This diagram shows the chemical reactions of key ingredients and the sources of impurities and interferences in various process streams. Analytical procedures were developed for synthetic mixtures representing various sampling points. Any one given sample consisted of numerous species, some of which behaved as interfering chemical agents.

A modified Hall polarographic method was found to be a rapid procedure with an acceptable precision and accuracy for the determination of elemental sulfur that was present in the complex compositions along the guanidine nitrate process line.

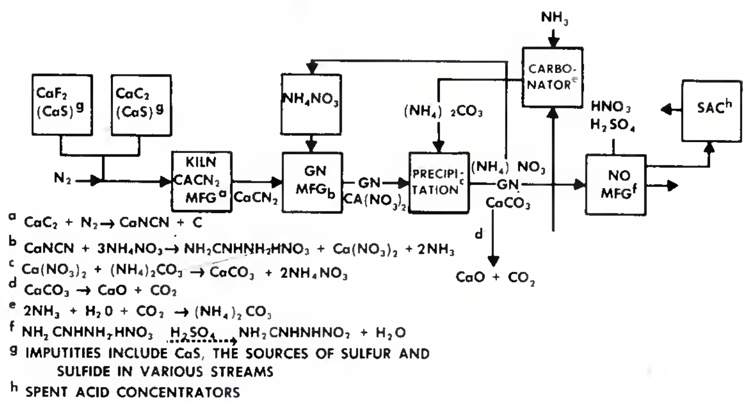


Figure 1 - Continuous Nitroguanidine Process at SFAAP

The determination of total sulfates in a solution of free sulfuric acid and sulfate salts by passing the solution through the hydrogen form of a sulfonic acid resin was rapid and accurate. The standard deviation for sulfate concentrations ranging from 50% to 80% was approximately 1%. The sole restrictions of the method was that sulfate ion had to be present in large excess. If nitrate ion was present, a correction was to be made from the ultraviolet absorption spectra. Other anions required formulation of salt complexes or volatilization.

A simple, rapid method for analyzing cyanamide in the guanidine nitrate reaction liquor was developed. This method was based on the reaction of cyanamide and the sodium nitroprusside-potassium ferricyanide-ammonia reagent to form an intensely colored complex, which was subsequently determined spectrophotometrically at 525 nm. This method required a reaction time of 16 minutes, and the complete analysis including sample preparations could be accomplished in about 20 minutes. This method was, therefore, suitable for on-line process and quality control of the continuous nitroguanidine manufacturing plant. The relative standard deviation and the relative error were found to be about 1% and -2%, respectively.

A systematic investigation of the effects of various component species in the guanidine nitrate reactor liquor revealed that the combined effects on the absorption characteristics of the cyanamide-reagent complex could be quantitatively accounted for in terms of the formation of guanidinium-reagent complex and the dissociations of both cyanamide and guanidinium ion-reagent complexes by ammonium ion.

The interference studies also established the feasibility of employing the developed method for analyzing not only the single component systems, ie, cyanamide and guanidinium ion, but also the rapid, simultaneous multi-component analyses of any combinations of two key ingredients or all three ingredients; namely, cyanamide, guanidinium ion, and ammonium ions in mixtures containing calcium nitrate and dicyandiamide.

Direct, rapid, ultraviolet absorption spectrophotometric determination of cyanamide in the guanidine nitrate reactor liquor could not be accomplished because of the weak absorption of cyanamide and the presence of large amounts of nitrate ion which absorbs intensely in the absorption range of cyanamide.

Ion chromatography showed direct applicability to various nitroguanidine process streams. Multi ionic samples could be separated and quantified in a relatively short period of time with no sacrifice in either precision or accuracy. This represented a considerable manpower saving when compared to classical methods of chemical analysis.

BENEFITS

Timely availability of analytical results will reduce response time required to prevent or correct process upsets. This will result in better yield and product quality; also, off grade product rework will be reduced. It is estimated that manpower requirements for chemical analysis will be reduced by one man per shift.

IMPLEMENTATION

Analytical systems are being implemented during the prove out of all nitroguanidine facilities at Sunflower AAP.

MORE INFORMATION

Additional information can be obtained by contacting the project officer, Mr. A. Litty at US Armament Research and Development Command, AV 880-3637 or Commercial (201) 328-3637.

Summary report was prepared by Andy Kource, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 578 4449 titled "Process Improvement for Composition C-4" was completed by the US Army Armament Research and Development Command in September 1981 at a cost of $120,000.

BACKGROUND

Composition C-4 is a mixture of RDX explosive and a polyisobutylene binder which is prepared at Holston AAP (HAAP). The Class 3 version of C-4 is used as an extrudable explosive and is extruded at Louisiana AAP (LAAP) for M112 Demolition Blocks and M18A1 Mines. Before this project, the Class 3 Composition C-4 contained specific granulations of Class 1 and Class 5 RDX in a mixture of 3:1. It was realized that substantial cost savings could be obtained if C-4 could be prepared using production run material such as nominal Class 1, nominal Class 5, and nominal Class 7 RDX. This project was then initiated to determine the feasibility of substituting nominal classes of RDX mixture in the manufacture of Composition C-4.

SUMMARY

The objective of this project was to improve the present process for the manufacture of Class 3 Composition C-4 by using production run nominal RDX. Initially, seven test lots of Class 3 Composition C-4 were prepared by Holston AAP and shipped to Louisiana AAP for extrusion, firing tests, and evaluation. The test lots contained nominal Class 1/nominal Class 5 and nominal Class 1/ nominal Class 7 mixtures in ratios from 3:1 to 4:1. The percent binder was varied from 9.9% to 10.1%.

The Composition C-4 as received by LAAP was extruded using their new, improved extruders. The extruders were fed by an overhead container conveyor. The C-4 was extruded from the die head in a continuous ribbon as shown in Figure 1. A cutter was used to cut the ribbon into proper lengths and then weighed automatically. Conveyor belts then carried the blocks to the receiving and inspection area.

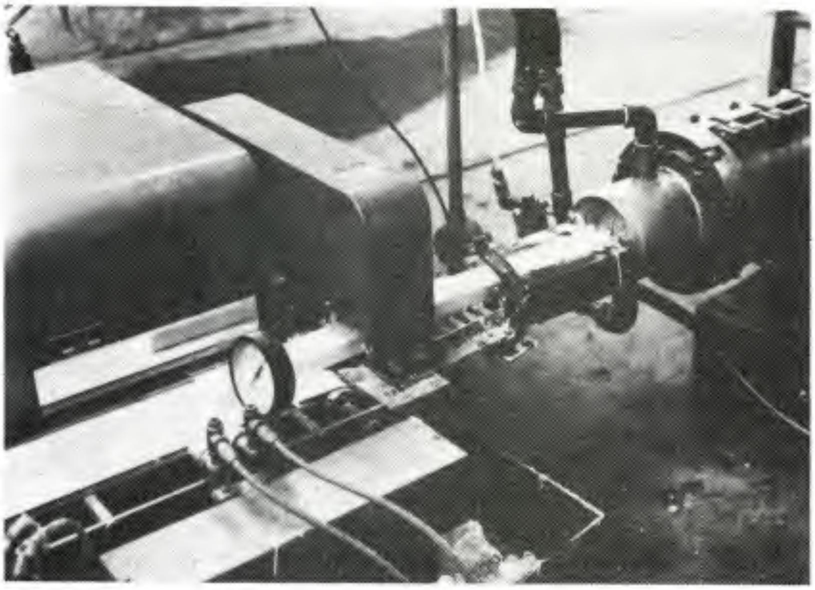


Figure 1 - Extruded Composition C-4 Exiting the Die Head

LAAP used each of the special test lots of Composition C-4 to extrude M112 demolition blocks and/or M18A1 mine blocks. In addition to normal extruder operating data, the extrusion characteristics of the special lots were noted and recorded. Reliability/availability/maintainability (RAM) data covering operating and down times of equipment was collected.

Loading data was analyzed in an effort to correlate lot and batch composition with extrusion characteristics. In general, ease of extrusion appears to be a function of binder content. RDX granulation was found to be insignificant for the classes and ratios represented by these lots of Composition C-4.

Forty M112 demolition blocks from each lot and twenty M18A1 mine blocks from two lots were test fired. The blocks were fired on gravelly soil. The resulting craters were measured, then filled and leveled after each firing. Blocks loaded with standard Composition C-4 were fired for comparison with the special lots.

Examination of the data shows that the average crater size increased as percent binder decreased. However, crater size variations between and within batches indicated that soil crater size is not a very accurate index of block detonation. This is reinforced by comparing M112 demolition block craters with M18A1 mine block craters. In many cases, the larger M18A1 blocks created smaller craters than did the M112 blocks.

Test results indicated no statistically significant differences between experimental Composition C-4 manufactured from nominal Class 1/nominal Class 5 RDX or standard Composition C-4.

Therefore, a result of the work performed at both HAAP and LAAP, the existing specification for the manufacture of Composition C-4 (MIL-C-45010A(MU)) was amended to include the use of nominal Class 1/nominal Class 5 RDX in lieu of Class 1/Class 5 RDX in the manufacture of Class 3 Composition C-4.

BENEFITS

A cost savings of approximately $55,000 per year (1981 dollars), at current production levels, is currently being realized at Holston AAP due to the use of nominal Class 1/Class 5 RDX in the manufacture of Composition C-4.

IMPLEMENTATION

The results of this MMT effort have been implemented into production operations at Holston AAP for the manufacture of Composition C-4.

MORE INFORMATION

Additional information on this project is available from Mr. L. Silberman, ARRADCOM, AV 880-2160 or Commercial (201) 328-2160.

Summary report was prepared by Pete Martin, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 578 4498 titled "Development of Methodology for Consolidation and Automated Assembly of Small Mines" was completed in December 1981 by US Army Armament Research and Development Command at a cost of $325,000.

BACKGROUND

The Army has developed a family of systems to deliver scatterable mines. Many of the internal components are identical or very similar. The developmental Producibility Engineering and Planning Phase established a manual method to assemble each system. Multiple handling and several off-line operations were labor intensive, hazardous and error prone. This 3-phase effort was undertaken to establish the design requirements, prove out and install prototype equipment for mechanized or automated assembly.

SUMMARY

The objective of this 3-phase effort was to increase the reliability of scatterable mines and to improve the safety of the soldering and explosive loading operations. The approach was to determine the manufacturing system requirements under this project. The next phase under a follow-on MMT project 579 4498 was to design and build prototype equipment. Mechanized assembly, in-process electrical testing, automated soldering, and improved techniques for loading explosives were individual modules. The prototype equipment would be installed into actual production lines under MMT project 580 4498 and facility projects at Iowa Army Ammunition Plant (AAP) and Lone Star AAP.

The engineering analysis indicated that a totally automated or mechanized assembly of the mines was not cost effective for the planned peace time production rates. In lieu of a totally automated assembly line, several individual operations were selected for mechanization.

The technical specifications for an electronic test set and an automated solder machine were prepared and approved for design. Equipment capable of meeting these requirements are depicted in Figure 1. The electronic test set is required to check individual non-activation cell voltage, verification of shorts across the firing capacitor, verification of shorts in series with the electronic battery primer, and anti-personnel mine trip line continuity.

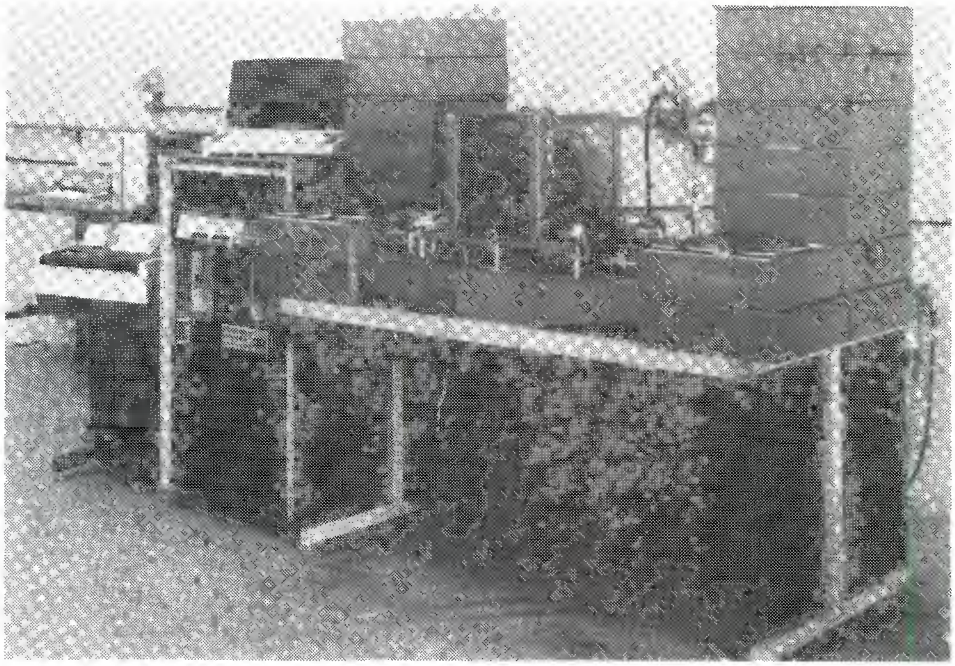


Figure 1 - Electronic Test Set - Computer Automation
Model - Capable 4100

The automated solder machine requirements were to solder at all points simultaneously on the flexible cable for the Safety and Arming (S&A) assembly to the Electronics assembly. The solder machine would then automatically inspect the resistance of the S&A circuits as well as the magnetic coupling device circuit of the Electronics assembly. Procedures were established for the assembly of two mines. Improved techniques were determined for dispensing adhesive and assembling the S&A assembly.

An improved procedure for loading the explosive in M74 Ground Emplaced Mine Scattering System (GEMSS) anti-personnel mine was established. A nylon funnel or riser was used to preclude the need for preheating, and aluminum core pins were used to eliminate a drilling operation.

BENEFITS

An effective method of pouring explosive (Comp B-4) into a mine (M74) was established. Requirements were determined for an electronic test set, automated solder machine, and fixtures to aid assembly of mines. Costs were avoided when it was decided to only automate selected operations.

IMPLEMENTATION

The prototype equipment defined under this project will be built and demonstrated under follow-on MMT projects 579 4498 and 580 4498, respectively. In addition, the prototype equipment will be made operational under facility projects at Iowa AAP and Lone Star AAP.

MORE INFORMATION

Additional information can be obtained from the project officer, Mr. Joseph Bracigliano, ARRADCOM, AV 880-5569 or Commercial (201) 328-5569.

Summary report was prepared by Stephen A. McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 578 6753 titled "Methods for Orienting and Feeding of Small Caliber Ammo Components" was completed by the US Army Armament Research and Development Command in June 1981 at a cost of $489,400.

BACKGROUND

The project was originally submitted to correct design deficiencies in the prototype SCAMP submodule feeders. Prior to project approval, the scope of work was changed and the approved effort that was undertaken was a study of the processes and techniques required to produce the 7.62mm cartridge case on modified SCAMP lines.

SUMMARY

This study was undertaken to define the processes and tooling that would be required to convert the 5.56mm SCAMP equipment to production of 7.62 cartridge case. An additional stipulation was that the standard US cup be used as the starting material. The geometry of this particular cup mandated a three-draw process. The particular grain structure further required an anneal operation prior to the final draw. A third change to the process was a pre-pocketing operation prior to heading to assure a reliable primer pocket and adequate internal head hardness. All of the development work was carried out using SCAMP tool modules and simulators. Simulators are used to duplicate the essential features of a rotary press and have been found to provide good correlation with the operating hardware. A sample of the cartridge cases was loaded to the high pressure test specification and fired in a pressure barrel with no deficiences noted.

Relative to the SCAMP case submodules operating at Lake City, the following additional equipment would be required to produce the 7.62mm cartridge cases:

1. A draw press for the additional draw operation.
2. An additional drive motor and control system.
3. An interdraw anneal station including a 250kw power unit (Figure 1).
4. A header press to perform the pre-pocket operation.
5. Two transfer turrets to correct the pass-line changes.
6. Extension of the layout equivalent to one upstream station.

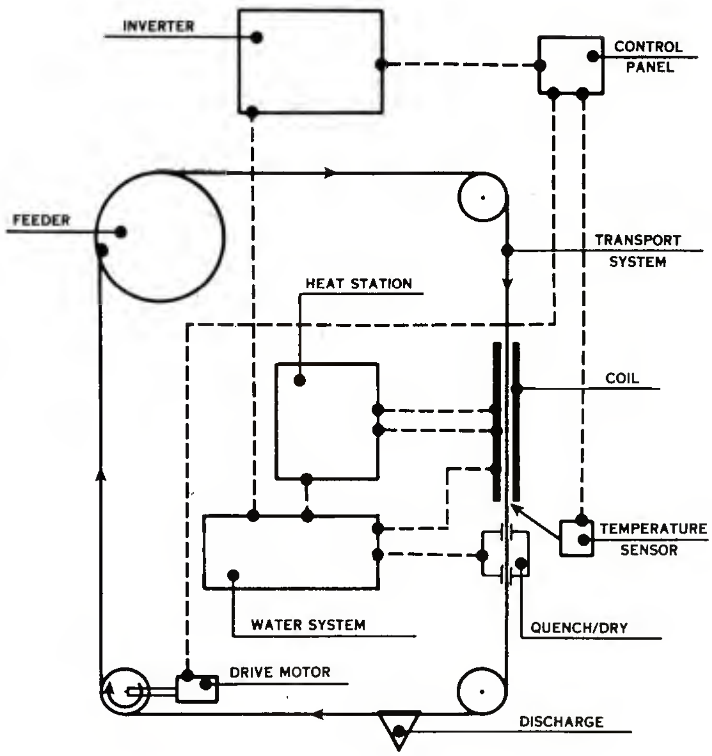


Figure 1 - Interdraw Anneal Station

BENEFITS

This project has provided a definition and supporting documentation for additional equipment required to convert a SCAMP 5.56mm case submodule to 7.62mm cartridge case production. The follow-on project that would have defined changes to the current SCAMP equipment was not funded because additional 5.56 requirements will require use of all available modules.

IMPLEMENTATION

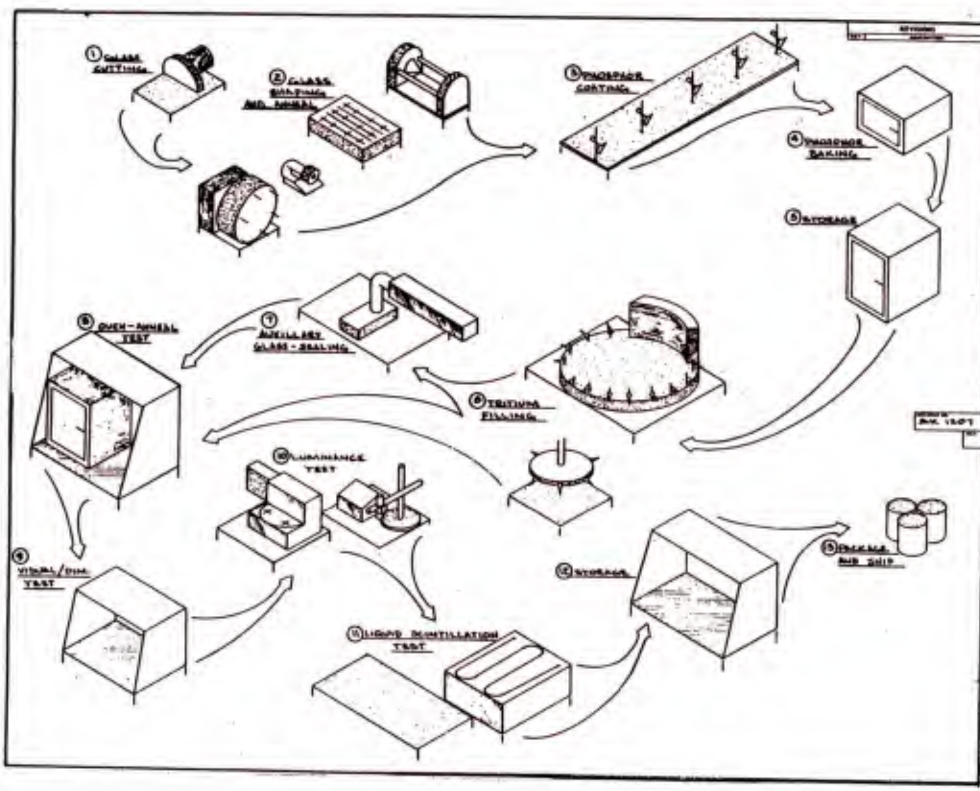
Implementation of this effort was dependent upon the conversion of an idle SCAMP line. Current and future requirements for 5.56mm ammunition will require all modules; therefore, no implementation is planned at this time.

MORE INFORMATION

Detailed information is available in the technical report for contract DAAK10-78-C-0165 titled "7.62mm Cartridge Case Feasibility Study." The project engineer at ARRADCOM is Mr. Edward Rempfer, AV 880-3737 or Commercial (201) 328-3737.

Summary Report was prepared by Hal Weidner, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

NON-METALS



SELF-LUMINOUS LIGHT SOURCE PROCESS

ABSTRACTS

Project Number	Project Title	Page
176 7079	MMT Braiding of Reinforced Plastic Structural Components for Helicopters	N-3

This project established the manufacturing technology to produce helicopter rotor spar sections. Processing and resin impregnation techniques and design criteria were determined. The braided spars matched existing spars in the areas of shape, mass, stiffness, longitudinal and torsional strength, center of gravity and polar moment of inertia. The blade also demonstrated substantial improvement during ballistic testing by reducing fiber brooming and delamination.

277 9751	Manufacturing Methods for Fabrication of YAG Laser Rods	N-11

This project developed batch processing methods for fabricating the Nd: YAG laser rods used in the AN/GVS-5 system. A polishing fixture holding 16 rods was designed and built to allow rod grinding using five sizes of A1203 slurry. This method is currently in use and has reduced the average processing time from 5 to .57 manhours, a savings of $30 per rod.

37T 3287, R79 3287	Production Methods for Low Cost Strip Laminate Motor Cases	N-21

Motor cases for the Free Flight Rocket and the CHAPARRAL were fabricated using steel strip lamination. The strip, prepared by degreasing, grit blasting and priming, is coated with adhesive and wound around a steam-heated mandrel. The resulting product is accurate to tight tolerances, demonstrates high performance and shows a 19% cost reduction over previous motor cases. This process is scheduled for use in future production of the CHAPARRAL.

R80 3445	Precision Machining of Optical Components	N-26

A production base to meet current and future DoD optical component requirements was established. A diamond turning machine was used to determine a manufacturing process, check out the facility and produce a set of proof parts. This

Page

machine can produce a wide range of optical components with a projected cost savings of $380 million over other alternatives based upon a machine investment of $3.5 million.

T80 5062 | Production of Armored Vehicle Vision Blocks | N-28

Current soda-lime glass used in armored vehicles is heavy and has poor optical clarity. This project investigated new glass/plastic and ceramic/glass/plastic laminates for optical qualities, high and low temperature reachons, and ballistic properties. The glass/plastic design was chosen because of acceptable performance during testing and its much lower cost and is being considered for use on the M-1 tanks and future Marine vehicles.

578 1339 | Manufacturing Technology for Preparation of B-1 Dye | N-37

This project established a safe chemical process for the manufacture of B-1 dye by utilizing Tobias acid instead of B-naphthylamine, a known carcinogen, as the starting material. The process thus eliminated the need to handle and store the carcinogenic material and reduced B-naphthylamine concentration in the final product. A manufacturing directive was prepared and will be available to future industrial producers of B-1 dye and M9 Chemical Agent Detector Paper.

678 7743 | Application of Anti-Fog Conductive Films | N-40

Direct surface heating of exposed optical surfaces, such as tank periscope windows, is the preferred method of reducing icing and fogging. This project developed manufacturing methods for the windows, utilizing a thin film of electrically and thermally conducting indium tin oxide and chromium and gold electrodes along the long window edge. These coatings meet durability requirements, may be retrofitted to existing windows, and have been tentatively approved for the M60 tank.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 176 7079 titled "MM&T Braiding of Reinforced Plastic Structural Components for Helicopters" was completed by the US Army Aviation Research and Development Command in April 1981 at a cost of $156,000.

BACKGROUND

Mechanical braiding has demonstrated substantially higher rates of automated fiber laydown than can be achieved with conventional filament winding. Additionally, the high level of weaving in braided composites should yield a greater degree of ballistic tolerance than is achieved with filament winding. Because of these properties, mechanically braided parts are good candidates for structural helicopter components.

SUMMARY

The purpose of this project was to establish the manufacturing technology for braiding Helicopter Rotor Spar Sections. The OH-58 blade shape was chosen to demonstrate the process. No compromise in the blade's advanced aerodynamic shape was necessary to accommodate manufacturing by braiding.

A study was conducted to match fiber braiding characteristics with the shape, mass and stiffness distribution required of the final spar. The braided spar was designed to match the natural frequencies of the existing metal blade in order to insure dynamic compatibility with existing OH-58 Helicopters.

The final blade structure consisted of a leading spar of braided Kevlar 49 fiber and epoxy resin, a nomex reinforced afterbody, a Kevlar/epoxy trailing edge spline, and a glass fiber/epoxy skin. Blade root attachment is made through bushed holes in the braided spar which mate directly with the existing hub and pin.

The manufacturing procedure consisted of braiding 12 layers of 7100 Denier roving from root to tip. Four low angle layers provided longitudinal strength and stiffness while eight high angle layers satisfied torsional and chord wise property requirements. Each braided layer was applied at a constant pitch, which allowed the fiber orientation angle to decrease and the layer thickness to increase along the tapered spar.

A bundle of molded uni-directional E-Glass/epoxy was overbraided onto the leading edge of the spar. This provided ballast necessary for the correct center of gravity and protection against tree strikes and ballistic impact. An Eastomer coated weight was overbraided to the spar tip to achieve needed dynamic tuning and the optimum polar moment of inertia.

The dry roving was braided onto an aluminum mandrel, Figure 1. The braided spar assembly was then vacuum impregnated with a liquid epoxy resin in a matched tool which provided accurate resin content control. The spar was then cured in a matched steel mold. The mandrel was withdrawn, and, with the addition of bushings, closures and trim weights, the manufacturing process was completed.

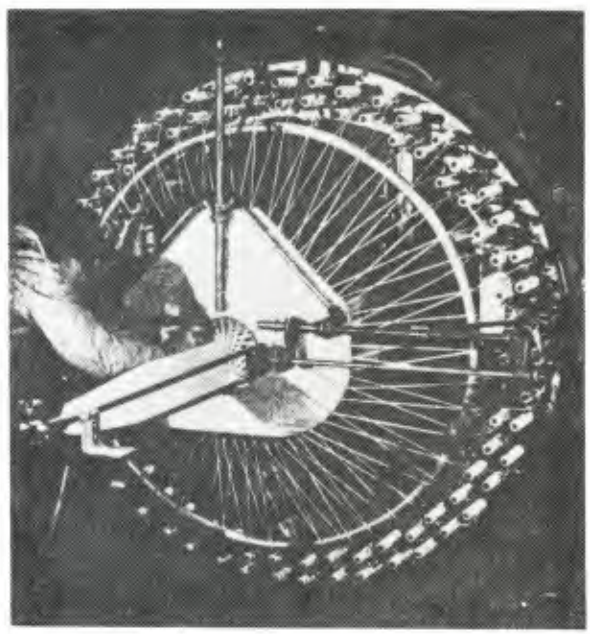


Figure 1 - Composite Braiding

Coupon test panels and seven foot spar sections were fabricated. Measured fiber angles were checked and found to be within one degree of the attempted angle. The test panels were then bagged, vacuum impregnated with liquid epoxy/aromatic amine resin, rebagged and cured. Microexamination of one section revealed sound, low void laminate quality. Tested tensile and shear properties exceeded accepted minimums. Stiffness correlated well with analytical predictions, and design load limits were sustained without damage.

Ballistic tests with a 30 caliber fragment simulator projectile and a fully tumbled, 50 caliber armor piercing projectile caused damage extending only slightly beyond the actual puncture. This is a marked improvement over existing spars where brooming of fibers and delaminations often occur.

BENEFITS

This project demonstrated that mechanical braiding is a viable manufacturing technology for helicopter main rotor spars. Processing and impregnating techniques and design criteria were determined. If a composite blade program were developed for the OH-58, a cost savings of $486 per spar (FY80 dollars) over conventional filament wound spars would be realized.

IMPLEMENTATION

The final technical report is available for use in the fabrication of full scale spars or other structural components via braiding.

MORE INFORMATION

Additional information can be obtained from Mr. Jim Reese at AVRADCOM, AV 693-1625 or Commercial (314) 263-1625.

Summary report was prepared by Sandy Jackson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 179 7297 titled "MM&T Low Cost Production/Installation of Urethane Leading Edge Guards on Rotor Blades" was completed by AVRADCOM in June 1981 at a cost of $130,000.

BACKGROUND

The current Attack Helicopter (AH) composite main rotor blade utilizes a thermoplastic polyurethane leading edge erosion guard which is autoclave molded from sheet material and then bonded to the blade with an epoxy adhesive, using pressure diaphragm tooling and modest heat.

SUMMARY

The purpose of this project was to establish an improved manufacturing technique for the fabrication and installation of the leading edge erosion guard on the rotor blade. The approach followed was to co-cure the guard onto the blade with an expected cost savings of $560 a blade.

The effort began with a survey of manufacturers and literature for suitable erosion guard materials. The material chosen was that used in current leading edge guards, Estane 82-083, from B. F. Goodrich. Estane was selected because of its established rain and sand erosion resistance and because it is available in 0.125 inch thick sheets compounded especially for aerospace use. Adhesive tests were conducted and a 20 percent solution adhesive of Estane/methyl-ethyl-keytone (MER) was chosen.

Tooling was developed and manufactured using the Versitool process. This employs a 0.04 inch tin-zinc face on a cast, aluminum-filled epoxy compound substructure. This prototype mold was designed to match the contours of the outboard 48 inches of the leading blade edge, Figure 1. The tool design concept for the total blade is shown in Figure 2.

A spacer was attached to the outboard end of the mold to indicate when the blade had settled to its final position. The solid urethane was then inserted into the mold, with the spar resting on top. As the mold was heated, the urethane melted and extruded upwards over the blade surface.

The boots molded in this manner show a profusion of trapped air bubbles and surface indentations. An attempt was made to solve this problem by heating the final product to 250°F at 60 psi. While this did reduce porosity, the results were not considered satisfactory. Pinhead size bubbles were still present and the extra operations added to the process cost.

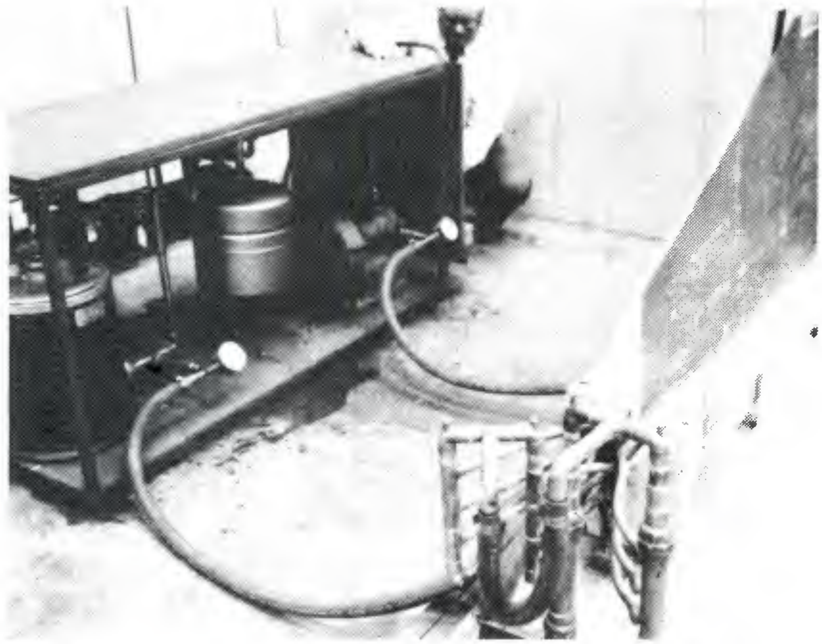
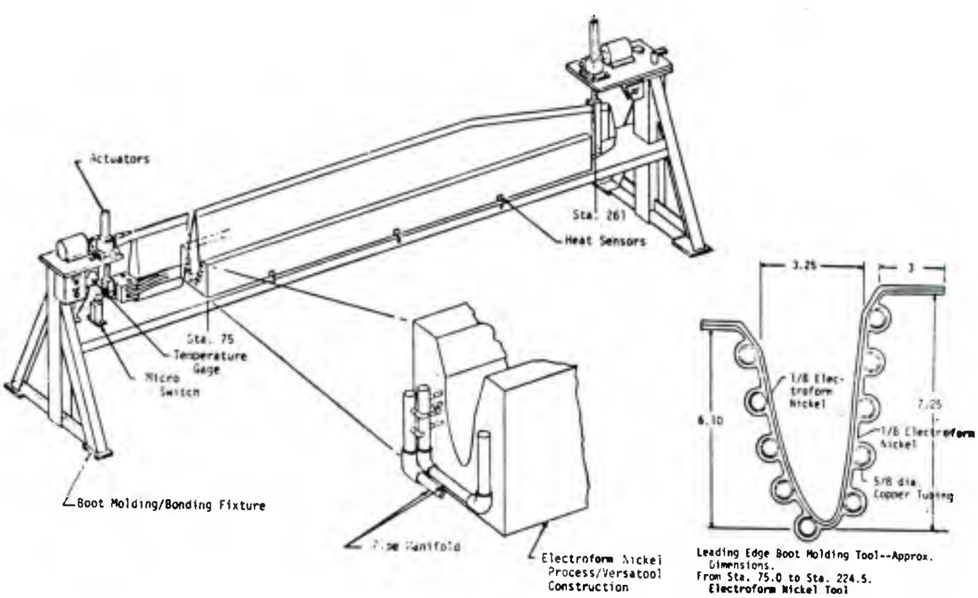


Figure 1 - Blade tip section in place in prototype boot
molding fixture with heating/cooling unit.



Although the basic manufacturing process had been verified on small coupon panels (approximately three inches long), twenty-six test runs yielded no satisfactory full-scale boots. The contract was terminated on 4 Nov 80 when it was determined that further basic development work was necessary to produce a satisfactory boot. While alternate materials or tooling might reduce air bubbles and indentations to a permissible size, the amount of research required was determined to be beyond the scope of this study.

BENEFITS

Because this project was unsuccessful, the expected benefits were not realized.

IMPLEMENTATION

No implementation of this process is planned.

MORE INFORMATION

Additional information can be obtained from Mr. Joe Pratcher at AVRADCOM, Autovon 693-1625 or Commercial (314) 263-1625.

Summary report was prepared by Sandy Jackson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 174 8008 titled "Broadgoods Layup System" was completed by the US Army Materials and Mechanics Research Center (AMMRC) and the US Army Aviation Research and Development Command in June 1979 at a cost of $700,000.

BACKGROUND

The use of tape for large or irregularly shaped contoured fuselage sections in Army helicopters was labor intensive and error prone. The locating of each individual strip and maintaining tolerances were time consuming and costly in process controls for the use of tape. This effort was undertaken to establish a broadgoods lay-up system for the semi-automated fabrication of contoured aircraft structures. Prior Army MMT efforts (MMT Project 1XX 6050) addressed the establishment of automated hardware and support software for tape layup. There were no prior efforts in the public domain to automate the layup of broadgoods, uncured pre impregnated materials wider than 12 inches.

SUMMARY

A reduction in manufacturing time and direct labor costs was the objective of this effort. The original approach was to try to establish a production capability starting with fiber and resin or a prepreg tape (12 inches wide) and producing a multi-ply broadgoods sheet (up to 5 feet wide) having up to 5 plies at various orientations.

A contract was awarded to fabricate a machine to lay up this sheet into large structures such as helicopter fuselages. Preliminary machine design was reviewed. However, with the advances made in woven structures since the project start, it was determined that there did not exist a need for oriented unidirectional broadgoods and a machine to fabricate and handle broadgoods. The contract was terminated and the approach was changed. A 3 axis milling machine was retrofitted with a new numerical control machine control unit, tape head, and motor drive system. The retrofited machine tool would then be used to fabricate prototype broadgoods. This capability would be used to evaluate broadgoods handling and fabrication techniques at a Army laboratory (AMMRC). The machine was retrofitted as shown in Figure 1.

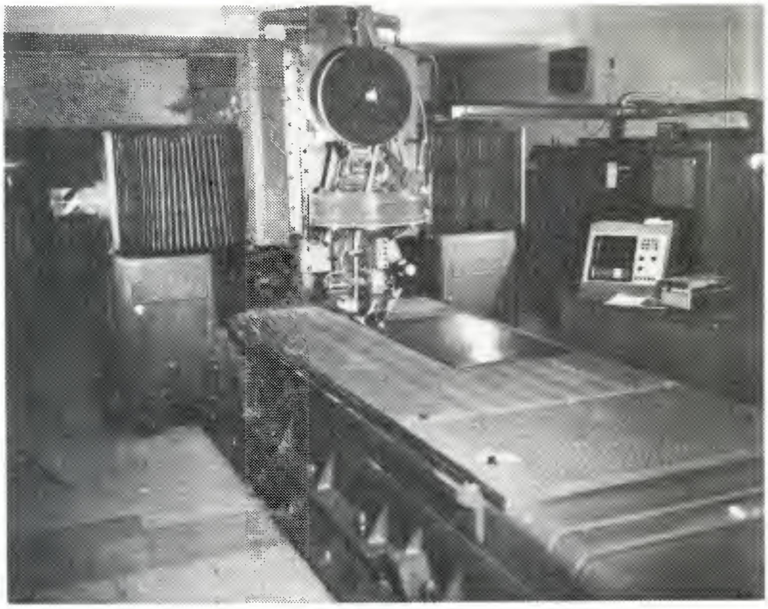


Figure 1 -

Retrofitted EKSTROM-CARLSON 3-Axis Milling Machine

A sample part was completed using 3-inch wide graphite/epoxy prepreg tape, and consisted of a 14-ply laminate 2 1/2 ft. x 4 1/2 ft.

BENEFITS

The automated tape layup machine is available at AMMRC and is capable of laying prepreg tape broadgoods up to the following dimensions:

x-axis	12 feet
y/axis	6 feet
z/axis	17 inches

Composite parts designed up to these dimensional limits might be laid up by this machine.

IMPLEMENTATION

Other commercially available tape heads now exceed the capabilities established by this effort. A new tape head is recommended for the retrofitted machine tool. Prototype fabrication at AMMRC would use manual methods for flat panels up to 4 ft. x 4 ft. by 1 1/2 inches. Panels at or above this size could justify fabrication on an automated system.

MORE INFORMATION

Additional information can be obtained from the project officer, Mr. Dana Granville, AMMRC, AV 955-5172 or Commercial (617) 923-5174.

Summary Report was prepared by Steve McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 277 9751 titled "Manufacturing Methods For Fabrication of YAG Laser Rods" was completed by the US Army Electronics Research and Development Command in August 1981 at a cost of $142,000.

BACKGROUND

Low production requirements of the military for Nd: YAG laser rods did not provide the initiative for the suppliers to develop high volume production capability. Rods were fabricated to the acceptable geometry and inspected on a one by one basis. The onset of the AN/GVS-5 development set a requirement for higher volume production. The cost of fabricating the rods needed to be brought down so that the cost of the system could be kept down.

SUMMARY

Airtron was contracted to accomplish the project's objective of developing batch processing methods for fabricating the required geometry of the Nd: YAG laser rods used in the AN/GVS-5 system. They designed and built the polishing fixture shown in Figure 1. This was the main piece of equipment used to facilitate batch processing.

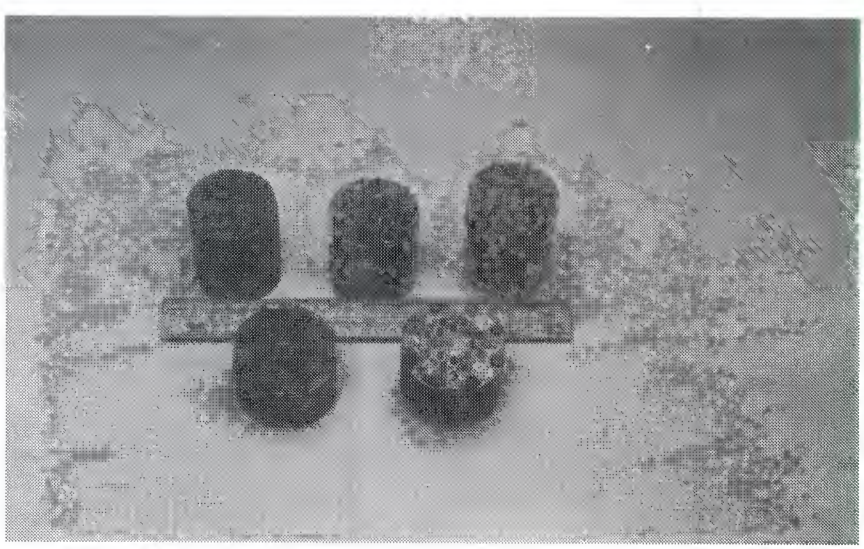


Figure 1 - Polishing Fixture

The design of the fixture was based on a number of requirements and data. Yield data generated in earlier experiments and the design goal of 12 rods per eight man hours were the main factors in determining that the fixture should hold 16 rods. The block was made of hot roll low carbon steel (SAE 1020). The mounting pattern was chosen so that each rod is symmetrically surrounded by other rods or polishing feet in order to work each face evenly. Bushings were pressed into the block to hold the rod at each end. This eliminates stressing the rod during polishing. The finished ends were protected with an aluminum cap.

The flow chart for batch processing is shown in Figure 2. The rods were mounted by heating the fixture with the rods in place. They were then removed, waxed, reinserted and rotated to insure the rods have parallel axis. The grinding was done on a lap using a 20, 12 and 5 micron Al_2O_3 slurry. The strokes and duration of the grind varied to account for a decreasing amount of material removal and a finer surface finish. The polishing was done with a 1 and .3 micron Al_2O_3 slurry. The surface finish was determined by comparing to scratch and dig standards. The end coating was optimized and reflectivity was measured using a spectrophotometer. This coating had to meet thermal, mechanical, and chemical solubility requirements.

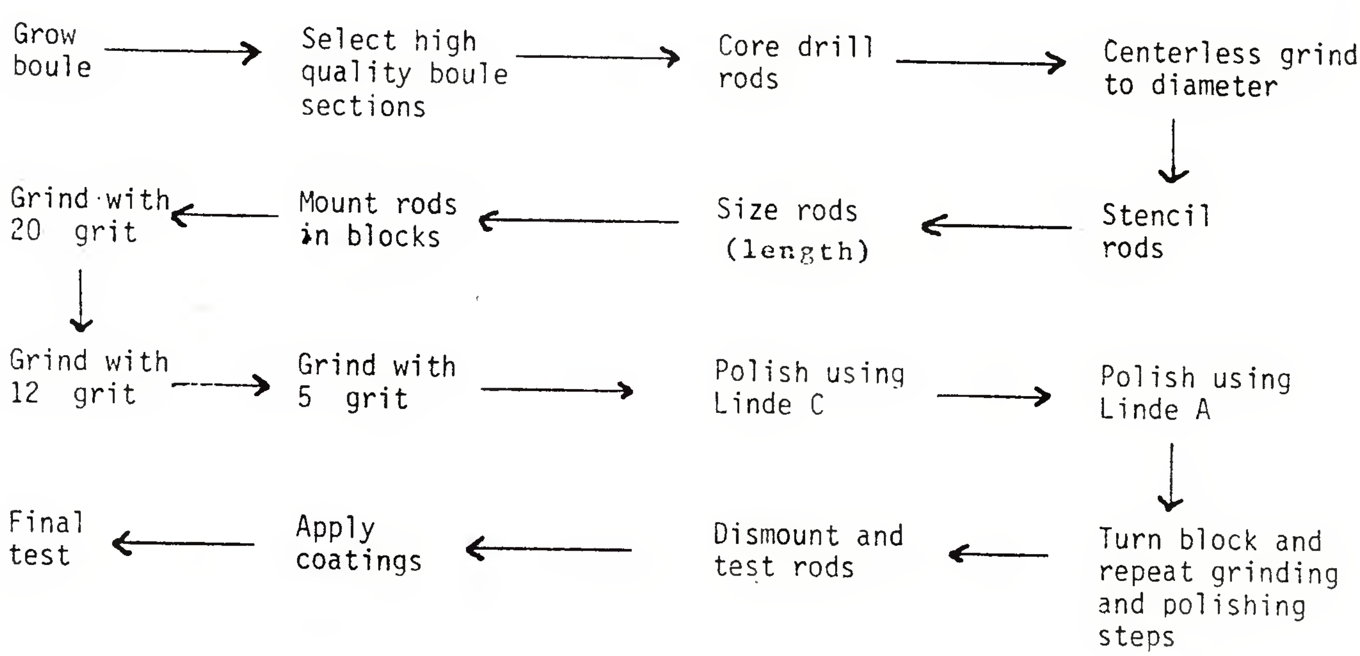


Figure 2 - Flow Chart of Manufacturing Process

BENEFITS

This project established a fixture, procedures and a pilot line for the batch processing of Nd: YAG laser rods. An eightfold increase in the rod fabrication rate was demonstrated with a pilot production of 100 rods. The average processing time was reduced from 5 to .57 manhours per rod. The cost savings amounts to approximately $30 per rod. The increasing use of Nd: YAG rods will result in a significant total savings for the military.

IMPLEMENTATION

This method is currently used to produce rods for AN/GVS-5 and has been used for rods of many sizes. The method is directly transferable to any producer of Nd: YAG laser rods.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Jeffery Paul, NV&EOL, AV 354-5310 or Commercial (201) 544-5310. A final technical report is available from DTIC; the contract number is DAAB 07-77-C-0375.

Summary report was prepared by Dan Richardson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project R80 1026 titled "Production of Low Cost Missile Vanes" was completed by the US Army Missile Command in September 1982 at a cost of $305,000.

BACKGROUND

Control vanes, fins and external rocket and missile fairings are generally fabricated from machined metal castings and forgings. These methods are necessary to meet temperature and strength requirements; however, they have three basic drawbacks: high cost, weight penalties, and long lead times. Application of composite materials offers the potential to overcome all three.

Advances made in the past decade have led to acceptance of composite materials for primary structures on aircraft, missiles, and space vehicles. The cost of these composite structures are becoming cost competitive with metal structures. To capitalize on composite technology, automated fabrication methods are needed.

SUMMARY

The objective of this effort is to develop automated production techniques and procedures for fabricating composite air vanes (see Figure 1). The effort was divided into two projects, R80 1026 and R81 1026. The FY80 project was

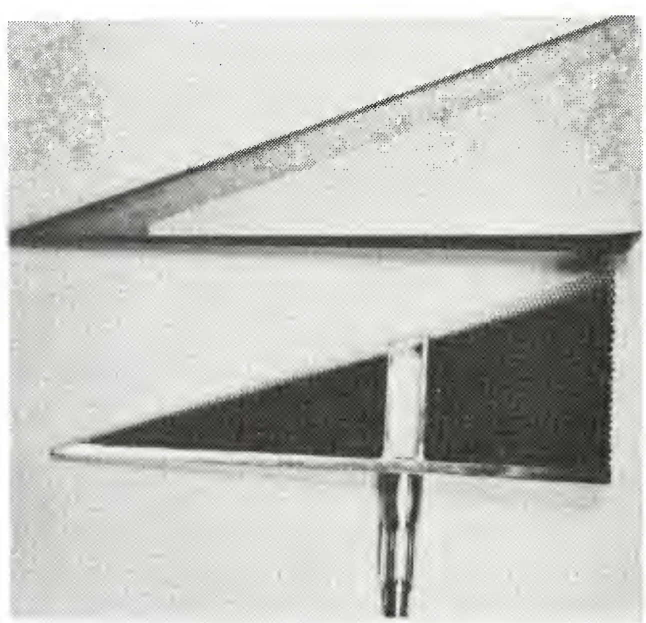


Figure 1 - Prefit for Final Bonding of Honeycomb Torque Box to Cocured Structure

directed toward establishing feasibility and establishing the fabrication process. The FY81 project is concerned with optimizing the manufacturing process via mechanization and automation techniques. This report addresses the FY80 project.

Work was divided into five tasks: (1) Planning to include the initial implementation plan, (2) Material and mechanical property evaluation, (3) Design requirements and current vane redesign, (4) Tool design and fabrication, and (5) Process demonstration and vane fabrication.

Task 1 concluded that the weight savings created by the use of composites materials apply directly to any missile that has trajectory limitations. A Pershing II missile vane was chosen for development application. Other systems that would greatly benefit from composite air vane technology include Patriot, cruise missiles and ICBMs.

During Task II, the graphite epoxy material, honeycomb, and adhesive were selected. A two-dimensional NASTRAN finite element model was generated to compare mechanical properties with design criteria. Task III involved performing a structural and thermal analysis and developing a structural test plan. A three-dimensional finite element structural model was developed for this purpose.

Once the materials were identified and the design established, tools were designed and fabricated under Task IV leading to the manufacture of seven composite air vanes under Task V. Two of these vanes underwent static testing. The results were very successful.

BENEFITS

It was demonstrated that composite air vanes can adequately replace metallic air vanes. The net molding and cocuring technologies that were developed are directly applicable to other missile systems requiring cocured details. Weight, labor, and material savings are significant by using composite air vanes. Cost savings of $1.5 million over a five year period are possible.

IMPLEMENTATION

A final implementation plan and automation techniques are being developed under MMT Project R81 1026.

MORE INFORMATION

Additional information and a copy of the final technical report No. OR 16, 579 titled "Manufacturing Methods and Technology Project for Production of Low Cost Missile Vanes" is available from Mr. E. Croomes, US Army Missile Command, AV 746-1740 or Commercial (205) 876-1740.

Summary report was prepared by James H. Sullivan, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project R79 3116 titled "Improved Production Methods for the Rosette Air Defense Seeker Optics and Detector" was completed by the US Army Missile Command in August 1981 at a cost of $675,000.

BACKGROUND

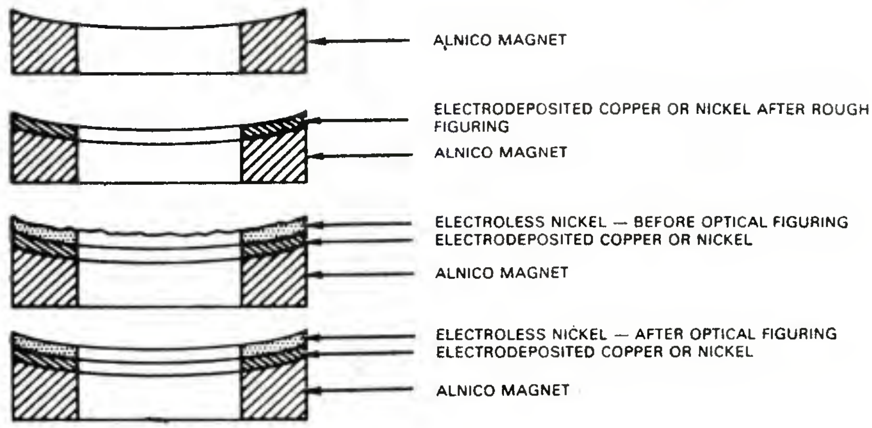
In prior year project R78 3116, General Dynamics Pomona Division contracted to establish improved production methods for selected portions of the optical, gyro-optic and detector/preamplifier components of the Stinger-POST Rosette Scan Seeker. In optics, the objectives were to improve methods for producing the spherical mirror and mirror inertia band through modification of current fabrication techniques and to develop improved methods for aligning, securing and testing these elements. The detector/preamplifier tasks included UV/IR sandwich detector improvements and detector/preamplifier production and assembly techniques. Seeker component and subassembly tasks encompassed development of improved methods for fabricating seeker support structures and assembly, alignment and test seeker components and systems.

Approaches were developed for each of the tasks in fourteen separate areas and were compared against existing approaches except two - the spherical mirror rotor assembly and the mirror inertia band. The purpose of this project was to complete the work in these two areas.

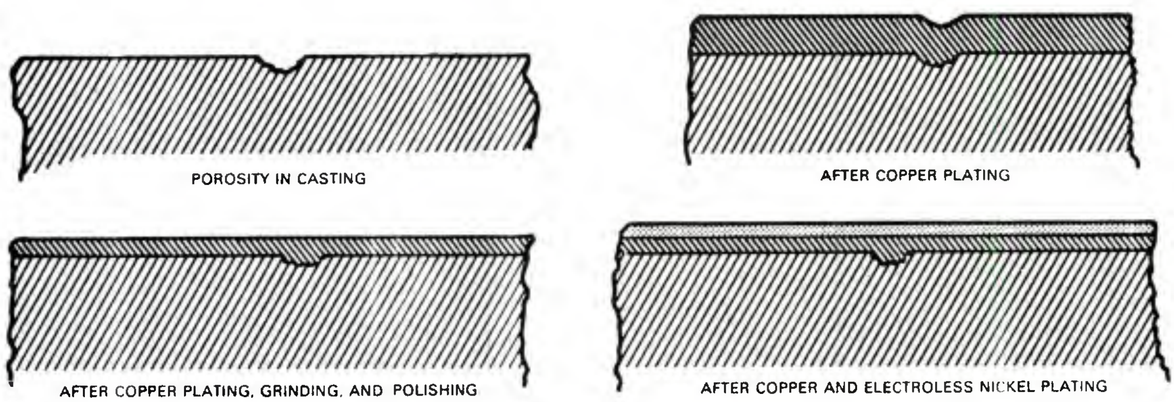
SUMMARY

Improvement of mirror fabrication yield was addressed through examination of failure modes and their probability of occurrence, and through the development of alternative mirror substrate materials, improved bonding methods, and lower temperature UV enhancement coatings. Reduction of fabrication and tooling costs for the mirror inertial band were addressed through investigation of powder metallurgy isostatic preform approach.

Two approaches to mirror fabrication were developed. Integral all-metal mirror process steps of the first approach are shown in Figure 1. A copper plating fills the porosities and surface imperfections in the spherically ground Alnico casting to provide a smooth homogeneous pore-free surface. This is then rough ground and electroless nickel is deposited to provide a surface with high hardness for resistance to scratches. This surface was then subjected to optical figuring and polishing.



Steps in Making Electroless Nickel Mirror.



Filling Porosities in Alnico Casting.

Figure 1 - Integral All-Metal Mirror Process Steps

The second approach is to bond a thin glass substrate to the Alnico magnetic gyrorotor to form the primary mirror. The surface-machined magnet was coated with adhesive to fill pores, cured, and ground to remove excess adhesive. The glass substrate is then bonded to the smooth preshrunk adhesive surface with additional adhesive and cured. The adhesive was Lunar Products LP3750 which will produce low, stable deformation of the substrate and meets the environmental requirements. A maximum temperature bake is then performed to stabilize the stresses to a final point. Optical figuring, polishing, and coating of the glass substrate were then done to get the mirror in final form.

The glass substrate mirror was recommended because it is 20 percent less expensive and because of the industry-accepted glass mirror fabrication techniques.

The two viable candidates for the mirror inertia band were tungsten and depleted uranium because of the necessity of high density material. The cost difference between the two is very small but the cost of licensing for using depleted uranium was large enough to recommend using tungsten. The tungsten tube machining costs were high due to the large amount of material lost in the process. The powder metal tungsten preform approach proved to be the most cost-effective technique which meets the structural integrity, dimensional stability, machinability and magnetic property requirements.

BENEFITS

The improved manufacturing methods and technologies developed on this project would benefit the Army by reducing life cycle costs and improving reliability.

SUMMARY OF MM&T COST ANALYSIS
(IN FIRST-QUARTER 1978 DOLLARS)

TASK NO.	PERCENT SAVINGS	DOLLARS/ UNIT
1 Mirror Fabrication Improvements (Adhesive Bonded Glass)	8	$ 11.20
2 Mirror Inertia Band Improvement	32	6.33

IMPLEMENTATION

Although some of the improvements have been implemented on ED hardware, a final decision for production of Stinger POST is not expected until January 1983.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Ted Peacher, MICOM, AV 746-3484 or Commercial (205) 876-3484. Information may also be obtained by contacting Mr. Michael Crisp, General Dynamics, AV 947-4182 or Commercial (714) 620-7511. The contract number is DAAK40-78-C-0281.

Summary report was prepared by Dan Richardson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 378 3126 titled "Processing of Laser Optical Ceramics" was completed by the US Army Missile Command in August 1980 at a cost of $132,000.

BACKGROUND

At the outset of this effort, the only available method for growing laser quality Nd:YAG crystals was the Czochralski process. The boules were of small diameter (2 inches) and therefore, few rods could be cored from each boule. This fact, combined with the low yield due to internal stress, made the Nd:YAG laser rods expensive.

This project is the second year of a two year effort to develop the Heat Exchanger Method (HEM) for producing Nd:YAG laser rods. The HEM uses a gradient furnace for controlling the solidification of the melt interface. This method had previously been successful in growing GaAs crystals and single crystal sapphire for armor.

SUMMARY

In the HEM process, the seed crystal is mounted on a helium-cooled heat exchanger which prevents the seed from melting when the rest of the material in the crucible is melted. The heat exchanger draws off heat from the melt so that a solid ingot grows outward from the seed in a regular crystal structure. The crucible is inside a cylindrical heating chamber with a resistance heater. It is surrounded by a cylindrical molybdenum retainer and rests on a molybdenum disk that is supported by graphite rods on a graphite plate.

In operation, the crucible is loaded and the furnace is evacuated. The temperature is raised to above the melting point of the stock. Once the stock is melted, the temperature is reduced to slightly above the melting point, so that the melt starts to solidify on the seed. The solid/liquid interface advances from the seed so that there is a thin annulus of liquid between it and the crucible wall and a small region of liquid above the ingot. When the liquid has solidified, the temperature is reduced below the melting point and the crucible is cooled.

Many difficulties were encountered in developing the process. Second phase inclusions and growth interface breakdown have prevented the production of laser quality crystals. These problems persisted despite attempts to improve the temperature gradient. The Nd concentration was relatively uniform in the samples but it was not high enough to sustain lasing action.

BENEFITS

Because insufficient R&D had been completed prior to this effort, the difficulties encountered were not detected prior to the manufacturing technology effort. These problems were fatal to the technical success of the project and therefore no benefits have been derived from this effort.

IMPLEMENTATION

There has been been no implementation.

MORE INFORMATION

Additional information may be obtained by contacting Dr. Dennis Viechnicki or Dr. Jaroslav Caslavsky, AMMRC, AV 955-5464 or Commercial (617) 923-5464.

Summary report was prepared by Dan Richardson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 37T 3287 and R79 3287 titled, "Production Methods for Low Cost Strip Laminate Motor Cases," were completed by the US Army Missile Command in March 1979 and August 1981 at costs of $275,000 and $250,000, respectively.

BACKGROUND

Metallic tactical rocket motor cases comprise up to 50% of propulsion missile system costs. This expense results from the extensive labor and tooling associated with forming, welding, heat treating, and machining round motor tubes and attachments to tight tolerances. The strip laminate tubular process offers a promising reduction for motor component costs. The problem is to optimize mill fabrication procedures to obtain lowest cost while increasing reliability.

SUMMARY

The objective of this manufacturing technology program was to fabricate and deliver rocket motor components utilizing strip laminate products. The process, illustrated in Figure 1, consists of laminating adhesive coated, ultra-high strength strip steel on an accurately dimensioned mandrel, curing the adhesive, cutting tubes to length and bonding end closures and external components to form completed cases.

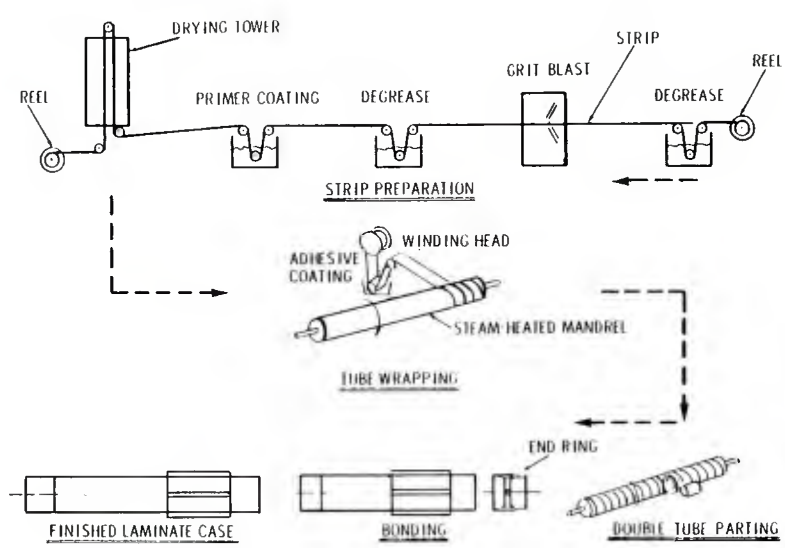


Figure 1 - Strip Laminate Fabrication Sequence

The strip is prepared for winding by passing it through a degreasing solution, grit blasting both sides, and again passing the strip through a degreasing solution. For adhesive systems requiring a primer, the primer coat is applied to one or both sides of the strip at this time followed by drying the primer in a heated tower. The prepared strip is wound on a reel for immediate use or is sealed in a plastic bag until needed for tube winding.

In preparation for tube winding, the reel of metal strip is mounted on a delivery head of the winding machine. The adhesive used to bond the wound layers of strip together is applied by spraying it on the strip or by passing the strip through a bath of adhesive. Film adhesives can be used also.

The strip is spirally wound in individual layers in a single circuit, helical pattern on an accurately dimensioned mandrel with adhesive applied between layers. The mandrel may be internally heated with steam to cure the adhesive and thus form a cured structural strip laminate tube. The mandrel is cooled, and the strip laminate tube is removed. The laminated tube is machined to a specified length and fins, lugs, and end-closures containing attachment fittings for nozzles and igniters are bonded to the laminated tube section(s) to form a completed case. The inherent simplicity of the process permits a high degree of automation.

The approach was to conduct trade-off studies of materials, hardware, and processes to identify a minimum cost and a maximum performance case. Forty demonstration cases (20 minimum cost and 20 maximum performance) were manufactured for delivery. After evaluation of the demonstration cases, a process and case design were selected, and 60 cases were manufactured for a reproducibility demonstration. The 6.65-inch diameter case used in the Free Flight Rocket (FFR) program was the baseline design evaluated in the trade-off studies, and the 5-inch diameter CHAPARRAL case was selected for the reproducibility demonstration.

The specific objective of the trade-off study was the identification of the lowest cost FFR design and the maximum performance FFR design. As it turned out, the lowest cost case also provided the maximum performance. Type 301 high strength stainless steel provided the lowest cost strip material. Machined aluminum forgings provided the lowest cost end ring and closures, and a continuous winding process provided the highest production rates and lowest total costs. The component design and material trade-off studies identified no cost reduction, but the processing studies resulted in a significant saving of 34%.

BENEFITS

The major benefit derived from this program has been the successful production demonstration for economical-high performance strip laminate rocket motor cases. It has been demonstrated that low cost configurations can be achieved by the strip laminate process with no performance penalties.

The continuous wind process developed will provide the lowest cost for the CHAPARRAL case. Based on 1000 unit buys, CHAPARRAL unit costs can be reduced from $694 to $560 (19% reduction) by tooling the existing process for production. A further unit cost reduction to $484, i.e., a 30% cost reduction possible by using a translating mandrel process.

IMPLEMENTATION

Copies of the final report have been distributed to the appropriate missile system project managers. The information has been made available to the Defense Advanced Research Project Agency Office, the Advanced Missile Systems Concepts Office and the Defense Documentation Center. A paper which reviewed the program results was presented at the 1980 Joint Army-Navy-NASA-Air Force Propulsion Meeting. Also, the results have been published in the 1980 JANNAF Meeting proceedings.

It is planned to use this procedure for future production of the CHAPARRAL. Another likely future application is a new rocket now in advanced development called the SPIKE.

MORE INFORMATION

Additional information can be obtained from Mr. William S. Crownover, MICOM, AUTOVON 746-5821 or Commercial (205) 876-5821. A technical report titled, "Strip Laminate Case Manufacturing Technology," RK-CR-81-5, was published in February 1981.

Summary report was prepared by Wayne R. Hierseman, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project R79 3445 titled "Precision Machining of Optical Components" was completed by the US Army Missile Command in December 1981 at a cost of $300,000.

BACKGROUND

Due to the increasing DOD emphasis on electro-optical and laser material programs, the optics industry cannot keep up with demand, meet optical design requirements, or meet production schedules at a reasonable cost. Existing precision machining facilities are research and development oriented and are not compatible with production needs. The purpose of the entire 3445 program (FY79-$300K, FY80-$400K, FY81-$625K) is to establish a production base to meet current and future DOD optical components requirements.

SUMMARY

The major objective of the program is to integrate the ERDA developed single point diamond machining capabilities and interferometric aided computer control technology into a production method for mirrors, lenses, and windows for laser, electro-optical, and missile system application. This project was directed toward the following four tasks:

Task 1 - Survey

A survey of DOD applications and requirements for precision machined laser and optical support items was conducted. Existing and planned capabilities were identified. It was determined that twenty precision machines were required to meet requirements.

Task II - Machine Specification

A specification for a diamond turning machine capable of producing aspherical surfaces was developed.

Task III - Metrological Specification

A detailed analysis of the various inspection tools was made and specifications for various metrological instruments presented.

Task IV - Facility Specification

A facility providing a compatible environment for precision machines was designed. Detailed descriptions and specifications for the primary enclosing structure, the secondary enclosing structure and modularly constructed local enclosures were provided.

BENEFITS

Savings totaling approximately $380 million are projected based upon a machine investment of $3.5 million. In light of the lack of available skills in this area, it appears that numerically-controlled precision machining may be the only practical way to produce the required surfaces.

IMPLEMENTATION

A machine capable of manufacturing optical components ranging in diameter from a few millimeters to 75 centimeters, weighing between a few grams up to 90 kilograms, is being fabricated under MMT Project R81 3445.

MORE INFORMATION

For additional information on this project, contact Mr. W. A. Friday, MICOM, AV 746-8611 or Commercial (205) 876-8611.

Summary report was prepared by James H. Sullivan, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project R80 3445 titled, "Precision Machining of Optical Components," was completed by the US Army Missile Command in December 1981 at a cost of $400,000.

BACKGROUND

Due to the increasing DOD emphasis on electro-optical and laser material programs, the optics industry cannot keep up with demand, meet optical design requirements, or meet production schedules at a reasonable cost. Existing precision machining facilities are research and development oriented and are not compatible with production needs. The purpose of the entire 3445 program (FY79-$300K, FY80-$400K, FY81-$625K) is to establish a production base to meet current and future DOD optical components requirements.

Under the FY79 program, the following four tasks were completed:

1. Survey of capabilities and requirements;

2. Development of machine specifications;

3. Development of metrological specifications;

4. Development of facility specifications.

SUMMARY

The major objective of the program is to integrate the ERDA developed single point diamond machining capabilities and interferometric aided computer control technology into a production method for mirrors, lenses, and windows for laser, electro-optical, and missile system applications. The goal of this project was to:

1. Select and train personnel to operate precision diamond turning equipment;

2. Establish manufacturing processes using an available single axis precision machine tool;

3. Establish and check out the facility to house the precision machinery;

4. Manufacture a set of proof parts;

5. Implement metrology equipment;

These tasks were accomplished using an existing diamond turning machine, see Figure 1.

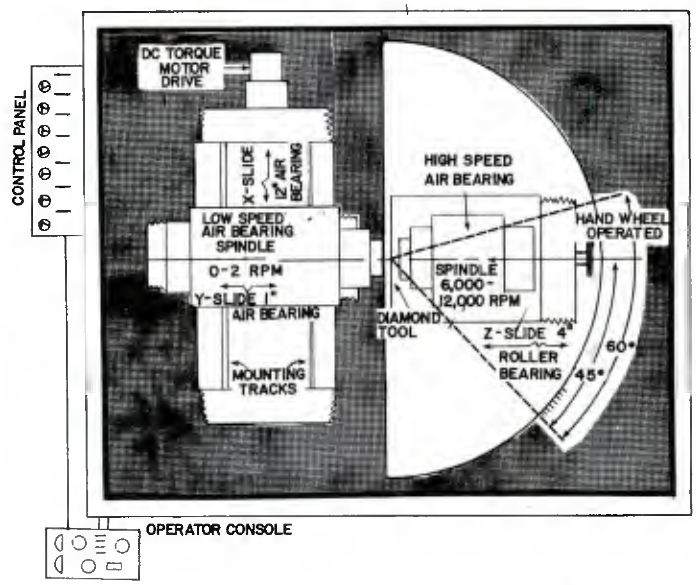


Figure 1 - Diamond Turning Machine

BENEFITS

Savings totaling approximately $380 million are projected based upon a machine investment of $3.5 million. In light of the lack of available skills in this area, it appears that numerically-controlled precision machining may be the only practical way to produce the required surfaces.

IMPLEMENTATION

A machine capable of manufacturing optical components ranging in diameter from a few millimeters to 75 centimeters, weighing between a few grams up to 90 kilograms is being fabricated under MMT Project R81 3445.

MORE INFORMATION

Additional information on this project may be obtained by contacting Mr. W. A. Friday, MICOM, AUTOVON 746-8611 or Commercial (205) 876-8611.

Summary report was prepared by James H. Sullivan, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project T80 5062 titled "Production of Armored Vehicle Vision Blocks" was completed by the US Army Tank Automotive Command in February 1982 at a cost of $19,558.

BACKGROUND

The performance of the newer lightweight armored vehicles has been severely hindered by the current technology vision blocks. These vision blocks have extremely thick soda-lime glass to provide the ballistic protection desired, resulting in problems of space, weight and poor optical clarity.

Previous R&D programs have made extensive studies in advancing the state of the art in the transparent armor field. The new glass/plastic laminates have lighter weight, improved optical characteristics due to reduced vision block thickness and have eliminated backside spalling. The goal of this project was to continue the work of MMT Project T78 5062 to study, develop and test comparative technologies, maximizing vision-block visibility and armor-piercing ballistic-defeat capability. This will establish a manufacturing technology to produce vision blocks that provide greater operational performance and protection.

SUMMARY

The two competing designs were glass/plastic and ceramic/glass/plastic laminates shown in Figure 1. The choice of materials was based upon optical transmission, density and commercial availability. The ceramic design was considered because of the very hard surface of the ceramic which allowed a smaller thickness than the glass/plastic design. Goodyear Aerospace Code 706 abrasion-resistant coating was used on the inner surface of the block to protect the polycarbonate ply from chemicals and mechanical abrasion of maintenance. Goodyear Aerospace Code 806 sealant was used to bond the vision block to the metal test fixture because of its low modulus of elasticity and low rate of moisture penetration.

Tests of preliminary laminate specimens were used as a base line for establishing an optimized design. The most significant change in going to a production design was the use of an F6X-2 interlayer which replaced the SR-41 PVB between the glass and ceramic face ply. This facilitated production and demonstrated better adhesion. The shape was also changed from square blocks to a tank vision block form.

Figure 1 - Direct Vision Blocks

Optical tests of the vision blocks indicated a totally acceptable performance for both types. In both the pre and post environmental tests, transmission, haze and distortion were well within the design limits.

The high temperature tests resulted in areas of delamination of the Code 806 sealant on both types of blocks. The low temperature tests resulted in smaller areas of delamination. The temperature shock test resulted in a fracture in the outermost borosilicate glass plate which was probably initiated from an undetected defect on the edge of the glass. The humidity test resulted in small delaminations of the F6X-2 interlayer and the polycarbonate backply.

It was concluded that the glass/plastic design was the more desirable of the two types. The single crystal ceramic would never be cost-competitive with glass although it is superior in ballistic properties. Recommendations were cited to improve the performance of the vision blocks in the environmental tests.

BENEFITS

The Army has now established technology for manufacturing glass/plastic vision blocks for use in many vehicles. These can be modified for use in any area in which there is a significant ballistic threat and where reduced weight is a high premium.

IMPLEMENTATION

The final technical report has been distributed to the various armored vehicle program offices. AMMRC is continuing work on this vision block with R&D funding to change the form which will reduce cost. This vision block design is under consideration for implementation on M-1 Tanks and on future Marine armored vehicles.

MORE INFORMATION

Additional information may be obtained by contacting Mr. Gordon R. Parsons at AMMRC, AV 955-5514 or Commercial (617) 923-5514. The contract number was DAAG46-79-C-0093.

Summary report was prepared by Dan Richardson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 576 1296 and 578 1296 titled, "Manufacturing Technology for CB Filters," were completed by the US Army Armament Research and Development Command in September 1981 at costs of $350,000 and $654,000 respectively.

BACKGROUND

The history of the manufacture of gas and particulate filters shows that there is very limited industry response. This is because the work involved is uncommon to industrial practices, and one where industry must rely on the Army to solve industry's production problems. The consequence is the waiving of some requirements and assisting the contractor until he can produce a specification item. In many cases, Edgewood Arsenal produced small orders due to no response from industry. This arrangement has been successful in the past, however, if poor industry response continues, the production base for many items will be jeopardized. In addition, the work being done at Edgewood Arsenal was being accomplished on antiquated equipment in four different buildings.

SUMMARY

The overall purpose of this project was to analyze the current processes used in filter production, develop process data, process baselines, and manufacturing methods which would lead to a more effective production base. It would also provide pilot scale equipment for future process engineering efforts.

The production process for filters required charcoal grinding, blending, sieving, impregnation/drying and assembly operations for filling, sealing and final testing of the filters. Each process and/or operation was evaluated for process elements, requirements, parameters, process options, and process deficiencies. The following subtasks were accomplished to support the project.

Charcoal Blending and Handling

This task evaluated the techniques and commercially available equipment for conveying, blending, storing, and metering charcoal in filter production. As a result of the study, air conveying was selected for both transporting and blending of charcoal. A small air conveyor was procured for evaluation and an available air-agitated hopper was installed for testing. The air conveying system was successfully operated with no particle crushing observed. However, a small amount of abrasion and dusting occurred which was corrected by means of an externally mounted dust collector. The existing hopper caused gross particle size segregation of the charcoal. An alternate hopper was designed and proved successful.

Filling of Conventional Filters

The purpose of this task was to evaluate existing filling techniques, and develop new techniques for filling conventional filters with charcoal. A conventional filter is one whose depth of fill is less than its smallest cross-sectional dimension. The current filling techniques were composed of two types, "face filled" and "side filled". The face filled technique was selected for further analysis of performance requirements, and process/filling operation characteristics since it is the most difficult to perform. Packed density was determined to be the most important process characteristic. The filling rate, particle velocity, and uniformity of filling, all affect the packing density of the charcoal bed. Concept studies of new filling techniques were conducted. One of the most promising, the perforated-plate concept was selected for further study as a pilot model. The concept is illustrated in Figure 1. The carbon flows into a set of matched perforated plates. The middle plate is free to slide, thus opening or closing the release paths of the carbon. The flow is controlled by the perforation size and number. The primary distribution is accomplished by adjusting the locations of the perforations while the secondary by a set of stacked screens. The particles acceleration is determined by free fall in still ambient air.

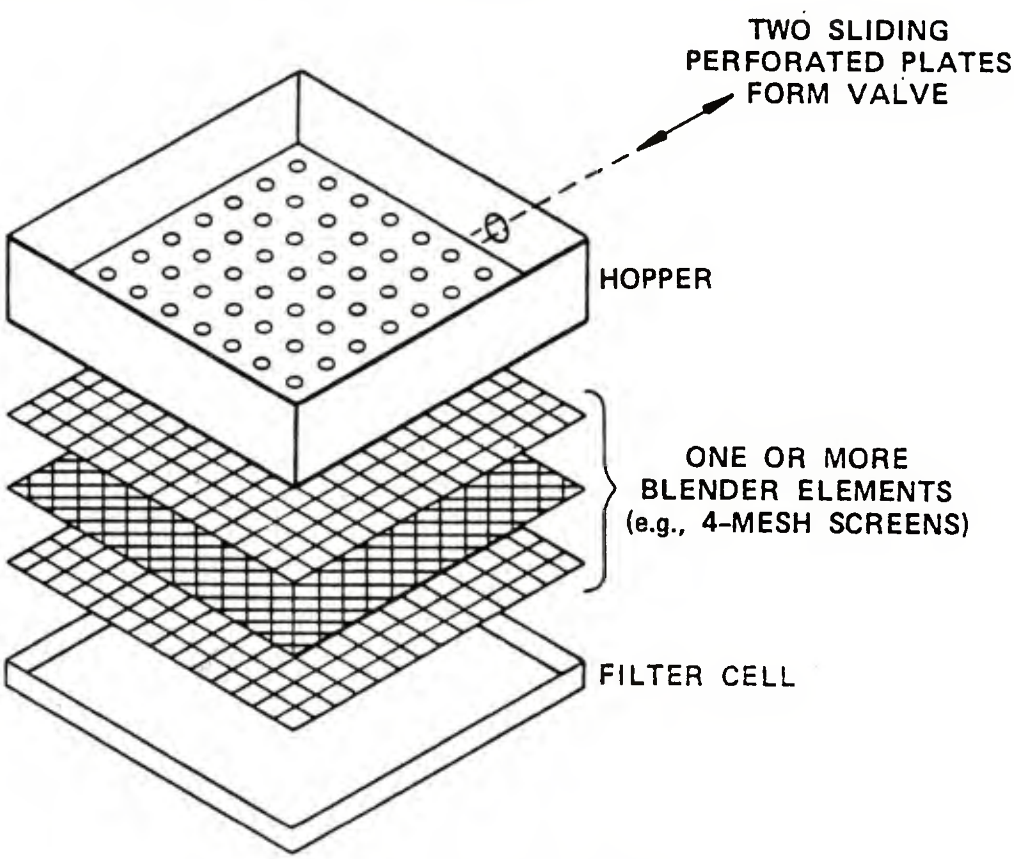


Figure 1 - Perforated-Plate Concept

Filling studies were conducted using the perforated-plate concept. The filling parameters were determined and idealized model was developed to optimize the cell density and uniformity. The prove-out and technical feasibility of a working model of the perforated-plate concept was evaluated and proved to be satisfactory.

Charcoal Impregnation

This task was necessary since the present process for producing impregnated (whetherized) charcoal involves one type of charcoal from a sole source producer. The objective of this effort was to identify alternate sources of activated carbon for making whetherite. The whetherite is formed by an impregnation process. This involved two operations: (1) wetting of the carbon with salt solutions and (2) evaporation or drying of the water from the carbon. Seven different types of charcoal were impregnated and evaluated for their performance. The results demonstrated the feasibility of producing whetherite from alternative carbons. All seven tested showed improved performance over their initial capacity. Two of the seven produced a whetherite as good or better than the current whetherite.

BENEFITS

An improved blending and handling system was developed for charcoal. A perforated-plate concept was developed and demonstrated for the face filling of charcoal filters.

IMPLEMENTATION

The hopper and vacuum transfer system has become part of the Chemical Systems Laboratory Engineering Facility. It will be used to fill the gap created by small production orders. The charcoal impregnation task will be studied further under MMT 581 0905.

MORE INFORMATION

Additional information can be obtained by contacting Mr. G. Dickey, ARRADCOM, AV 584-3910 or Commercial (301) 671-3910.

Summary report was prepared by Pete Martin, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 577 1327 titled "Improvement and Modernization of Gas Mask Leakage Testing" was completed by the US Army Armament Research and Development Command in July 1981 at a cost of $305,000.

BACKGROUND

Leakage in a gas mask is a critical defect which requires 100 percent inspection to comply with production acceptance requirements. The M14 leakage tester was designed over 25 years ago. The operator uses a probe to determine leaks while challenging the mounted mask with smoke. This technique and tester is archaic, tedious, semiquantitative, requires undue maintenance, and is operator dependent. New advances in technology for measuring trace amounts of aerosols and gases have obsoleted the use of the M14 gas mask leakage tester. Therefore, a need existed for an improved gas mask leakage tester.

SUMMARY

The main objective of the project was to design and develop a reliable, sensitive, more compact, and modernized mask tester for production, surveillance, rework and field testing.

A contract was let to Southern Research Institute (SRI) to design, fabricate, and evaluate a prototype mask tester. In addition, a reliability study and technical data package were to be established.

Initially SRI studied the M14 tester and investigated several types of tracer detector combinations. Based upon the design study, SRI breadboarded a gaseous tracer system (HNU Systems PI-101 detector and isobutylene gas) and an aerosol tracer system (Phoenix Precision JM-7000 aerosol photometer and Dow Corning DC-704 silicon diffusion pump oil generated aerosol). Due to a number of problems with the gaseous system such as slow response time and hydrocarbon levels in room air, the aerosol system was selected for further development.

After SRI fabricated the test enclosure and mechanical flexing device, it became obvious that although the mask would be flexed mechanically, the device was cumbersome, expensive and slow. At this point, the technical direction of the contract was changed to emphasize a compact tester utilizing manual flexing. SRI was tasked to construct the two prototypes simultaneously.

The tester designed by SRI consisted of four units; a flow control enclosure, vacuum pump enclosure, photometer and a test head assembly.

The flow control enclosure contained the aerosol generator and the basic valves, regulators, filters and gages for controlling and/or measuring aerosol generation and test flow and pressure drop. The photometer was a modified Phoenix Precision JM-7000 model and was used to determine 100 percent aerosol challenge and measure any leakage through the mask. The vacuum pump inclosure contained the vacuum pump and controls used to provide the vacuum for holding the mask to the test head. A flow diagram showing the arrangement of the equipment is given in Figure 1. The modular design of the tester permitted the placing of the test head in a laboratory hood, allowing easy evacuation of the test aerosol.

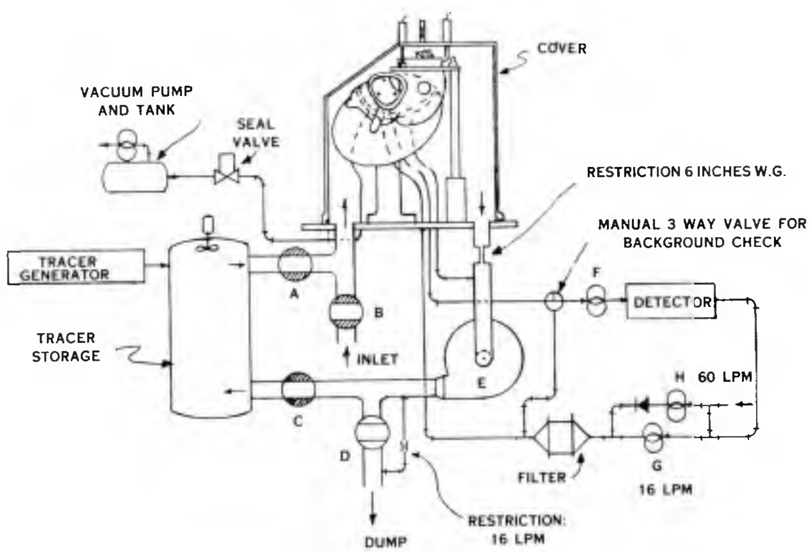


Figure 1 - Flow Diagram Showing Tentative Arrangement of Equipment

A new protective mask leakage tester (Model Q228), as designed, fulfilled the performance requirements. In addition, the tester was portable and required only compressed air and 120 VAC electrical service for operation. The modular construction facilitated cleaning and maintenance, and the fewer number of components as compared to the M14 provided for greater reliability.

An important consideration in this project was the development of cheap, reliable, standardized pass-fail calibration leaks. The use of pinhole apertures fulfilled this requirement and was demonstrated as a feasible calibration technique during the reliability and acceptance test phases of this project.

Although the Q228 was developed to function with a silicone oil aerosol, the Government directed, in the latter phases of this project, that a PEG 200 (Polyethylene Glycol 200) oil aerosol be used in preference to a silicone oil. Since the SG-20 aerosol generator can produce an aerosol from virtually any liquid, this presented no problem. However, the Q228 would not function properly with a PEG 200 aerosol since the aerosol tended to evaporate after generation.

New testheads were developed for the Q228 which used a vacuum sealing groove around the periphery of the mask. The mask was firmly held to the testhead and could vigorously be flexed without loss of adhesion. The new testheads were made from plaster casts of various masks. A method was developed for inexpensively casting new testheads from master molds by using a polyester resin type material.

Acceptance and reliability tests were performed on the two prototypes. During the reliability tests, the alarm meter on the aerosol photometer of the second prototype failed. It was determined that this was an unusual failure of a normally high-reliability component and it should therefore not be expected to require maintenance or replacement in the first 1000 hours of operation.

BENEFITS

Prototype gas mask leakage testers were developed which provided increased reliability and accuracy over the previous M14 leakage tester. These new testers should improve the quality of the end item and reduce maintenance and down-time costs.

IMPLEMENTATION

The prototype leakage tester was not applied to production acceptance testing. The initial design and data, however, formed the basis for a new improved leakage tester which has expanded operational scope. Establishing this improved tester will be performed under MMT Project 584 0925 and will be capable of evaluating performance under simulated usage.

MORE INFORMATION

Additional information can be obtained by contacting the project officer, Mr. A. Kohut, Chemical Systems Laboratory, AV 584-3608 or Commercial (301) 671-3608.

Summary report was prepared by Pete Martin, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 578 1339 titled "Manufacturing Technology for Preparation of B-1 Dye" was completed by the US Army Armament Research and Development Command in December 1980 at a cost of $501,000.

BACKGROUND

Detector papers use dyes that react with chemical agents to change color to indicate the presence of lethal chemical agents. The process used to produce B-1 dye [(1-4 nitrophenylazo)-2 naphthalenamine] involved the use of B-naphthylamine, a known carcinogen, as a starting material. RDTE studies resulted in an alternate process utilizing Tobias acid, a non-mutagenic/non-carcinogenic as the starting material. The final B-1 dye produced is still mutagenic; however, TRADOC has a continuing requirement for the detector kits. The manufacturing process for the B-1 dye needed to be scaled-up and the process parameters optimized.

SUMMARY

The primary objective of this project was to establish a process which can be used to manufacture B-1 dye for manufacture of the M9 paper without the use of B-naphthylamine. A secondary objective was the investigation of drying and grinding methods to produce B-1 dye with the particle size distribution required. The primary objective was accomplished by using Tobias acid (2-aminonaphthalene-1-sulfonic acid) which is not carcinogenic, as the starting material rather than the B-naphthylamine. The substitution would result in two benefits; ie, eliminate the need to handle and store the carcinogenic material and reduce to acceptable levels the B-naphthylamine concentration in the final product.

The basic step in the synthesis of B-1 dye was the coupling reaction between diazotized p-nitroaniline and the sodium salt of Tobias acid. A process flow sheet to produce the B-1 dye is shown in Figure 1. The p-nitroaniline was diazotized in the diazo reactor using sodium nitrite and hydrochloric acid. The Tobias acid was reacted in a separate vessel with sodium acetate to form the sodium salt of the acid. These two materials were then mixed in the coupling reactor to form the B-1 dye. The reactors were cooled by a chiller system and temperatures monitored by an automatic temperature controller system. The B-1 dye was then fed to a centrifuge for washing and filtering. The final dye was slurried with water and a dispersant before final packout.

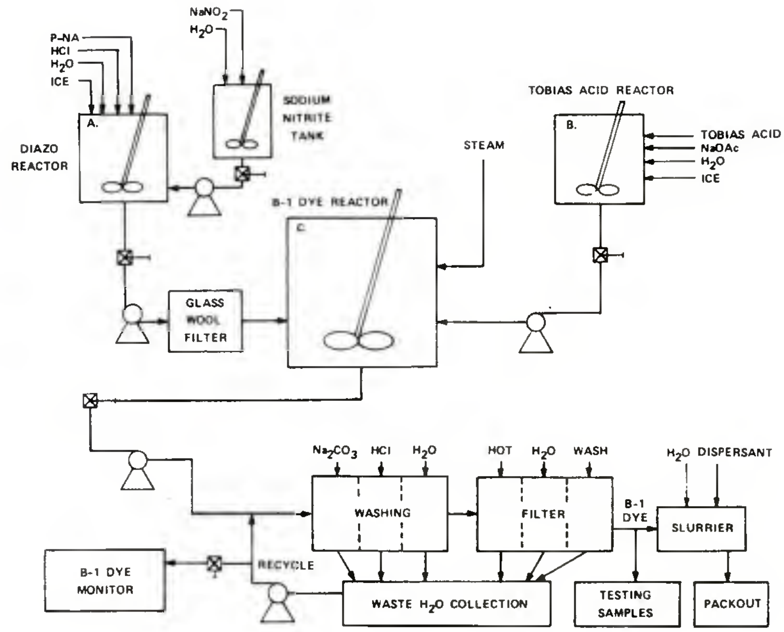


Figure 1 - B-1 Dye Process Flow Sheet

Runs were made using the pilot plant setup discussed above to investigate the parameters of reaction time, wetting point, and purity of the dye. Samples from the various batches produced were taken from the outlet of the centrifuge and sequentially provided for analytical testing against the specification requirements. Tests were done to establish the melting point, purity, solubility in acetane and heptane, and percent free B-naphthylamine.

A secondary objective was the investigation of drying and grinding methods to produce B-1 dye with the particle-size distribution required. Spray drying was investigated in a limited manner as a means of particle-size control. The results obtained in this investigation showed that although spray drying was an excellent drying method per se for B-1 dye, the resultant particles were much finer than required by the specification. Due to the fineness of the particles produced in the reaction, the grinding investigations were unnecessary; and, in fact, additional work is required on methods to increase the particle size of the dye during production.

The process investigation results showed that the B-1 dye produced met all of the chemical tests using a 2 1/2 hour coupling reaction time. The dye was used to make handsheets of the M-9 paper which were then tested for response to the VX simulant. Acceptable results were obtained in terms of color development and response times.

Based on the results of these trials, it appears that batches of B-1 dye which contain significant fines as well as larger particles could still be used to make acceptable M9 chemical agent detector paper. If this can be verified by additional indepth testing, the spray drying process could be recommended for the industrial production of B-1 dye in the event that dry dye, rather than the "water-dispersed formulation," is ever desired. Also, the particle-size requirement, as given in the specification, could be significantly relaxed. Disadvantages of the finer particles are increased interference from gasoline and other solvents as well as a pinkish blush on the paper.

From the results of the investigations made during the MMT project, a manufacturing directive for B-1 dye (100-lb batch) was prepared which provided detailed instructions for every step in the process, amounts of chemicals to be used, stirring and reaction times, temperature parameters for the various reactions, and a process flowsheet.

This manufacturing directive was incorporated into the TDP for the M9 chemical agent detector paper. The manufacturing directive was proven by industry through the manufacture of an 800-lb batch of B-1 dye made exactly as specified by the manufacturing directive.

BENEFITS

This project has resulted in the establishment of a safe chemical process for the manufacture of B-1 dye. The process eliminates the use of B-naphthylamine, a known carcinogen, as the starting material. A manufacturing directive for the process was prepared which enhanced industry's ability to produce this material.

IMPLEMENTATION

The manufacturing directive was included in the TDP for the M9 Chemical Agent Detector Paper. Atlantic Chemical Company was awarded a contract to produce an industrial batch of B-1 dye by the procedure defined in the manufacturing directive. The manufacturing directive will also be available to future industrial producers of the B-1 dye and M9 Chemical Agent Detector Paper.

MORE INFORMATION

To obtain additional information, contact the project officer, Mr. R. Vigus, AV 584-4424 or Commercial (301) 671-4424.

Summary Report was prepared by Pete Martin, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 678 7743 titled "Application of Anti-Fog Conductive Films" was completed by the US Army Armament Research and Development Command in July 1980 at a cost of $70,000.

BACKGROUND

Icing and fogging of exposed optical surfaces, such as tank periscope windows, under certain weather conditions lead to impaired visibility, leaving the weapons system vulnerable. Many methods are available to reduce the icing and fogging. The most preferable method is direct surface heating of the glass using electrically and thermally conductive optical films. The objective of this project is to develop the manufacturing methods for applying thin films to optical glass which are thermally conductive, electrically conductive and optically transparent.

SUMMARY

A T-46 periscope window was selected for developing the manufacturing methods. ARRADCOM's approach was to coat the entire glass surface with conductive material, deposit an antireflective coating and deposit electrodes as shown in Figure 1. This configuration allows an even distribution of heat and produces no optical aberations. The electrodes were deposited along the long sides of the glass to reduce the electrical resistance of the coating, to distribute the current evenly and to provide a convenient method of simultaneously mounting the window and making electrical contact.

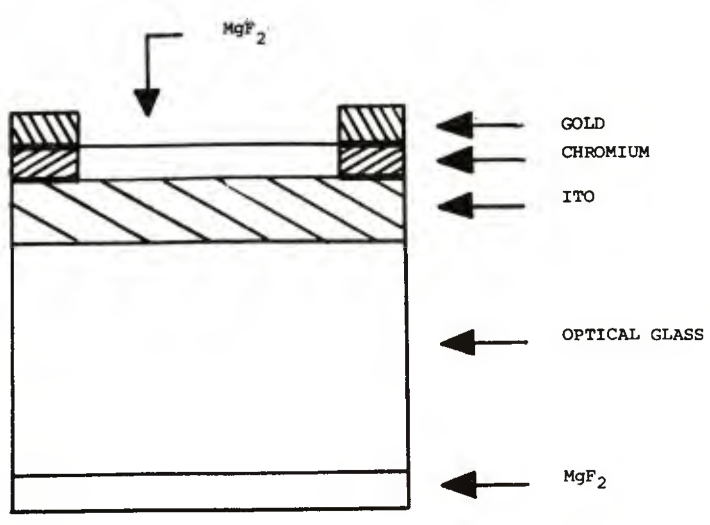


Figure 1 - Finished Window

The fabrication of the windows begins with the preparation of a sputtering target which is 96.3 percent indium and 3.7 percent tin by surface area. Even though other film materials are available, such as tin antimony oxide and gold, the coating material chosen was indium tin oxide (ITO) because of its superior visible light transmission property.

The optical glass substrates were hand-rouged, washed with soap and water, rinsed with distilled water, vapor degreased with ethanol and placed in the sputtering chamber. They were sputter-etched for 5 minutes at .5 KW of RF in argon plasma. The sputter target was sputter-etched clean before each deposition. The highest optical transmission of 88% and lowest resistivity of 750 ohm/square was achieved by post-baking the coated substrates in a vacuum at 250°C for 15 minutes and then in air at 350°C for 15 minutes.

The ITO coated window was masked off so that only 0.1 inch strips on the lengthwise edges were exposed to electrode deposition. A 0.03 microns thick chromium film was sputtered on followed by a 0.1 microns thick coating of gold. The masking was then removed.

An antireflection coating of MgF_2, optimized for .55 microns wavelength, was deposited until a minimum reflection from the ITO surface was achieved. This improved the transmission to 94%. A quarter wave coating of MgF_2 was deposited to the other surface, bringing the total transmission to 97%.

BENEFITS

A method for applying anti-fog coatings to small optical windows has been developed and is available. These coatings meet durability requirements of MIL-SPEC 675A for adherence and abrasion and meet the environmental requirements of many systems. Retrofit is simplified by the already existing window brackets that are common to most periscope windows.

IMPLEMENTATION

The anti-fog coatings have been tentatively approved for the upcoming FY83 PIP on the M60 Tank.

MORE INFORMATION

Additional information on these coatings can be obtained by contacting Mr. Louis Herczeg, ARRADCOM, AV 880-2873 or Commercial (201) 328-2873. The technical report number is ARSCD-TR-80013.

Summary report was prepared by Dan Richardson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Project 677 7744 titled "Improved Manufacturing Parameters for Optics" was completed by the US Army Armament Research and Development Command in June 1981 at a cost of $163,000.

BACKGROUND

Military specification MIL-O-13830 defines manufacturing criteria and in-process inspection procedures for optical elements, and is specified on optical component drawings.

The MIL-O-13830 was issued in 1954 to provide the product requirements and quality assurance provisions for the manufacture, assembly, and inspection of such optical components as lenses, prisms, mirrors, reticles, windows, and wedges for optical fire control instruments. It was revised in 1963. The specification defines the surface quality of glass optical components by reference to a sample set of visual Scratch & Dig comparison standards maintained by the US Army Armament Research and Development Command at Dover, NJ in the Product Assurance Directorate. The specification is mandatory for use by the Departments of the Army, the Navy, and the Air Force. As a result, much of the optical industry has adopted MIL-O-13830 as a procurement specification for glass optical components for other optical devices and systems, as well as for optical fire control instruments.

The requirements and testing procedures of MIL-O-13830 have not kept pace with present day technology in properly defining and assigning readily measurable acceptance testing parameters and in establishing objective manufacturing criteria for optical elements. The criteria and requirements of MIL-O-13830 were developed at a time when successful optical manufacture could depend on a qualitive statement of parameters to obtain acceptable optics. Current optical and electro-optical manufacturing technology with its emphasis on complex high quality optics demands a more precise statement of requirements.

SUMMARY

This project has been initiated to review the state-of-the-art in the manufacture/inspection of optics in order to update MIL-O-13830A1 to make it more compatible with current optics manufacturing technology and inspection procedures and to broaden the scope of this standard to provide a general specification for optical components suitable for fire control and other applications. The American National Standards Institute (ANSI) is currently working on a parallel specification for Optical Surface Quality.

The parameters set forth in the specification were reviewed in light of current manufacturing methods and testing technology. Parameters that no longer have meaningful application were marked for removal; others will be restated in modern quantitative terms, and new parameters will be recommended for manufacturing areas not now addressed. Test methods used to determine compliance with the manufacturing parameters were also reviewed and modified to reflect the quantitative output capabilities of current testing technology.

The project resulted in a final report which primarily presents a set of detailed areas that need to be investigated in MIL-O-13830, and could result in recommendations for changes in manufacturing parameters and test methods used to manufacture and accept precision optical components.

BENEFITS

Results of this project will help form either a new or revised specification for the manufacture, assembly and inspection of optical components for all kinds of instruments.

IMPLEMENTATION

In order to better resolve some of the major deficiencies found in the present MIL-O-13830A, the following FY79 MTT & FY80 MMT projects were initiated:

1. MTT Project No. 021-79 for "Development of Calibration Techniques for Scratch & Dig Standards", to replace the current visual method of comparative calibration.

2. MTT Project No. 022-79 for "Development of an Optical Performance Tester", to investigate the adaptation and application of optical performance testers such as those that determine the modulation transfer function to subjective determinations of such optical quality criteria as resolution.

3. MMT Project No. 6 80 8054 to "Improve Manufacturing Techniques and Quality of Optical Scratch & Dig Standards for Fire Control Systems", to obtain improved repeatable techniques for fabricating Optical Scratch & Dig Standards.

When the investigations of these projects are completed, new ideas will have been generated to be incorporated into a recommendation for a complete revision of MIL-O-13830A through proper DoD revision channels.

MORE INFORMATION

Additional information may be obtained from Mr. David Askin, ARRADCOM, AV 880-2964 or Commercial (201) 328-2964. The final technical report number for this project is FCSD-01-80.

Summary report was prepared by Dan Richardson, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

MANUFACTURING METHODS AND TECHNOLOGY

PROJECT SUMMARY REPORT

(RCS DRCMT-302)

Manufacturing Methods and Technology Projects 679 8010 and 680 8010 titled "Acoustic Microwave Filters" were completed by the US Army Armament Research and Development Command in June 1981 at a cost of $383,000.

BACKGROUND

Prior industry and Government efforts had used Electron Beam Lithography techniques to manufacture masks for integrated circuits and for the direct write fabrication of components.

Acoustic surface wave technology was established for the production of signal processing devices having frequencies in the megahertz and gigahertz range. Devices operating in the microwave or millimeter wave frequencies for application in Army fire control sensing systems were not readily available. The prime production problem was identified as the formation of complex metallic structures on suitable substrates with line spacing and tolerances measured in sub-micron range. The effort was undertaken to establish prototype equipment and build a pilot line operation at ARRADCOM, Dover, NJ.

SUMMARY

The objective of this effort was to establish a pilot production line to fabricate high yield devices for microwave filters, resonators, and opto-acoustic sensors and devices for signal processing.

The approach was to integrate commercially available manufacturing systems. The major work stations were to consist of a vacuum metalizing station, a high resolution electron beam mask generator and an ion milling station.

A high resolution electron beam system (Model AMR-1000 from AMRAY, Bedford, MA) was installed. Several exposures of Poly-Methyl Methacrylate (PMMA) were fabricated. A fly-spot scanner was installed and a successful test pattern was fabricated.

Interdigital grid structures of 1 micron to .3 micron were fabricated, as illustrated in Figure 1.

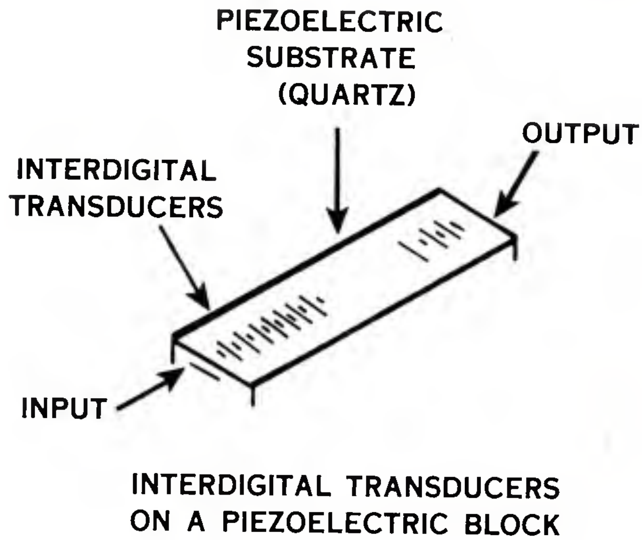


Figure 1 - Example of Interdigital Grid Structure Fabricated

BENEFITS

The resulting system was a low cost analog controlled electron lithography system. Sub-micron line widths (0.3 micron) for acoustic microwave filters can be fabricated. This system could potentially be used for prototype development. The acoustic microwave filter group in the Electronic Technology Device Laboratory, Ft. Monmouth, NJ, or other Government agencies have access to this equipment.

IMPLEMENTATION

Further effort to implement the results from this effort are not advisable. The Department of Defense Very High Speed Integrated Circuits program is evaluating alternatives to electron lithography for fabricating sub-micron line widths. The pilot line was disassembled and the equipment is being used for other purposes.

MORE INFORMATION

Additional information can be obtained from the project officer, Dr. T. Chin, ARRADCOM, Dover, NJ, AV 880-2188 or Commercial phone (201) 328-2188.

Summary report was prepared by Stephen A. McGlone, Manufacturing Technology Division, US Army Industrial Base Engineering Activity, Rock Island, IL 61299.

APPENDIX I

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APPENDIX II

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