THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Proceedings of the IREAPS Technical Symposium

Paper No. 2: PARTGEN: An Advanced Interactive Method for Highly Automated Parts Generation Based on the Design Model Data

U.S. DEPARTMENT OF THE NAVY CARDEROCK DIVISION, NAVAL SURFACE WARFARE CENTER

**PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
Naval Surface Warfare Center CD Code 2230 - Design Integration Tools
Building 192 Room 128 9500 MacArthur Blvd Bethesda, MD 20817-5700

**DISTRIBUTION/AVAILABILITY STATEMENT**
Approved for public release, distribution unlimited

**ABSTRACT**

The PARTGREN (PARTs Generation) system is an advanced method for the highly automated generation of parts design models. It takes advantage of the Design Model Data (DMD) that is available for shipbuilding projects. The system uses a set of rules and algorithms to generate parts based on the DMD, allowing for efficient and accurate part creation. The PARTGREN system is an interactive tool that facilitates the design process by automating the generation of parts, thereby reducing the time and effort required for manual part design. This system is particularly useful in shipbuilding projects where the design and generation of parts are critical to the success of the project.
DISCLAIMER

These reports were prepared as an account of government-sponsored work. Neither the United States, nor the United States Navy, nor any person acting on behalf of the United States Navy (A) makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness or usefulness of the information contained in this report/manual, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or (B) assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in the report. As used in the above, “Persons acting on behalf of the United States Navy” includes any employee, contractor, or subcontractor to the contractor of the United States Navy to the extent that such employee, contractor, or subcontractor to the contractor prepares, handles, or distributes, or provides access to any information pursuant to his employment or contract or subcontract to the contractor with the United States Navy. ANY POSSIBLE IMPLIED WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR PURPOSE ARE SPECIFICALLY DISCLAIMED.
Proceedings
I REAPS Technical Symposium
September 14-16-1982
San Diego, California

VOLUME 1

INSTITUTE FOR RESEARCH AND ENGINEERING FOR AUTOMATION AND PRODUCTIVITY IN SHIPBUILDING

IREAPS
PARTGEN: AN ADVANCED INTERACTIVE METHOD
FOR HIGHLY AUTOMATED PARTS GENERATION BASED ON THE DESIGN MODEL DATA

Frans von Cuilenborg
Development Project Leader
Shipping Research Services
Oslo, Norway

Mr. Cuilenborg has 19 years of shipbuilding experience, 14 of those years with Shipping Research Services in Norway.

ABSTRACT

This is a brief introduction to the present status of the AUTOMODL development effort (AUTOKON) and an indepth description of the first module of AUTOMODL named PARTGEN. PARTGEN works on a topological model of the ship and is stored in the database. PARTGEN uses extensively interactive graphics and will virtually eliminate 90 percent of what today is called partcoding in the production phase. In addition to performing part generation, PARTGEN also has other valuable functions. It can do fairing of lines, interactively, to establish a preliminary hull form for building up the design model in the database. It has a report generator whereby the user can make extensive reports from the database and make user formulated layouts on the reports. PARTGEN also includes extensive automatic updating procedures due to changes. This is a benefit of having parts for production stored as topological data instead of as geometry.
PARTGEN

The first module in AUTOMODL

Introduction

PARTGEN is the first available module in AUTOMODL. It is using the new Database system TORNADO which will be the common database for AUTOMODL. PARTGEN is an interactive tool to define steel structures in plane surfaces. The PARTGEN module can be used in three different ways.

0 PARTGEN can receive curves from other programs. These curves will then form various surfaces, and these surfaces will be in various stages of completion depending on the detailing level done with other programs. These curves may include boundary curves for the surfaces (edges), intersection curves, trace curves (stiffener traces), seam curves and curves with cutouts.

0 PARTGEN can also build up the structure within a surface using available commands and macros.

0 PARTGEN can also be used as a combination of the two above. This will typically be the case when the structure is only partially finished before PARTGEN is used.

The regular output from PARTGEN is production parts ready for nesting. However, output or information is also stored in the database, and various reports can be generated as regular output. Output from PARTGEN can also be used by AUTODRAW for generation of drawings.
PARTGEN IN AUTOMDL

AUTOMDL

NONE PLANAR SURF. DEF.
NONE PLANAR PROFILES
NONE PLANAR PARTS

PLANAR SURF. DEF.
PLANAR PROFILES

PLANAR PARTS
TODAY'S
PARTGEN

IS
D. B.
Systemphilosophy

In PARTGEN there are several basic concepts that need some explanation.

**Product.** A product in PARTGEN is the entire structure the user wants to work with. It can be an entire ship, a half ship or a group of units. A product is normally given a name like YN 228AB. A project identification (Project number) is also linked to the product.

**Surface.** A product is built up of various surfaces. A surface is defined as a U, V, W-coordinate system, related to the global X, Y, Z system. The surfaces in PARTGEN are given names by the user. The naming-conventions made so far should be familiar. PARTGEN is using names like: SHELL, DECK, PLTF, STRINGER, GIRDER, TFRAME etc.

**Curves.** A surface is built up by various curves, and a particular curve is always within a surface. These curves may be generated by PARTGEN itself, or they may be coming from other programs like BOF, TRALOS, TRADET etc. There are several types of curves, and each curve has a name (type) and a numeric identification number. The type of a curve also indicates what kind of curve it is. We have HOLE-CURVE (holes), SEAM-CURVES (seams, butts), TRACE-CURVES (traces of stiffeners), INTERSECTION-CURVES (curves formed by two surfaces intersecting each other) etc.

The three above mentioned concepts form the basis for part-generation with PARTGEN. Except for the Product, the user is free to manipulate surfaces and curves at any time in the PARTGEN process, thus being able to take care of last minute changes.
CONCEPTS AND RELATIONS

SURFACE (PLANE SURF.)

CURVES IN A SURFACE

PARTS

PRODUCT

ASSEMBLY

SUBASSEMBLY

SURFACE

CURVE

PART
CURVES IN A SURFACE

SEAM CURVES

TRACE-CURVES

HOLE CURVE

ALL CURVES COMING FROM TRALOS/TRADET/ISDRAW
ALL CURVES CAN BE MODIFIED OR DELETED BY PARGEN
NEW CURVES OF ANY TYPE CAN BE ADDED BY PARGEN

INT-CURVES

TRACE-CURVES

HOLE-CURVES

R COMMANDS TO GEN. HOLES
Assembly. The assembly concept is used when PARTGEN is used for generation of production parts. The user can establish a tree structure with assemblies and subassemblies, where the assembly normally will be a block or unit. The assemblies have identification numbers as also the subassemblies have. An assembly or subassembly is built up by parts for production. A part can not be defined without belonging to an assembly.

Parts. Parts are defined in PARTGEN as belonging to an assembly or subassembly. One particular part will reside in a surface and contain various curves, also belonging to a surface.

PARTGEN is not a part splitting program. It does not even have any part splitting capability. PARTGEN is using intersection points between curves to generate a part. The part is built up by topological points formed by the intersection points between the curves. This concept makes automatic updating of parts based on modifications to curves easy.
How PARTGEN works

Normally, the PARTGEN process will start up after, or at the end of building up the model of the structure in the database. The building up of the model in the database is today done by the programs BOF, LANSKI, TRALOS and TRADED. These are traditional batch oriented programs. However, they are not run as batch programs today. All the traditional waiting time in a batch environment has been eliminated by running the programs on-line on a minicomputer from a graphic screen (terminal) like Tektronix or LSI-ADM 32. Quick verification and response to changes are key words in this context. In the near future, the complete model build up in the database will be done by other AUTOMODL modules. Today, parts of the model can also be built up by PARTGEN. The initial bulk of data belonging to the model is transferred to the PARTGEN database by the programs DRAWIS and AUTOLINK.

From the PARTGEN database the user will bring up a particular surface or group of surfaces on the screen. This can be the whole surface or only a window of it. Normally a window is used for better clarity. If the surface is complete the part generation process starts immediately. However, if additional seams or holes have to be generated, this is now done with PARTGEN directly and included in the surface and stored in the database. The actual part generation is done by using the crosshair to point at intersection points of curves that form the boundary of a particular part. However, before the actual part generation takes place, an assembly must be started by the command BEG-ASS name. Every curve that is inside the part will be included. This includes holes and traces of stiffeners. By the crosshair pointing, the topology of the part is generated.
PART GENERATION

COMMANDS TO GEN. TWO PARTS.

RESULT ON SCREEN AFTER CLEAR.
CROSSHAIR-POINTING SEQUENCE.

FINISHED PART (PART 1)
PART GENERATION

FINISHED PART (PART 2)

PART GENERATION

ORIGINAL SURFACE

POINTING SEQUENCE: ONE PART
PART GENERATION

FINISHED PARTS

PART MODIFICATION

COMMANDS TO DELETE A HOLE. (BY POINTING)

MESSAGE ON THE SCREEN. PARTS DELETED DUE TO HOLE DELETE. (TOPOLOGY MODIFIED.)
PART MODIFICATION

NEW PART

PART MODIFICATION

ADDING A NEW HOLE INSIDE AN EXISTING PART.
RESULT ON SCREEN.

COMMANDS AND SYSTEM RESPONSE
NEW PART
GENERATED AUTOMATICALLY BY SYSTEM.

PART MODIFICATION

ORIGINAL SURFACE WITH SEAM-CURVE 25.
TWO PARTS HAVE BEEN GENERATED.
PART GENERATION

THE TWO NEW PARTS GENERATED AUTOMATICALLY BY SYSTEM.
<table>
<thead>
<tr>
<th>PARTS-HArd NUMBER</th>
<th>THICK, AREA</th>
<th>WEIGHT</th>
<th>COG, X</th>
<th>COG, Y</th>
<th>COG, Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>PART 11 0 0</td>
<td>15.00</td>
<td>5.58</td>
<td>681.48</td>
<td>11998</td>
<td>-2077</td>
</tr>
<tr>
<td>PART 12 0 0</td>
<td>15.00</td>
<td>10.29</td>
<td>1211.69</td>
<td>18977</td>
<td>-8294</td>
</tr>
<tr>
<td>PART 13 0 0</td>
<td>15.00</td>
<td>12.18</td>
<td>1464.50</td>
<td>16818</td>
<td>-6799</td>
</tr>
<tr>
<td>PART 14 0 0</td>
<td>15.00</td>
<td>5.55</td>
<td>651.48</td>
<td>11998</td>
<td>-2077</td>
</tr>
<tr>
<td>PART 15 0 0</td>
<td>15.00</td>
<td>10.29</td>
<td>1211.69</td>
<td>18977</td>
<td>-8294</td>
</tr>
<tr>
<td>PART 16 0 0</td>
<td>15.00</td>
<td>12.18</td>
<td>1464.50</td>
<td>16818</td>
<td>-6799</td>
</tr>
<tr>
<td>PART 17 0 0</td>
<td>15.00</td>
<td>12.18</td>
<td>1464.50</td>
<td>16818</td>
<td>-6799</td>
</tr>
<tr>
<td>PART 18 1 1</td>
<td>3.50</td>
<td>12.61</td>
<td>340.85</td>
<td>14279</td>
<td>-1479</td>
</tr>
<tr>
<td>PART 19 1 1</td>
<td>3.50</td>
<td>12.61</td>
<td>340.85</td>
<td>14279</td>
<td>-1479</td>
</tr>
<tr>
<td>PART 20 1 1</td>
<td>3.50</td>
<td>0.71</td>
<td>50.85</td>
<td>14518</td>
<td>8240</td>
</tr>
<tr>
<td>PART 21 1 1</td>
<td>3.50</td>
<td>0.71</td>
<td>50.85</td>
<td>14518</td>
<td>8240</td>
</tr>
<tr>
<td>PART 22 1 1</td>
<td>3.50</td>
<td>0.76</td>
<td>55.76</td>
<td>15142</td>
<td>8240</td>
</tr>
<tr>
<td>PART 23 1 1</td>
<td>3.50</td>
<td>0.76</td>
<td>55.76</td>
<td>15142</td>
<td>8240</td>
</tr>
<tr>
<td>PART 24 1 1</td>
<td>3.50</td>
<td>1.08</td>
<td>90.65</td>
<td>15765</td>
<td>-8240</td>
</tr>
<tr>
<td>PART 25 1 1</td>
<td>3.50</td>
<td>1.08</td>
<td>90.65</td>
<td>15765</td>
<td>-8240</td>
</tr>
<tr>
<td>PART 26 1 1</td>
<td>3.50</td>
<td>1.11</td>
<td>92.32</td>
<td>15895</td>
<td>-8240</td>
</tr>
<tr>
<td>PART 27 1 1</td>
<td>3.50</td>
<td>1.11</td>
<td>92.32</td>
<td>15895</td>
<td>-8240</td>
</tr>
<tr>
<td>PART 28 1 1</td>
<td>3.50</td>
<td>0.76</td>
<td>57.50</td>
<td>15765</td>
<td>8240</td>
</tr>
<tr>
<td>PART 29 1 1</td>
<td>3.50</td>
<td>0.76</td>
<td>57.50</td>
<td>15765</td>
<td>8240</td>
</tr>
<tr>
<td>PART 30 1 1</td>
<td>3.50</td>
<td>0.84</td>
<td>62.96</td>
<td>16098</td>
<td>8240</td>
</tr>
<tr>
<td>PART 31 1 1</td>
<td>3.50</td>
<td>0.84</td>
<td>62.96</td>
<td>16098</td>
<td>8240</td>
</tr>
<tr>
<td>PART 32 1 1</td>
<td>3.50</td>
<td>0.91</td>
<td>67.85</td>
<td>17014</td>
<td>8240</td>
</tr>
<tr>
<td>PART 33 1 1</td>
<td>3.50</td>
<td>0.91</td>
<td>67.85</td>
<td>17014</td>
<td>8240</td>
</tr>
<tr>
<td>PART 34 1 1</td>
<td>3.50</td>
<td>1.18</td>
<td>86.87</td>
<td>14190</td>
<td>1012</td>
</tr>
<tr>
<td>PART 35 1 1</td>
<td>3.50</td>
<td>1.18</td>
<td>86.87</td>
<td>14190</td>
<td>1012</td>
</tr>
<tr>
<td>PART 36 1 1</td>
<td>3.50</td>
<td>2.46</td>
<td>185.65</td>
<td>11630</td>
<td>8240</td>
</tr>
<tr>
<td>PART 37 1 1</td>
<td>3.50</td>
<td>2.46</td>
<td>185.65</td>
<td>11630</td>
<td>8240</td>
</tr>
<tr>
<td>PART 38 1 1</td>
<td>3.50</td>
<td>2.59</td>
<td>218.98</td>
<td>13945</td>
<td>8240</td>
</tr>
<tr>
<td>PART 39 1 1</td>
<td>3.50</td>
<td>2.59</td>
<td>218.98</td>
<td>13945</td>
<td>8240</td>
</tr>
<tr>
<td>PART 40 1 1</td>
<td>3.50</td>
<td>1.16</td>
<td>86.87</td>
<td>14190</td>
<td>1012</td>
</tr>
<tr>
<td>PART 41 1 1</td>
<td>3.50</td>
<td>1.16</td>
<td>86.87</td>
<td>14190</td>
<td>1012</td>
</tr>
<tr>
<td>PART 42 1 1</td>
<td>3.50</td>
<td>1.17</td>
<td>87.25</td>
<td>15585</td>
<td>1080</td>
</tr>
<tr>
<td>PART 43 1 1</td>
<td>3.50</td>
<td>1.17</td>
<td>87.25</td>
<td>15585</td>
<td>1080</td>
</tr>
<tr>
<td>PART 44 1 1</td>
<td>3.50</td>
<td>6.54</td>
<td>264.18</td>
<td>15585</td>
<td>8240</td>
</tr>
<tr>
<td>PART 45 1 1</td>
<td>3.50</td>
<td>6.54</td>
<td>264.18</td>
<td>15585</td>
<td>8240</td>
</tr>
<tr>
<td>PART 46 1 1</td>
<td>3.50</td>
<td>6.91</td>
<td>301.99</td>
<td>14890</td>
<td>8240</td>
</tr>
<tr>
<td>PART 47 1 1</td>
<td>3.50</td>
<td>6.91</td>
<td>301.99</td>
<td>14890</td>
<td>8240</td>
</tr>
<tr>
<td>PART 48 1 1</td>
<td>3.50</td>
<td>6.91</td>
<td>301.99</td>
<td>14890</td>
<td>8240</td>
</tr>
<tr>
<td>TOTAL</td>
<td>11100.20</td>
<td>11718</td>
<td>620</td>
<td>15732</td>
<td></td>
</tr>
</tbody>
</table>
Any time, later, that the topology of the part is changed, the user will get a message on the screen that part nos. involved will be deleted.

If, on a finished part, the internal structure is changed, by adding a hole or removing a stiffener trace, the parts involved will be automatically updated without any interference by the user. If the user wants to generate snipes (corner cutouts) at one or more corners of the parts this is done by initially using a SET-command to establish a basic radius.

(SET-CORNER-OUT-RAD 10). Now 10 mm is set as basic radius for corner snipes. When pointing at a corner with the crosshair and using the 2 key on the keyboard when pointing, a corner cutout with radius 20 mm is generated at that corner.

By proceeding in this way parts are generated and stored in assemblies in the database. Weights and center of gravities can be generated for assemblies and printed out in various formats. Also other reports from the database can be generated by report-generator facilities.

The PARTGEN commands include all the AUTOPART commands familiar to the yards using this module presently. This means that all the geometry possibilities in AUTOPART are available in PARTGEN, and so are the macro facilities. This fact will make the transition from AUTOPART to PARTGEN easy and quick for old users.

By using the PARTGEN module for production part generation, the actual part coding, as we know it from ALKON and AUTOPART will in effect disappear, and thus represent a tremendous saving in time required to generate production parts. A conservative estimate of 30-50% savings in manhours at the loft for part generation can be expected.