Tribological Limitations in Gas Turbine Engines

A Workshop
To Identify The Challenges and Set Future Directions

Sponsored By
ASME / Tribology Division
NASA/Glenn Research Center
Industrial Tribology Institute
Mohawk Innovative Technology, Inc.

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Albany Hilton Hotel
Albany, New York
Early in the development of the gas turbine aircraft engine, tribology played a key supporting role in extending the life and performance of oil lubricated rolling element bearings permitting operation at ever higher speeds, loads and temperatures. A major factor in the success of rolling element bearings has been a clear understanding of the operating conditions and improvements in both bearing materials and lubricants. However, current projections and recent experience are that advancements to existing bearings and lubricants will likely only be incremented at best.
Objectives:

Explore limitations of and advances needed for current and future aircraft gas turbine engine bearings, including existing rolling element bearings and alternative technologies that may provide design freedom such as air foil bearings, novel seals, rotordynamic analyses and related technologies.

Benefits:

Guidance and direction to maintain U.S. global competitiveness will be provided for focused and accelerated developments and applications of revolutionary technologies in gas turbine engines.

Description:

Early in the development of the gas turbine aircraft engine, tribology played a key supporting role in extending the life and performance of oil lubricated rolling element bearings permitting operation at ever higher speeds, loads and temperatures. A major factor in the success of rolling element bearings has been a clear understanding of the operating conditions and improvements in both bearing materials and lubricants. However, current projections and recent experience are that advancements to existing bearings and lubricants will likely only be incremental at best.

This workshop has, as its goal the exploration of current rolling element bearing technology limitations in aircraft gas turbine engines. Further, this workshop will investigate the design freedom that may result from alternative rotor support technologies, such as compliant foil air bearings, hybrid foil/magnetic bearings, improved seals, rotordynamic analyses and related technologies.

It is expected that the major issues and benefits concerning the adoption of new bearing technologies will be highlighted. Keynote speakers and discussion leaders are being sought for this workshop. The workshop results will be documented in an effort to provide valuable guidance for future research on revolutionary oil-free aircraft engines.

Co-Chairs

Dr. Christopher Della Corte (NASA)  
Dr. Hooshang Heshmat (MiTi)
Tribological Limitations From a User's Perspective: Naval Air Systems

Darrell Grant
Naval Air Warfare Center Aircraft Division
Naval Air Systems Command
The Business We Are In

- Develop, acquire and support aircraft and related systems which can be operated and sustained at sea
- Work with industry on behalf of the user to deliver our products and services

COMPARATIVE SCALING
USS NIMITZ (CVN-68) OVERLAID ON TYPICAL AIRFIELD RUNWAY
(8000 FT. X 150 FT)

We Are Different
Navy Propulsion Environment

BASING, OPERATIONS AND ENVIRONMENT

NAVY AIRCRAFT DO EVERYTHING THAT LAND BASED AIRCRAFT DO...BUT IN A MORE HOSTILE ENVIRONMENT AND UNDER MORE ADVERSE CONDITIONS

MISSIONS
• LOITER AND CRUISE SEGMENTS
• MULTI-MISSION CAPABLE
• V/STOL

CATAPULT TAKEOFF AND ARRESTED LANDING
• HIGH IMPACT STRUCTURAL LOADS
• HIGH THERMAL/CYCLIC LOADING
• RAPID, PRECISE THROTTLE CHANGES

ENVIRONMENT
• HIGHLY CORROSIVE SALT AIR/SPRAY
• HIGH HUMIDITY
• HIGH FOD, STEAM INGESTION, AND EMI

LIMITED SPACE
• MAINTENANCE/STORAGE
• SUPPORT EQUIPMENT

AIRCRAFT CARRIER TO SCALE

TYPICAL 300'x10,000' RUNWAY
Our Core Processes

We execute on behalf of the fleet

- Perform acquisition management for the development, production, and in-service support of aircraft and weapons systems
- Test and evaluate aircraft, weapons and integrated systems
- Provide for the repair and/or modification of aircraft, engines, systems and components
- Provide for in-service engineering and logistics support
- Conduct efforts focused on the advancement of technology, research and development and delivery of software / hardware products
Affordable Readiness

THE METHODS / MEANS NAVAL AVIATION IS USING TO:

FY98 TOA

MAINTAIN SAFETY
SUSTAIN READINESS

RECAPITALIZATION / MODERNIZATION

OPERATIONS AND SUPPORT

REDUCE O&S COSTS

RECAPITALIZE
MODERNIZE

(FUTURE)

INCREASE FUNDS AVAILABLE FOR
RECAPITALIZATION & MODERNIZATION

COST REVERSALS WE CAN IMPACT

- INVENTORY
- MANPOWER
- TECHNICAL DATA
- INFRASTRUCTURE
The Environmental Challenge

Long Life, Corrosion and Damage Tolerance Are Vital

To Reduce Maintenance Cost & Improve Mission Readiness
Technology Approach

Near Term “Evolutionary”

• Corrosion Inhibited Lubricants
• Corrosion Resistant Bearings & Gears
• Longer Life / Higher Load Capacity Components
• Improved Seals

Far Term “Revolutionary”

• Requirements from New System Capabilities
• Alternative Configurations Made Possible by Expanding SOA
Bearing Development

Severe Environments: Corrosion Resistant Bearing Steels

High Speeds, Longer Life & Structural Capability: New & Improved Bearing Steels

Higher Speeds: Hybrid Bearings w/ Ceramic Rolling Elements

Increasing Rotor Speed = Improved Efficiency

Increased Diameter Due to Loads & Envelope

Bearing Bore, inches

Shaft Speed, 1000 RPM

3.0 MDN
2.8 MDN
2.6 MDN
2.4 MDN
2.2 MDN
2.0 MDN
1.8 MDN
1.6 MDN
Programs

IHPTET 6.2 & 6.3 Funding
Dual Use S&T
Small Business Innovative Research

Advanced Rotorcraft Technologies

Joint Strike Fighter

Component Improvement Programs
CANDIDATE
FUTURE NAVAL CAPABILITIES

- Information Distribution (includes ELB-ACRE)
- Time Critical Strike
- Decision Support System
- Autonomous Operations
- Littoral ASW
- Local Ownership (Coal)
- Missile Defense
- Platform Innovation
- Experimental Capability
- Organic UGM-133

Existing:
- Organic UGM-133
- DD21 (steric issues)
- others
Autonomous Operations

- Autonomous systems
  - vehicles
  - payloads
- Extend the horizon for:
  - intelligence
  - surveillance
  - reconnaissance
  - tactical engagement
  - tactical logistics service
Autonomous Operations (Air) Goals/Objectives

- Demonstrate **Naval Unit Autonomy**: the ability of the Unmanned Aerial Vehicle (UAV) system to operate from Navy & Marine Corps units at sea and deployed ashore, and be controlled by, and interact with their associated human-centered command & control stations.

- Demonstrate a high degree of **UAV System Self-reliant/intelligent Autonomy**: the ability of the UAV system to perform critical Naval missions at extended ranges over the horizon, and with greatly reduced cost, human interaction, and human risk
Total Ownership Cost

• Reduce total ownership costs
  – longer life components
  – design and manufacturing improvements
  – enhanced maintenance
• Power & Power Distribution (DD21)
  – Electronically Reconfigurable Ship
• Hull & Mechanical Systems (DD21)
• Condition Based Maintenance (DD21)
Total Ownership Cost

Goals/Objectives

To develop, demonstrate effectively and transition to the Fleet technologies and products that will reduce the total ownership costs of Navy resources.