DOD Initiatives to Rapidly Transition Advanced Coating & Surface Finishing Technologies for Military Turbine Engine Manufacture and Repair

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The Propulsion Environmental Working Group (PEWG) is an established competency for collaboration within the DOD propulsion community to rapidly transition advanced pollutant free technologies for use in manufacturing, maintenance and rework of gas turbine engines (GTEs). PEWG industry members include environmental executives and material process engineers from major turbine engine manufacturers and their major vendors. Military members of the PEWG include acquisition and logistics representatives of Army and Air Force Materiel Commands, Naval Air and Sea Systems Commands.

Industry is seeing the PEWG collaboration as a way to develop and transfer advanced technologies across military and commercial enterprise boundaries. The paper will tell about the revised PEWG Charter and Concept of Operations and their relationship to transformational initiatives within the propulsion community, especially within the Air Force. Progress on projects in work will be summarized. The paper will conclude with technical summaries and project plans of new project starts that involve advanced metallurgical coatings and surface engineering technologies.

The theme of the paper is that the PEWG focuses on technology opportunities that promote waste reduction in the military propulsion value stream. The Group targets waste of any factor of production and commits to product stewardship. The vision is to manufacture and field gas turbine engines such that (1) the parts do not fatigue, corrode, erode, or wear; (2) engines are manufactured and sustained without reliance on use or generation of toxics; (3) engine designs minimize noise and air pollutants; (4) valuable components are reclaimed and reused when engines are retired.

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Propulsion Product Stewardship—The PEWG Role

What is product stewardship? For the USEPA, product stewardship is a product-centered approach to environmental protection, also known as extended product responsibility (EPR). The Agency's product stewardship advocacy calls on those in the product life cycle--manufacturers, vendors, users, and disposers--to share responsibility for reducing the environmental impacts of products. For the Air Force and the DoD, product stewardship has a larger import. Here is the view expressed by Mr. Tim Dues, the Air Force Propulsion Product Group Manager (PPGM) at the Summer 2003 meeting of the PEWG:

"I am the Propulsion Project Manager for the Air Force. My responsibility is to manage 22,000 engines across the portfolio -- all engine types, all models, all series. No matter whether they're an airlift engine or a transport engine or a trainer engine, fighter engine, bomber engine, they're on my portfolio. My responsibility is to make sure there's consistent policy and procedure across the portfolio to make sure that we not only develop the best engines in the world, but we also maintain and sustain them as well. So that's my job as the Propulsion Product Manager… I am the Air Force Product Manager but there are similar project managers in the Navy and in the Army. As a tri-service working group we work together to make sure that the technology that's developed – no whether in the Navy or the Army or the Air Force – but those then translate to engines across the board. So it is a tri-service organization…

Our mission in the Propulsion Environmental Working Group reads this as efficient, effective combat capability for the war fighter. Simple – to the point. We need to make sure that what we develop for the war fighter is the best they could possibly have and we need to make sure it's the best value for their dollar. Overall goals? Five goals:

- No. 1-- Safety. Safety is our number one priority. We don't do anything unless we consider safety in every aspect, whether it's getting an environmentally friendly technology in an engine or whether it's fixing a design problem. Safety is our number one priority.
- No. 2 -- Timely and Effective Sustainment of Engines. That's what we're all about. Most of our engines are in sustainment today and that's where most of our costs are.
- No. 3 – Take the technology that's developed today, that's ready today and put it in not only the new engines, but legacy engines as well. We're creating an environment to make sure our industry people can excel.
- No. 4, last but not least, make sure our business processes are there to enable all those other goals to be achieved."

Thus the PEWG product stewardship paradigm is to engage with all mission areas under our Air Force PPGM and the tri-service Joint Propulsion Coordinating Committee auspices and promote the "valorization" of the entire propulsion product life cycle. The PEWG premise is that all forms of waste are bad and all increases in performance, durability, and affordability are good.

Therefore, the "green engine" programs of the JPCC organizations and the industry members contribute to a community attack on the following kinds of value destroying waste:

- Corrosion damage
- Erosion damage
- Thermal damage
- Fatigue losses
- Noxious air emissions impacts
- Excessive noise impacts
- HazMat management costs
- Workplace hazard response
- Response to toxic releases
- Fuel waste
- Facility energy waste
- Excess inventory management

On the positive side, product stewardship includes management and technology improvements to maximize "goodness" in areas such as workforce efficiency, and conservation/recovery of valuable materials.

From the product development side, our industry partners embody product stewardship in their corporate practices. The Rolls-Royce policy is typical. Here is an excerpt from their Health, Safety, and Environmental (HS&E) policy:

"Product stewardship is a key part of our HS&E policy at Rolls-Royce. We endeavor to deliver power for air, sea, and land vehicles by the most appropriate efficient means while minimizing the environmental impact of our products. ISO 14001 certification of all Rolls-Royce business units recognizes a commitment to continuous improvement in addressing the environmental aspects of our operations and our products.

Design standards and information tools ensure that new products are designed to achieve 'the highest standards of environmental, health and safety performance by all reasonable and practicable means.' Early in the product concept and design process, all new products must be assessed for environmental impact using a life cycle analysis approach, and environmental performance targets are required. Selection of materials and processes for product design is guided by an on-line material and process database, including the 'Material Selector' which lists those materials allowed for new design. A Product Stewardship Board promotes proactive initiatives aimed at reducing the impact of our products, including programs for reduction of hazardous materials and processes utilized in the product life cycle. Progress against HS&E goals for the various product lines is published in the company environmental report titled *Powering a Better World*, available on the Internet at www.rolls-royce.com".

PEWG Program Interfaces with other PPGM Initiatives

The reader should understand that the PEWG program efforts do not, should not, be executed in a vacuum. In addition to the projects that the PEWG initiates and manages, the PEWG

participates in other PPGM and JPCC programs to achieve the product stewardship mandates and expectations outlined in Mr. Dues remarks quoted earlier. Here are some of the major initiatives that involve PEWG interface:

Integrated High Performance Turbine Engine Technology (IHPTET) Program – improve performance

Versatile, Affordable, Advanced Turbine Engine (VAATE) Initiative - Follow-on to IHPTET – Reduce propulsion system cost

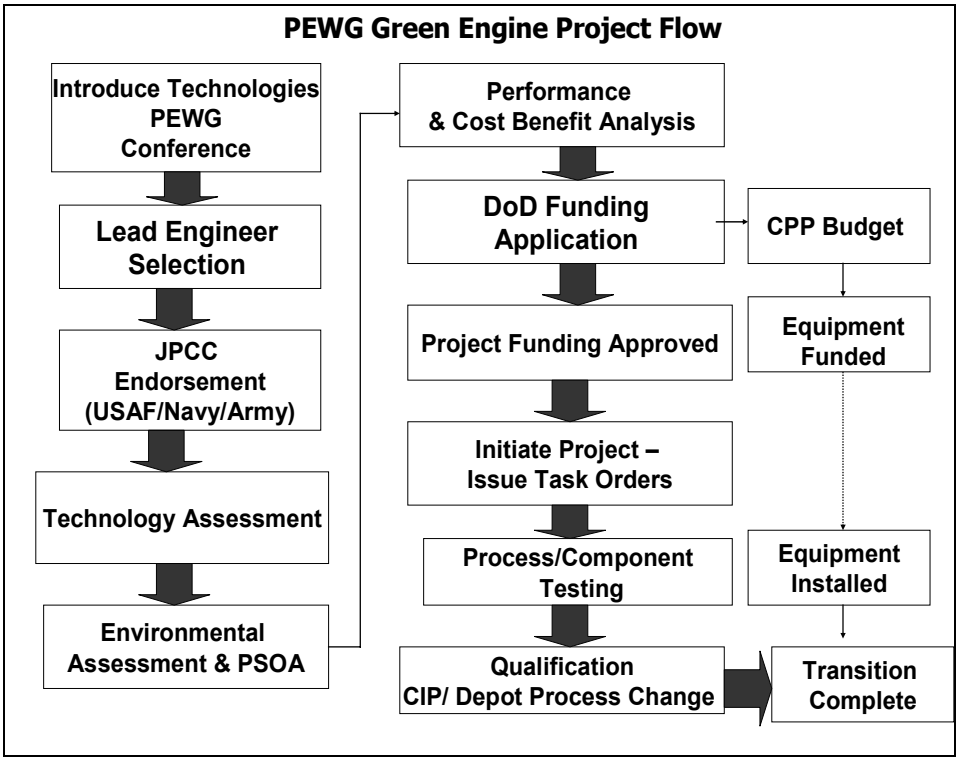
National High Cycle Fatigue Program (Eliminate HCF problems that account for 50% of engine failures).

Engine Rotor Life Extension (ERLE) - mature, transition and implement technology to eliminate components that have potential to fail and reuse the components that have significant safe remaining life. Included in ERLE: materials and process development for repair and refurbishment

Depot Technology Modernization Programs – Create “world class” military depot capability incorporating advanced materials and processes and lean manufacturing concepts.

PEWG Project Methodology

The PEWG Charter requires the PEWG to identify projects planned or being performed by PEWG members, individually or jointly, which support the collective environmental excellence goals of the membership. The PEWG members may also nominate projects of interest which are being pursued by non-affiliated parties. Project management and oversight procedures will be developed and implemented to address PEWG participation in "PEWG Projects". These procedures will include development of strategies to extend results of successful projects to all PEWG members. Procedures will also be developed to measure economic and environmental security benefits of PEWG projects to the entire PEWG community.



Typical Milestones for PEWG Projects

1. Initiate project
2. Obtain Project approval and funding – Phase 1
3. Negotiate contracts to assess technology readiness
4. Perform cost benefit and performance analyses
5. Review potential alternatives and perform screening tests
6. Develop project plan to assess selected alternatives
7. Review project plan and validate for implementation
8. Release funding – Phase 2
9. Identify candidate engines, parts, part families
10. Summarize part specifications
11. Obtain OEM advice and assistance
12. Secure Government engineering authority review and Engine Program manager approval
13. Develop new technology process specification
14. Develop test plan to dem/val process
15. Obtain engineering assistance and test plan support (time and materials)
16. Procure or requisition materials and equipment
17. Perform testing
    a. Coupon testing
    b. Functional test parts

c. AMT (Accelerated Mission Test)

18. Analyze results
19. Prepare decision document
20. Process source qualification
21. Implement document changes (product/process specs; Technical Orders)

Overview of PEWG Projects Involving Plating, Coating, and Surface Engineering

- Qualify HVOF thermal spray coatings to replace hard chrome plating of gas turbine engine manufacture and repair. Develop and implement "producibility" improvements (off angle spray, safe coating removal, spray and grinding best practices, engine oil analysis, inspection methods)
- Demonstrate electrospark deposition technology applications to reduce chrome plating requirements for engine repair
- Qualify engine part substrate restoration via laser cladding
- Assess and validate non-spray alternatives to chrome and nickel plating for gas turbine part manufacture and repair
    - Powder coating technology for wear, erosion, and thermal damage resistance (Also potential alternative to aluminum-ceramic coatings with chromium content)
    - Alternatives to chrome plate using nickel-based chemistry
    - Alternative to chrome and nickel plate using nanocrystalline Co-alloy pulse plating
- Assess and validate kinetic spray alternatives to thermal and plasma spray processes
- Qualify improved high temperature diffusion coatings to extend life of engine augmentor components
- Demonstrate technology and identify applications for thermionic cleaning (improve cleaning performance and increase part survivability without generating solvent or aqueous waste streams)

The government program managers are unable to publish details on these projects in this paper. Details on these projects will be available by accessing the project workspace at www.pewg.com . Interested parties may apply to the author for password access.

Conclusions

The PEWG is setting an example of collaborative technology transition enterprise for the Department of Defense. Technical societies like the AESF are important partners in this enterprise. The AESF is a source for advanced technology discovery and a way to share successful demonstrations. As stated, details on these projects will be available by accessing the project workspace at www.pewg.com. Interested parties may apply to the author for password access.