Structurally Integrated Coatings for Wear and Corrosion Resistance

Emerging Deposition Processes Will Enable Fabrication of Low-Cost, Metallurgically Bonded Coatings on Steels with Improved Performance

Materials degradation by simultaneous wear and corrosion is responsible for failure and life reduction of many components in track undercarriages, groundengaging tools, piston rings and liners, engine valves, pumps, and other mobile systems. Research has shown that engineered surfaces, such as thin-film coatings applied by physical and chemical vapor deposition on corrosion-resistant sublayers, can address combined wear and corrosion issues in applications that have lacked solutions for decades. However, some of the major issues that remain include the relatively high cost and the inability of thin films to provide enough wear resistance for heavy, abrasive wear applications. Processes that form metallurgically bonded coatings of 1-mm thickness or more have been shown to be substantially more resistant to wear than baseline heattreated steel materials.

There is a need to develop improved, yet affordable surfacing materials and processes for wear and corrosion resistance in both sliding and abrasive wear applications. The magnitude of performance improvement sought is four to eight times that for carburized steels, while affordability needs to be assessed against competing hard-surfacing or coating techniques and balanced with overall coating performance. Deposition processes including arc lamp fusing of thermal spray coatings, laser-aided thermal spraying, hybrid laser-arc cladding, and plasma transferred arc (PTA) are candidate processes that will be evaluated in this project.

Shovel Bucket

Low-cost wear-resistant coatings will replace carburized components in various applications.

Benefits for Our Industry and Our Nation

Improved and cost-effective coating technologies will result in decreased use of carburized parts, wear- and corrosion-resistant coatings, coatings free of cracking, and coatings with favorable residual stresses. Energy benefits will be obtained through reduced carburization treatments and potential use of lightweight parts in heavy equipment.

Applications in Our Nation's Industry

Materials with wear resistance four to eight times that of carburized steels will find applications in the aluminum, forest products, mining, and steel industries.

Project Description

The goal of the project is to develop two or more materials systems that provide a four- to eight times increase in wear resistance over current carburized steels. In addition, two processes that are economically attractive will be developed from four emerging technologies for the deposition of these coatings.

Barriers

Major barriers to be overcome include:

- The need to balance cost and materials-performance factors in the development of coatings;
- The tendency for coatings to crack after processing due to the use of hard materials and the presence of residual stresses; and
- Lack of thermodynamic and other data required for microstructural modeling.

Pathways

The objectives of this project will be achieved through the following concepts: (1) alloy composition development and feedstock evaluation for each of the four coating processes; (2) coating deposition and individual process optimization; (3) screening of coatings using corrosion, wear, and fracture toughness testing; (4) laboratory component testing using simulated conditions; (5) materials property evaluation for input to computational models; (6) microstructural modeling that incorporates thermo-fluid process models; and (7) process evaluation to downselect two processes that will be commercially viable.

Milestones

- Conduct economic and industrial feasibility analyses of coating processes and select candidate processes and materials
- Estimate viability of feedstock materials and associated processing required prior to coating deposition
- Produce initial coatings using downselected coating process, using up to four material systems per process
- Determine material and coating properties required for microstructural modeling
- Complete coating microstructural evolution modeling
- Complete mechanical/toughness screening of promising coating systems
- Complete laboratory and inplant wear and corrosion tests and evaluate properties of coatings

Commercialization

Caterpillar is a major manufacturer of equipment for various industries. New materials developed as part of the project will be commercialized through implementation in equipment manufactured by Caterpillar. Materials will also be made available to other potential users through. Various manufacturing processes are available for licensing from their owners and will facilitate the commercialization of the materials and processes developed as part of this project.

Project Partners

Caterpillar Inc.
Peoria, IL
(M. Brad Beardsley:beardmb@cat.com)

Albany Research Center
Albany, OR

Iowa State University
Ames, IA

Oak Ridge National Laboratory
Oak Ridge, TN

Questek Innovations
Evanston, IL

University of Illinois
Urbana, IL

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For more information contact:
EERE Information Center
1-877-EERE-INF (1-877-337-3463)
www.eere.energy.gov

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