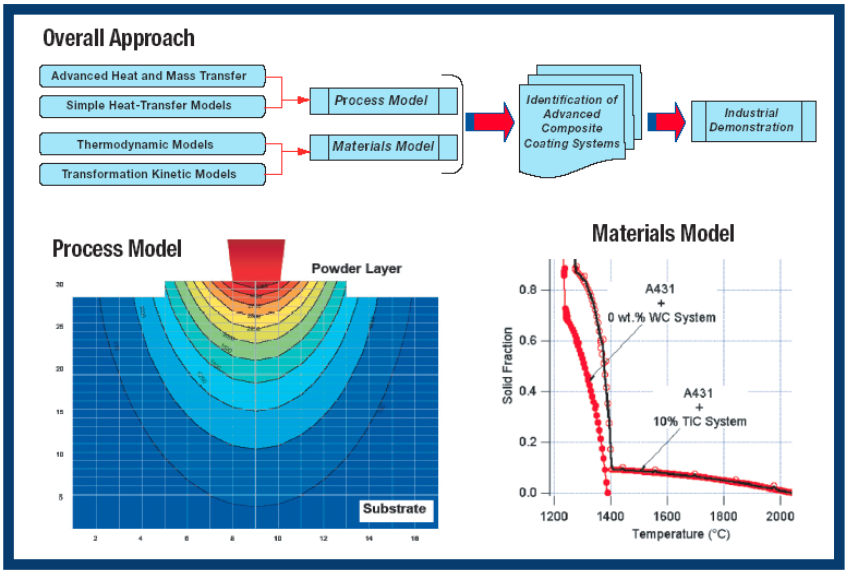
Development and Implementation of Advanced Wear- and Corrosion-Resistant Systems through Laser Surface Alloying and Materials Simulation

New Computational Tool Will Enable Improved Coating Designs and Optimized Deposition Parameters for Laser Surface Alloying

Laser surface alloying (LSA) is a versatile process through which one can modify the surface properties of metals and ceramics. Incorporation of hard particles (such as carbides, borides, or nitrides) onto the surface of ferrous, nickel-based, aluminum, and bronze alloys offers significant benefits for improving wear and corrosion resistance. However, the retention of these particles during laser surface alloying is currently limited by the reactions and transformations that occur at elevated temperatures during processing. The ability to efficiently design superior coating systems requires a detailed understanding of these reactions so that processing conditions and coating performance may be optimized for particular applications.

Development of an advanced computational model that can predict microstructural evolution in the LSA regions will help to establish material and process parameters required to produce advanced coatings by the LSA process.



An integrated computational approach composed of process and materials models would enable more efficient and improved laser claddings.

Benefits for Our Industry and Our Nation

Advanced wear- and corrosion-resistant coating systems will result in energy benefits and cost savings due to increased operational efficiency, extended life of components, decreased downtime, and superior wear-performance. Energy benefits of up to 4 trillion Btu are estimated to accrue by 2020.

Applications in Our Nation's Industry

The coating technology will be applied in the chemicals, forest products, mining, and steel industries for applications requiring wear-resistant coatings.

Project Description

The goal of the project is the development and implementation of processing and material simulation techniques for identifying and creating advanced coatings consisting of hard particles alloyed with a corrosion-resistant matrix through the LSA process.

Barriers

Major barriers to be overcome include:

- Lack of thermodynamic data for the many material components of interest;
- Inability to accurately predict microstructural evolution through the existing models; and
- Lack of ability to control heat input during laser processing to prevent dissolution of particles.

Pathways

The objectives of this project will be achieved through (1) the development and application of materials computational techniques that incorporate thermodynamic and kinetic factors; (2) integration of the materials simulation with a numerical process model incorporating heat transfer to accurately predict microstructural evolution; (3) development and application of laser processing techniques that offer improved control of heat input; and (4) detailed wear and corrosion testing in laboratory and industrial environments.

Milestones

- Refine existing simulation techniques and integrate them into a single system capable of predicting composite coating microstructures
- Identify and collect thermodynamic data on prospective material systems that depict a wide range of processing conditions
- Conduct analysis directed at identifying specific coating requirements using the new simulation system
- Develop and verify advanced composite coating systems and laser processing technology
- Conduct tests of new LSA coatings in laboratory and industrial environments
- Confirm the enhanced performance characteristics of LSA coatings
- Integrate the new technology in an initial pilot-scale system

Commercialization

Commercialization will occur through a number of mechanisms, which include:

1. Close co-operation by the partners, which include technology developers, companies that would utilize the new coatings and processes, and companies that supply materials and coating systems;
2. Development of new coatings with commercial-scale applications; and
3. Integration of the new technology into a pilot-scale LSA system shown to provide improved coatings.

Project Partners

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Praxair Surface Technologies Inc.
New Castle, PA

Spirex Corporation
Youngstown, OH

Synergis Technologies Group
Grand Rapids, MI

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

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