



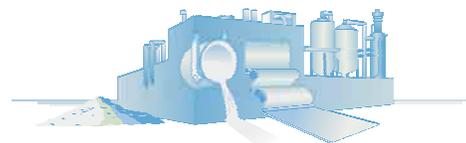
INDUSTRIAL TECHNOLOGIES PROGRAM

Development of Materials Resistant to Metal Dusting Degradation

New Metal Dusting-Resistant Materials Will Lead to More Energy- and Cost-Efficient Chemical Processes

Degradation of metallic structural components by metal dusting is a major issue in plants such as those involved in hydrogen production, ammonia synthesis, methanol reforming, and syngas (H_2/CO mixtures) production. Metal dusting is also experienced at high temperatures in the oxidizing-carburizing environments that are prevalent in the heat-treating industry and in processes that involve direct reduction in the production of iron. While experiments have proved that metal dusting does occur, industries could not develop an approach to combat this problem because of a lack of understanding of the mechanisms that lead to metal dust-

ing. The problems due to metal dusting have been mitigated in the past by designing processes to avoid conditions under which this phenomenon occurs. Such approaches, however, incur significant penalties in terms of lower energy efficiency, wastage of materials, and decrease in product yield. Recently, work performed at Argonne National Laboratory has clearly established the mechanisms that can lead to the initiation and propagation of metal dusting in iron, and nickel-based alloys. This knowledge base will be used to develop alternate structural alloys with improved resistance to metal dusting.

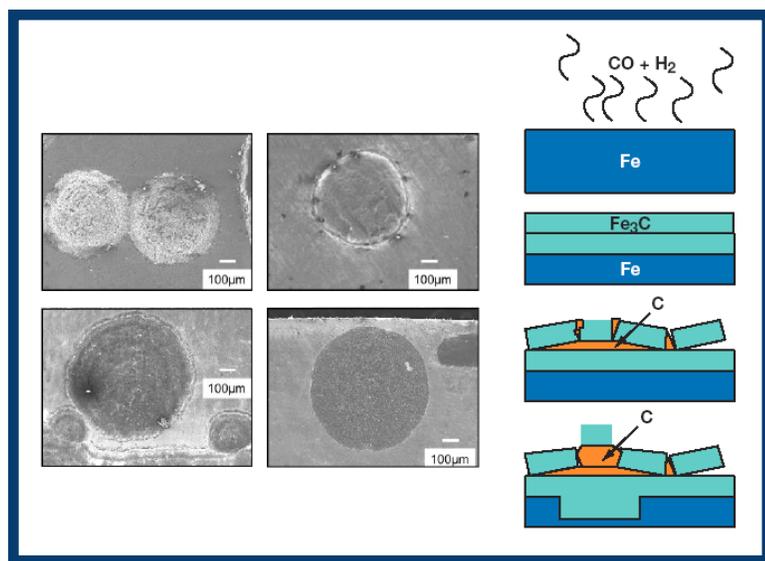


Benefits for Our Industry and Our Nation

The materials developed in this work will possess better resistance to metal dusting degradation, and their use will result in more efficient recovery of heat from effluent gas in various processes due to higher gas temperatures, extended life of reforming systems, and increased productivity due to decreased downtime.

Applications in Our Nation's Industry

Improved alloys which are more resistant to metal dusting will find applications in equipment used in various industries, including chemicals, petroleum, and steel. These processes include methanol reforming, syngas production, hydrogen production, and catalyst regeneration units in the chemicals/petroleum industry, and heat treating equipment, equipment used for the direct reduction of iron ores, and blast furnaces in the steel and heat treating industries.



Typical metal dusting damage and damage mechanism

Project Description

The goals of this project are to develop new high-strength copper-based alloys that are resistant to metal dusting attack in various process-industry sectors at temperatures up to 800°C; and to engineer the surfaces of currently available metallic structural Ni-based alloys to provide adequate mechanical properties at temperatures of interest to resist metal dusting degradation.

Barriers

Major barriers to be overcome are:

- The inability to accurately simulate industrial process conditions that accelerate metal dusting degradation;
- Lack of information on the resistance of Ni-based alloys to metal dusting degradation;
- Lack of knowledge on the performance of surface-modified alloys; and
- Nonavailability of commercial copper alloys with sufficient strength at 800°C to resist metal dusting degradation.

Pathways

The objectives of this project will be achieved through (1) understanding the relationship between alloy chemistry and metal dusting characteristics in Ni-based alloys and identifying candidate alloys; (2) developing through computational thermodynamic analyses, Cu-based alloys which are more resistant to metal dusting since their surfaces do not catalyze carbon deposition; (3) developing Ni-based alloys surface-engineered with alumina, chromia, and/or silica surface layers that form barriers to dissolution and diffusion of carbon; (4) testing candidate materials under simulated exposure condi-

tions at temperatures up to 700°C and pressures of 600 psi; (5) determining the mechanical properties of the alloys after exposure; and (6) exposing and evaluating the behavior in laboratory-scale, pilot, and/or production units.

Milestones

- Develop metal dusting rate data for current Ni-based alloys and correlate results with alloy chemistry
- Develop and characterize the microstructure and mechanical properties of new copper-based alloys
- Develop surface-engineered materials based on candidate Ni-based alloys
- Expose modified copper alloys and surface-engineered materials in pilot or production units
- Complete evaluation of Cu- and Ni-based alloys after metal dusting exposure
- Develop a knowledge database on the metal dusting behavior of metallic alloys

Commercialization

The project team includes research and development organizations, chemical processing companies, materials suppliers, and a supplier of surface modification technology. Materials Technology Institute will coordinate with its more than 60 member companies in the petroleum and chemicals industry and with user companies who are project partners to test the newly developed materials in typical industrial process environments. The participation of materials suppliers will ensure the availability of the new materials for incorporation into process equipment.

Project Partners

Materials Technology Institute
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Air Products and Chemicals Inc.
Allentown, PA

Alon Surface Technologies Inc.
Leechburg, PA

Argonne National Laboratory
Argonne, IL

ConocoPhillips Inc.
Ponca City, OK

ExxonMobil Chemical Company
Baytown, TX

Haldor Topsøe A/S
Denmark

Haynes International
Kokomo, IN

ThyssenKrupp VDM USA Inc.
Houston, TX

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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