Argonne NATIONAL LABORATORY

Office of Technology Transfer

NEW ALLOYS RESIST METAL DUSTING AND EXTEND EQUIPMENT LIFE

2006 R&D 100 Award Winner

BENEFITS

- 475 billion Btu savings daily with 30 to 50 percent heat recovery
- Fewer maintenance shutdowns
- Increased productivity
- Annual operating cost reduction of $50,000 per plant
- An estimated $500 million to $1.3 billion could be saved annually by the hydrogen industry alone.

POTENTIAL APPLICATIONS

- Hydrogen and synthesis gas production
- Other chemical processes such as methanol production and hydrocarbon and ammonia synthesis
- Processes in the forest products and petroleum industries

RESEARCH PROGRESS AND MILESTONES

Argonne's research focused on:

- Modeling of gas phase reactions that characterized chemical process environments
- Corrosion tested commercial alloys in simulated metal dusting environments

Gases used at high temperature and pressure in various chemical and petrochemical industries cause metal components made from commercial alloys to rapidly pit and ultimately disintegrate into powder, a phenomenon called "metal dusting."

Metal dusting occurs in strongly carburizing gas atmospheres at temperatures ranging from 400° to 800° C. These conditions prevail in many chemical and petrochemical processes used to produce hydrogen, ammonia-synthesis processes, methanol-reformer systems, and syngas (H_2/CO) systems. Currently, the only way to protect materials against metal dusting is by adding sulfur-containing compounds, but this often deactivates catalysts needed in the process.

New alloy developed to resist metal dusting (right), a long-standing corrosion problem for materials used inthe chemical and petrochemical industries (left).

Research conducted at Argonne National Laboratory has resulted in surface-engineered materials that are resistant to metal dusting. Improved resistance to metal dusting attack will result in longer service lifetimes, fewer maintenance shutdowns, and higher productivity. These advanced alloys can lead to a complete redesign of reformers that feature improved efficiency, increased product yield, and decreased energy consumption. The cost of the new Argonne-developed alloys is comparable to currently available alloys.

Key Features of Argonne Alloys compared to Existing Products

Alloy	Weight loss* (mg/cm2)	Pit depth (µm)
800	344	818
321	282	1930
310	32	284
600	28	185
601	1.6	243
214	67	93.7
602CA	2.3	246
Argonne Developed	0	0

* After 5,700 h exposure at 593° C

The table above confirms that the Argonne alloys perform significantly better than currently available commercial alloys. Tests reveal that altering the chemistry and structure of the surface minimizes the reaction between the surface and carbonaceous materials in the gas phase.

- Developed surface-engineered alloys based on corrosion tests
- Evaluated the role of system pressure in initiating corrosion/metal dusting of materials
- Corrosion tested weldment materials in simulated chemical environments
- Developed methods to mitigate metal dusting by intermediate oxidation
- Develop a knowledge database on the metal dusting behavior of metallic alloys

Future research will focus on exposing and evaluating the behavior of Argonne-developed alloys in laboratory-scale, pilot, and production units.

Principal Applications

Argonne-developed alloys initially can be used in plants involved in hydrogen and synthesis gas production. These materials can also be used for components (such as waste heat boilers and gas bypass lines) exposed to metal dusting environments in methanol and ammonia reformer plants. The Argonne-developed alloys can be effective in gas-to-liquid plants, which convert natural gas into liquid fuels. The process environments in such systems are expected to have much lower steam/carbon ratios (when compared with those in hydrogen reformer plants), which will exacerbate metal dusting degradation of the components.

Market Potential

Currently, a Cooperative Research and Development Agreement (CRADA) between Argonne and the Materials Technology Institute (MTI) is in effect.

MTI will coordinate with its more than 60 member companies in the petroleum and chemical industries and with user companies who are project partners to test the newly developed materials in typical industrial process environments. Materials suppliers will ensure the availability of new materials to incorporate into process equipment.

U.S. industry will benefit from the application of Argonne's new alloys in process equipment used in chemical, petroleum, and steel production. The processes include methanol reforming, syngas production, hydrogen production, and catalyst regeneration units in the chemicals and petroleum industries. Additional applications can be realized in heat treating equipment, blast furnaces used in steel production and heat treating, and equipment used for direct reduction of iron ores.

Use of the new alloys can lead to the complete redesign of reformers that feature improved efficiency, increased product yield, and decreased energy consumption. With the current thrust toward a hydrogen-based economy, the hydrogen industry alone could benefit by estimated annual savings of $500 million–$1.3 billion. Various other chemical and petrochemical industries could realize fewer maintenance shutdowns and higher productivity.

ABOUT ARGONNE TECHNOLOGY TRANSFER

Argonne National Laboratory is committed to developing and transferring new technologies that meet industry's goals of improving energy efficiency, reducing wastes and pollution, lowering production costs, and improving productivity. Argonne's industrial research program, comprised of leading-edge materials research, cost-saving modeling, and unique testing and analysis facilities, is providing solutions to the challenges that face U.S.

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