Advanced Industrial Materials Program

Project Fact Sheet

Advanced Intermetallic Alloys

Benefits

- Improved high-temperature mechanical properties of Ni_3Al enable higher thermal efficiencies in industrial processes
- The superior carburization resistance of FeAl alloys will enable more efficient chemical processing
- Development of castable and weldable Ni_3Si alloys will enable fabrication of complex components for use in chemical-process systems

Applications

- Advanced Ni_3Al alloys: Heat-treating fixtures, transfer rolls for hot metal processing, forging dies, radiant burner tubes
- FeAl alloys: Components for steam/methane reformer conditions or ethlyene pyrolysis, hot gas filters, heat-treating fixtures
- Ni_3Si alloys: Tubes, nozzles, piping for chemical processing, wear- and erosion- resistant components, seawater heat exchangers, ammonia reactors, gas burners

The energy utilization and efficiency of manufacturing processes can be improved by operating at the higher temperatures or with the better environmental resistance provided by advanced intermetallic alloys

There is a need in the manufacturing and power generation/cogeneration industries to push the safe service temperatures of metallic alloys ever higher. Increasing the operating temperature of some processes can improve their thermodynamic efficiency. In other cases, increases in operating temperature can reduce the residence time of materials at critical reaction temperatures. Each of these conditions can result in significant energy savings by promoting more efficient energy utilization, increased productivity, and reduced process downtime. Likewise, there is a need to identify and utilize intermetallic alloys with improved or unique environmental resistance, which can result in similar efficiency benefits and energy savings. Currently, a Ni_3Al alloy is being developed that can withstand service temperatures of 100 to 150°C higher than commercial Ni_3Al alloys. Other alloys under study are based on the intermetallic alloy FeAl. Under certain conditions, these alloys have resistance to carburization and sulfidation that far exceeds that of most commercial alloys. Also being developed are alloys based on Ni_3Si. Initial testing indicates that the Ni_3Si alloys have good mechanical properties coupled with excellent resistance to oxidizing conditions, such as in sulfuric acid and seawater, and to ammonia at temperatures up to 900°C.

High-Temperature Corrorion-Resistant Intermetallic Alloys

Centrifugal casting of FeAl alloys is being evaluated for producing tube forms

Project Description

Goal: Provide the processing, fabrication, and materials-property expertise necessary to implement advanced intermetallic alloys in high-performance applications that can benefit the most from the unique properties of these alloys.

Issues: Alloy-development activities have identified the chemical composition of a number of advanced intermetallic alloys including Ni_3Al, FeAl, Ni_3Si, and TiAl. Various properties of the alloys have been determined to associate them with potential applications. Commercialization of the alloys depends on a more thorough description of their physical, chemical, and mechanical properties, as well as on extensive evaluations of their processing and fabrication characteristics.

Approach: Both large-scale laboratory and commercially melted heats of the advanced intermetallic alloys are being prepared. These heats are providing the materials required for extensive property determinations, including strength testing, creep and fatigue behavior, and thermal-expansion behavior. Oxidation and corrosion behavior is also being assessed. Metal-casting issues are being determined, including solidification behavior, mold interactions, fluidity, and hot shortness. Metalworking issues are being addressed through hot ductility testing. Welding studies are evaluating cracking susceptibility, weld properties, process development, and thermal and environmental aging behavior. The results of these efforts are being used to adjust alloy compositions as necessary to address commercialization. The knowledge base needed to gain commercial acceptance of the advanced intermetallic alloys will be established. Key collaborations with potential producers and users are being developed.

Potential payoff: Alloys which can operate at higher temperatures will lead to improved energy and process efficiences. The high corrosion resistance minimizes downtime leading to improved productivity. Environmental benefits occur through the increased industrial process efficiencies. Energy savings and efficiencies are estimated to occur in a variety of manufacturing industries.

Progress and Milestones

- A Ni_3Al alloy was developed with higher temperature capability than existing alloys. Thermal expansion, tensile, creep, and fatigue properties of the alloy were measured
- Radiant burner tubes of FeAl alloy were produced by centrifugal casting in a trial at a commercial foundry. Statically cast return fittings were also produced
- Studies identified compositional ranges where Ni_3Si alloys can be welded
- Corrosion resistance of composites being determined

Project Partners

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Alloy Engineering and Casting Company,
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FMC Corporation,
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