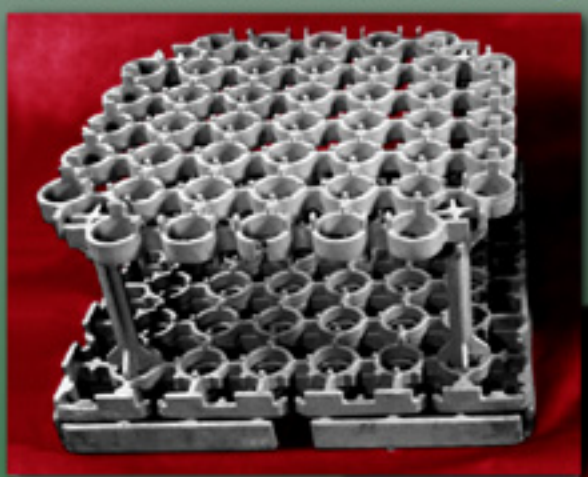
Newly Developed Ni_3Al Heat Treating Furnace Assemblies Are Being Commercialized at Delphi

High-temperature strength and durability of Ni_3Al enables

- Processing more parts per assembly
- Up to 33% energy efficiency improvements, and corresponding economic and environmental benefits

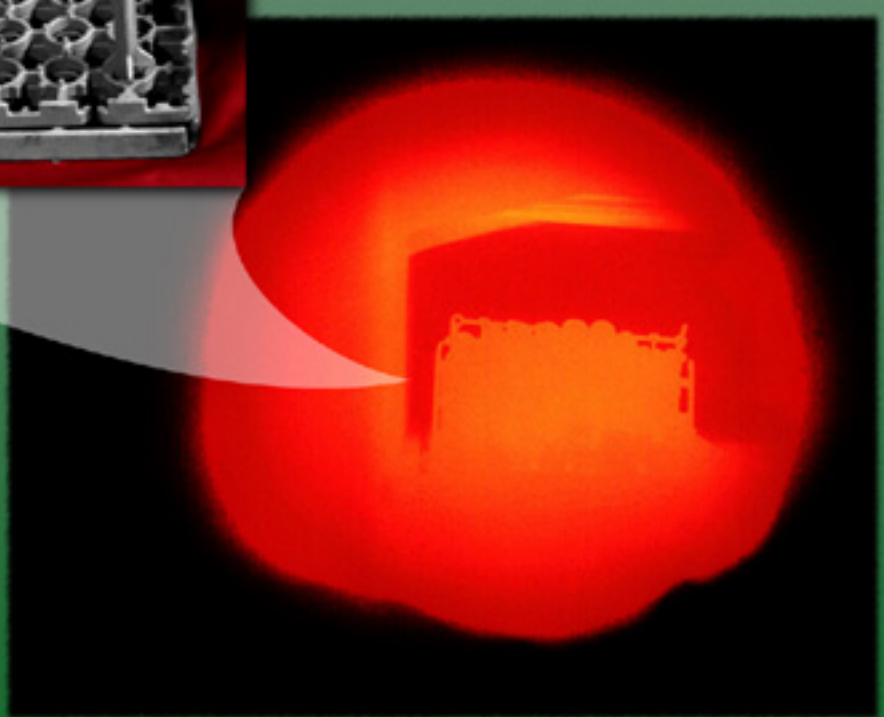
Nickel Aluminide Furnace Assembly



Delphi, Saginaw, Michigan

- Over 500 fixtures being installed
- Material of choice for fixtures worldwide
- Over 5,000 tons of steel parts are processed per day

Assembly in Furnace



Participants

DELPHI Automotive Systems
Driving tomorrow's technology

OAK RIDGE NATIONAL LABORATORY

- Enabled building only two new heat treating furnaces rather than the three that would have been required if current materials were used
- CRADA was the first to be signed with General Motors

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Nickel Aluminide (Ni_3Al) Heat Treating Fixtures at Delphi Automotive Systems Corporation

Implementation of nickel aluminide alloy heat treating fixtures enables more reliable, energy-efficient manufacturing of steel parts.

Goal: To meet the needs outlined in *Vision 2020 — The Heat Treating Industry of the Future* by replacing traditional heat-treating fixtures such as trays and support posts with nickel aluminide fixtures, thus boosting their lifetimes by a factor of two.

The nickel aluminide alloy used by Delphi is commonly referred to as IC221M and is covered by ASTM A1002-99, *Standard Specification for Castings, Nickel-Aluminum Ordered Alloy*. The ordered crystal structure of IC221M contributes to its unusual properties. For example, the strength of the alloy increases above its room-temperature strength as it is heated to between 700 and 900°C. Additionally, it maintains relatively high strength to nearly 1100°C. Besides having high strength, the alloy forms a highly protective aluminum oxide surface scale that makes it very resistant to further oxidation and carburization. These properties make the IC221M alloy an attractive replacement for the traditional heat-resistant alloys commonly used for heat treating fixtures. The typical life of a heat treating tray at Delphi is 12 to 15 months. Initial testing of nickel aluminide trays in the same facility began in January 1998, when six trays were installed in a batch furnace operation and 65 trays were installed in a pusher furnace. These trays are still in use with no failures after more than $3\frac{1}{2}$ years of service. The initial cost of the nickel aluminide trays is $1\frac{1}{2}$ to 2 times higher than that of traditional alloys, but the extended tray life more than offsets their higher initial cost. It is anticipated that the nickel aluminide trays will also permit a 10% increase in throughput per furnace. The total savings to Delphi for implementing the nickel aluminide trays are projected to be nearly $1.1 million. Delphi anticipates a range of additional heat treating applications for the nickel aluminide alloys. Targeted applications include fixtures for carburizing furnaces at other Delphi divisions as well as other furnace applications, including radiant tubes and fans.

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