Industrial Materials For The Future

Project Fact Sheet

Exploring Ultrahigh Magnetic Field Processing of Materials for Developing Customized Microstructures and Enhanced Performance

Benefits

Successful demonstration of this concept will yield the following benefits:

- A new class of materials with novel microstructures and superior properties.
- Enhanced phase transformation kinetics.
- A new industrial processing methodology.
- Major manufacturing cost savings, reduced scrap, energy savings, and environmental benefits. The elimination of the final normalization heat-treatment step through magnetic processing for bar and rod products alone would yield an energy savings in excess of 3 trillion Btu.

Applications

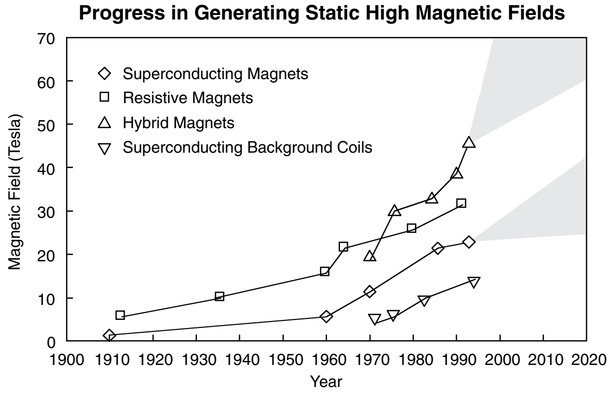
An example of an application is the elimination of cryogenic treating or double-temper heat-treatment cycles to eliminate retained austenite in quenched steels.

It will be applicable to most materials that exhibit ferromagnetism or paramagnetism. This technology can impact the following industries:

- **Aluminum,**
- **Casting,**
- **Chemical,**
- **Forging,**
- **Heat Treating,**
- **Steel,** and
- **Welding.**

A new high-payoff industrial processing methodology whereby alloys and microstructures with superior properties will be developed

Because essentially all materials have some form of ferromagnetism or paramagnetism, magnetic field processing is directly applicable to a multitude of materials for dramatically influencing phase stability and phase transformations for an alloy or a compound. This ability to selectively control microstructural stability and alter transformation kinetics through appropriate selection of the magnetic field strength promises to provide a very robust mechanism to develop and tailor microstructures (even nanostructures) for a broad spectrum of materials applications. For this project, ferrous alloys will be studied initially because this alloy family exhibits ferromagnetism over part of its temperature range of stability and therefore would demonstrate the maximum impact of this novel processing mechanism.



Past and projected progress in developing magnets that have higher ultrahigh magnetic field strength indicates the broad range of field strengths that can be investigated for developing novel microstructures with enhanced performance.

Initial experiments are being performed in a very compact 6-Tesla superconducting magnet system in the ORNL Fusion Energy Division.

Project Description

Goal: Demonstrate and document the influence of ultrahigh magnetic field processing on the phase equilibria in ferrous alloys.

Issues: This project will overcome a significant limitation for exploiting this potential major breakthrough in materials processing technology. It will establish the capability to predict the response of materials to an applied magnetic field. In addition, the lack of data characterizing the magnetization response of materials to ultrahigh magnetic fields will be overcome by establishing a methodology to measure these data for input into a simulation code that incorporates magnetic field effect factors.

Approach: The principal objective is to evaluate magnetic processing as a viable and robust new technology for altering phase equilibria and phase transformation kinetics in a ferrous alloy with the goal of developing novel microstructures and properties unattainable through conventional thermomechanical processing approaches. The secondary objective is to develop the predictive capability to establish the influence of an applied magnetic field on ferrous alloys with the ability to extend this capability to more general ferromagnetic, paramagnetic, and diamagnetic materials of relevance to the IOF.

Potential payoff: This research and development activity has the potential to develop a new high-payoff industrial processing methodology whereby alloys and microstructures can be developed with superior properties that normally would be impossible to achieve with conventional thermomechanical processing techniques. The elimination of the final normalization heat-treatment step through magnetic processing for bar and rod products alone would yield an energy savings in excess of 3 trillion Btu.

Progress and Milestones

- Magnetic field processing of candidate ferrous alloys.
- Development of a predictive capability to understand the phenomena.
- Determination of material magnetization response data for high magnetic field exposures.
- Phase transformation kinetic response evaluation.

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