
Improved Energy Efficiency and Cost Efficiency through Non-Thermal, High Magnetic Field Processing

Conventional heat-treating is the most common processing method that industry currently utilizes to achieve desired metallurgical properties, such as strength and toughness. This high-temperature materials process consumes more than 500 trillion Btu/yr of energy at a cost of $20 billion/yr to industry. In addition, traditional thermal processing techniques are nearing the limit of property-design possibilities due to fundamental thermodynamic equilibrium and transformation kinetic barriers. If U.S. industry is to remain globally competitive, further advances in the energy efficiency and materials performance of processing methods must be coupled with cost-effectiveness.

A partnership between government and industry researchers intends to address this challenge by developing a heat-free processing technology involving high magnetic field processing (HMFP). This innovative, non-thermal materials processing technology has the potential to eliminate and/or minimize traditional energy-intensive processing steps by employing superconducting magnets to apply high magnetic fields to manipulate materials structure at an atomistic level. The ability to tailor structure at microscales and nanoscales, using non-thermal HMFP, has the potential to enhance property performance at significantly reduced energy and processing costs.

Benefits for Our Industry and Our Nation

The use of HMFP in industrial materials processing will provide a cost-effective method for industry to improve materials performance and reduce energy intensity. By 2025, application of HMFP to bar/rod normalization, spheroidization heat treatments, and casting may yield the following potential savings:

- Energy savings of an estimated 371.5 trillion Btu/yr
- Carbon dioxide emissions reductions of 1.66 million metric tonnes/yr
- Cost savings of 5 billion/yr

These applications represent a small example of HMFP’s transformational and cross-cutting potential.

Applications in Our Nation’s Industry

Heat-treating materials has been the conventional method for industry to obtain desired metallurgical properties. HMFP would provide an energy-efficient alternative to the vast industrial treatment needs in both the primary market (e.g., forging, casting, rod and bar, and sheet metal products) and the secondary market intended for specific manufacturing components (e.g., bearings, axles, and wires).
**Project Description**

The main goal of this project is to research and develop HMFP technology for selected high-energy consumption heat treatment operations by reducing or eliminating the need for cryogenic cooling or double temper heat treatments. In addition, another project goal involves the demonstration of the noncontact electromagnetic acoustic transducer process, for casting of ferrous alloys under HMFP, to improve microstructural homogeneity and properties over conventionally cast products.

**Barriers**

- Identification of current energy-intensive, high-temperature processes that would benefit most from HMFP technology
- Adequate definition of the design characteristics of a commercially viable prototype at an economically viable cost

**Pathways**

Industry participants will identify applications for first commercial demonstration. Researchers will experiment with HMFP to develop enhanced microstructures and properties for the intended application. Completion of these experiments will lead to analysis and characterization of the properties of the resulting candidate alloys. Project participants will also develop the design requirements for an HMFP system that will help facilitate commercialization.

**Progress and Milestones**

This 3-year project started in August 2008 and includes the following milestones:

- Preliminary proof-of-principle trials for HMFP technology
- Development of several thermomagnetic processing schemes and resultant desirable microstructures in select ferromagnetic and paramagnetic alloys
- Optical metallography, scanning electron microscope, optical inspection microscope, transmission electron microscope, x-ray, and microprobe analyses to characterize and analyze these alloys
- In conjunction with industrial partners, definition of design requirements for a future HMFP system that will serve as the first prototype commercial system to facilitate market commercialization

**Commercialization**

HMFP technology is a potentially transformational, cross-cutting, and enabling technology that could revolutionize the energy requirements and performance of U.S. metals processing. American Magnetics Inc., a leading superconducting magnet manufacturer, will serve as the magnet designer and producer. Ajax TOCCO, a major induction heating system manufacturer, will be the primary equipment supplier. American Safety Razor has signed on to implement the HMFP technology as soon as it becomes commercially available. Caterpillar Inc. and Durabar will serve as end users and investigate HMFP as an energy-efficient, cost-saving materials processing technology that can help the company achieve its Corporate “Heat Treat for Tomorrow” energy goals.

**Project Partners**

- Oak Ridge National Laboratory
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  (Gail Mackiewicz Ludtka: ludtkagm@ornl.gov)
- Ajax TOCCO
  Warren, MI
- American Magnetics Inc.
  Oak Ridge, TN
- American Safety Razor
  Knoxville, TN
- Caterpillar Inc.
  Peoria, IL
- Durabar
  Woodstock, IL

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