U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

INDUSTRIAL TECHNOLOGIES PROGRAM

Energy-Efficient Thermomagnetic and Induction Hardening

Increased Energy Savings from Efficient Heat Treating and Net Shape Forming

To meet final dimensions and material properties, conventionally produced steel components in automotive, aerospace, hydraulics, and other industrial markets typically require significant machining and energy-intensive thermal heat treatment. Additional tempering is also often needed to relieve material stresses and achieve the concomitant fatigue properties. The tempering process is not only time- and energy-intensive, but it also degrades some of the attained properties if performed improperly.

This project focuses on reducing material processing energy by replacing conventional energy-intensive heat treatment and concomitant post-processing methods like carburization, tempering, and surface finishing with thermomagnetic processing (TMP), a new, transformational energy-efficient heat treatment and forging technology. The use of TMP will be hybridized with inductive high-frequency heat treatment to achieve the required bulk and surface properties of components at greatly reduced energy use. When the hybrid integrated heat treatment method is applied to forging applications, it will also result in related energy savings by enabling widespread use of net shape forging.

Benefits for Our Industry and Our Nation

The cross-industry deployment of the hybrid induction hardening and thermo-magnetic processing (ITMP) technology may yield significant energy savings. ITMP will also greatly reduce the scrapping of energy-intensive materials because ITMP can enable precision net shape forging in applications where it had previously been cost-prohibitive. This can be accomplished by treating the forming die with ITMP to extend its lifetime.

Applications in Our Nation's Industry

The project technology is applicable to virtually all ferrous materials used in industrial manufacturing heat treatment processes. There are roughly 10,000 manufacturing facilities within the United States that perform some type of heat treatment processing.

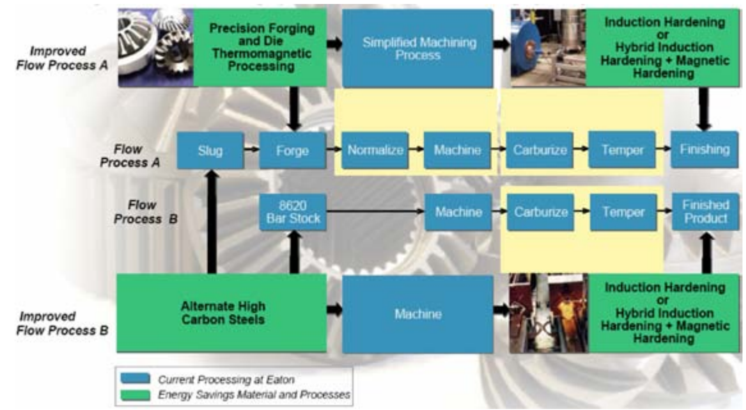

Figure 1. Improved flow processing for machining, heat treating, and forging. Flow process A: Improved machining and forging of bevel, spur, and helical gears and engine valves. Flow process B: Improved machining and heat treating of spur gears and gerotors.

Illustration courtesy of Eaton Corporation.

Project Description

This project will develop and test a hybrid thermo-magnetic and induction hardening technology to replace conventional heat treatment processes and enable adoption of the process by end users for the manufacture of specific components.

Barriers

The optimization of ITMP processing requires comprehensive expertise in cross-disciplinary fields such as product design, materials engineering, manufacturing, and heat treatment. ITMP must demonstrate the ability to produce desired properties at lower cost.

Pathways

The project approach will include the following:

- Develop a transformational TMP technology approach for bulk and surface treatment
- Develop more energy-efficient hybrid approaches that couple TMP, induction hardening, and heat treatment to replace conventional energy-intensive heat treatment and post-processing methods like carburizing for automotive gears
- Use novel, coupled induction hardening and thermo-magnetic processing approaches to extend forging die and tool life
- Use energy-efficient bulk and surface treatment technologies to produce precision net shape forgings of components at lower forging temperatures and reduced energy use to significantly reduce the carbon footprint

Milestones

This project started in September 2008. Milestones include:

- Development and selection of conceptual designs for building commercially integrated thermomagnetic and induction processing system hardware (Completed)
- Design of a prototype commercial coupled thermomagnetic and induction hardening system (Completed)
- Key acceptance test experiments conducted using the fully functional prototype
- Demonstration and verification of energy savings of at least 30% over current processing methods
- Delivery of a robust process modeling technique to assess how variations in process parameters and die material characteristics can be optimized to reduce energy
- Demonstration of the feasibility of the "optimized forging process" concept

Commercialization

Project partner Eaton Corporation will serve as a test bed for both laboratory-scale testing of concepts and application-level testing of prototypes. Eaton will also benefit from the commercial and economic potential of TMP.

New intellectual property emerging from this project will be managed through a cooperative arrangement between Eaton, Oak Ridge National Laboratory, and other project partners.

Project Partners

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