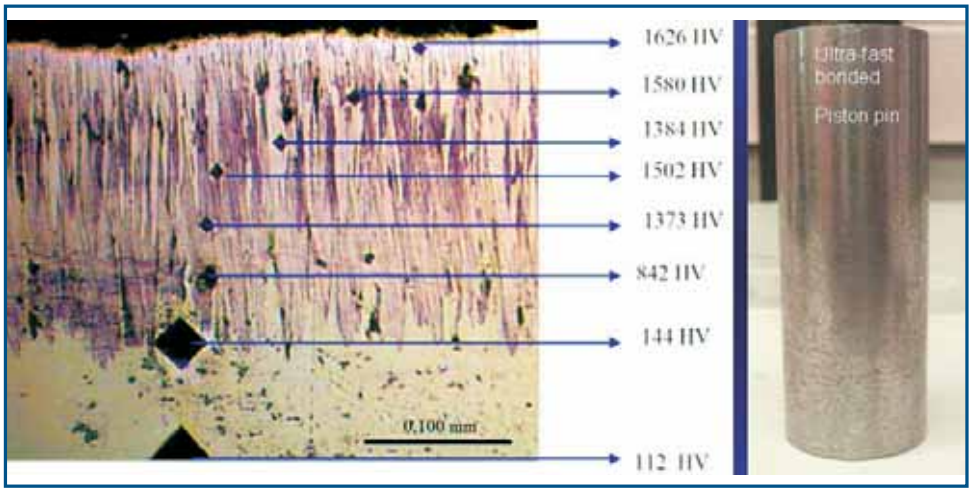
Ultra-Fast Boriding in High-Temperature Materials Processing Industries

Improved Energy Efficiency and Reduced Emissions in High-Temperature Materials Processing

U.S. manufacturing firms use a variety of heat treatments (such as nitriding, carburizing, carbonitriding, boriding, etc.) and coating technologies (such as laser-glazing/-cladding, electron and ion-beam deposition, etc.) to improve the performance and durability of machine tools and other mechanical components. However, these traditional technologies are very time-consuming, expensive, energy-intensive, and can be environmentally sensitive. To improve the competitiveness of companies involved in heat and/or surface treatment practices, there is an imminent need to develop more cost effective, energy-efficient, and more green materials processing technologies.

Researchers will further develop, optimize, scale-up, and commercialize an ultra-fast boriding (or boronizing) process that can provide much higher energy efficiency, productivity, and near-zero emissions in high-temperature materials processing.

Ultra-fast boriding could be a transformational and enabling technology with a high potential to displace, and/or complement, many of the very energy-intensive surface treatment processes that are in use today. When fully developed and implemented, the technology can provide an alternative for high-temperature surface enhancement techniques; improve energy efficiency; help near-net shape manufacturing; and provide a new means for the processing of conventional materials and components.



Cross-section SEM image of the structure and hardness profile of an ultra-fast borided piston pin

Benefits for Our Industry and Our Nation

This boriding method is very fast, clean, efficient, and has lower cost than more energy-intensive heat treatment and coating methods. Ultra-fast boriding could consume only 15% of the energy used in conventional pack boriding.

From an environmental standpoint, ultra-fast boriding does not produce any type of gaseous emissions, nor does it create solid and/or liquid wastes to cause concern.

There are several economic benefits of Ultra-fast boriding. It can increase productivity and product quality by shortening treatment time and by enabling much deeper and harder surface layers on borided parts (which can prolong life in actual applications). It can also markedly reduce cost due to initial capital investments as well as in-plant operations and maintenance.

Applications in Our Nation's Industry

Ultra-fast boriding is ideal for the treatment of iron and steel-based materials but it can also be used for the treatment of certain non-ferrous metals and their alloys (like titanium, tantalum, zirconium, tungsten, niobium, molybdenum, magnesium, most nickel-based and cobalt-based superalloys, cobolt-chrome alloys) and cermets. Pre-carburized, nitrided, and carbonitrided steels and non-ferrous alloys can also be treated by the new boriding technique.

Project Description

The main objective of this project is to further develop, optimize, scale-up, and commercialize an ultra-fast boriding (also referred to as "boronizing") process that can provide much higher energy efficiency, productivity, and near-zero emissions in many of the high-temperature materials processing industries.

Other goals of this project are to demonstrate scalability, cost-competitiveness, superior property, performance, and durability characteristics of the ultra-fast borided surfaces as well as transferring the optimized technology to an industry partner.

Barriers

- Start-up cost related to capital equipment and/or construction of a large process cell.
- Development of reliable test standards and measurement systems that can be broadly applied to distinguish one particular effect from another.
- The ability to boride intricate or odd-shaped samples or components uniformly in large batches.
- The possibility of stress-induced cracking or flaking of boride layers from top surfaces.
- The ability for the process to demonstrate dimensional predictability and minimize distortion from high-temperature processing.
- Reactions between ultra-fast boriding media and treated parts, requiring cleaning.

Pathways

Researchers will mainly focus on the scalability and viability of the new process for a broad spectrum of industrial applications and materials. The team will also perform extensive structural, chemical, mechanical, and tribological characterization of the borided surfaces using a large variety of microscopic, tribological, and surface analytical tools. Effects of contact pressure, temperature and other test parameters will be studied in detail and appropriate friction and wear maps will be generated. These bench tests will be followed by extensive performance and durability tests in actual or intended applications. Market share and industrial/economic impacts of this new technology will also be assessed.

Milestones

This project started in September 2008.

- Process development and optimization – design and develop a medium-size ultra-fast boriding unit and demonstrate the feasibility of larger-scale processing of several test samples and/or industrial parts.
- Technology development and field verification – study technology maturation, process validation, and field performance testing of a large number of industrial parts and components.
- Scale-up, validation and commercialization – design and manufacture an industrial-scale boriding system and start the production of borided parts and components for initial commercial offer.

Commercialization

After proven successful, the technology will be transferred to Bodycote for full-scale commercialization. Bodycote will obtain license from Argonne and will build several production units. They will then start the production of borided parts for commercial sale. After the technology is in full operation, expansion into other geographical centers will begin.

Project Partners

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable and affordable

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