Infrared Heating Technology: Crosscutting Applications, Widespread Benefits
March 2005

Infrared technology has been widely utilized throughout industry for drying, sterilization and curing operations. The Infrared Processing Center of the Materials Processing Group in the Metals and Ceramics Division at Oak Ridge National Laboratory (ORNL) saw additional opportunities to develop this technology to reduce industrial energy consumption and emissions, increase productivity, and improve product and process quality.

In support of this pursuit, EERE's Industrial Technologies Program has funded the development at ORNL of a number of applications of infrared heating technology in a variety of industries and market areas (For examples see references 1-6). Successes leading to full commercialization of the process have been realized with die-heating, heat-treatment, coating and surface treatments, and joining. Among the most notable achievements are the following:

- *Infrared Die Pre-heater*: used for rapid preheating of dies for isothermal forging of medical implants, these heaters cut heat time from four hours to ten minutes, enhance die life, and are roughly twice as energy efficient as conventional electric heaters.

- *The Advanced Heating System for High-Performance Aluminum Forgings* (Figure 1): a **2004 R&D 100 Award Winner**, reduces heating times by an order of magnitude, converts electric energy into radiant energy (heat) with greater than 90% efficiency, decreases energy consumption by factor of three, and produces high-performance forgings with significantly improved tensile and fatigue properties. The Advanced Heating System also offers applications in thermal processes, such as joining and heat treatment, and can be tailored to process additional materials such as steel, titanium and nickel-based alloys. Field testing of this system in a full-scale production setup has demonstrated cost savings of 40 to 50% through reduced energy consumption, increased throughput, and improved consistency in the process and the product.


Figure 1: the Advanced Heating System used for preheating aluminum billets at Queen City Forging Company, Cincinnati, OH

- *High Density Infrared (HDI)*: applications of the Plasma Arc Lamp-based HDI process extend to a number of materials and market areas; success has been achieved with coating and surface modification, die heating, joining, and heat treatment. The process has fused thermally sprayed coatings on mining machinery components for abrasive wear environments, resulting in a 50-60% increase in hardness, improved metallurgical

bonding of the coating with the substrate, and volume wear reductions of 6-10 times over current production steels. Joining applications include advanced materials joining, automotive parts, and titanium to steel for armor applications. High density infrared heating has also been used for powder metallurgical products; the rapid heating allows the fusing of powders into a solid mass for direct production of refractory metal sheet without significant oxidation.

- *Rapid Infrared Curing Process* (Figure 2): a focused tungsten halogen lamp line heater has been developed to perform epoxy curing as a part of the finishing process to the smooth welded seam on the C-pillar of the Lincoln LS. This new infrared line heater replaced five manual grinding operations and offers a safe, consistent and an environmentally friendly process that led to cost savings of $28 per vehicle, two-minute reduction in cycle time, and reduced energy consumption.

Figure 2: Infrared Line Heater installed at Ford Motor Company for epoxy curing

- *Infrared Boot Heater*: the infrared boot heater is an electric infrared heater and control system designed to heat thermoplastic and polymer boots for applications requiring placement of the boots on steering assemblies, CV joints, and the like. The infrared boot heater heats and expands the boot in a matter of 4 to 5 seconds, virtually eliminates the force required to install the boot, and subsequent cooling makes a better seal than if the boot had been forced on. The prototype system designed by ORNL has already installed over a half million parts.

- *Infrared Lamp Sheet Processing*: in conventional rolling reductions, a magnesium sheet is sent back to an off-line convection furnace after every pass to reheat the sheet to the annealing/preheating temperature, generally requiring about one hour. Alternately, magnesium sheets could be passed through an in-line infrared furnace between rolling reductions, requiring a heating time of about one minute. The resultant sheets have shown uniform microstructure throughout the 3-mm thickness in spite of the reduced annealing times, thus indicating considerable energy and cost savings in the sheet fabrication process.

Process feasibility and potential applications for infrared heating technologies have been demonstrated for a remarkably diverse set of industries, including powder metallurgy, semiconductor, information technology, ceramic processing and automotive and aerospace applications. A CD-ROM describing the facilities and developmental efforts at the ORNL Infrared Processing Center can be obtained from Dr. Craig Blue, ORNL Infrared Processing Center, at **blueca@ornl.gov**. Additional information about Industrial Materials for the Future is available at **http://www.eere.energy.gov/industry/imf/**

References:

1. Enhancement of Aluminum Alloy Forging fact sheet, Supporting Industries, project factsheet website: **http://www.oit.doe.gov/related/factsheets/enhanced_aluminum_alloy_forging.pdf**
2. Metal-Matrix Composites and Thermal Spray Coatings for Mining Machines, Mining project factsheet website: **http://www.eere.energy.gov/industry/mining/pdfs/abrasion.pdf**
3. Development of High -Density Infrared Based Surface Enhancement Technology for Mineral Processing Equipment, Mining project factsheet website: http://www.eere.energy.gov/industry/mining/pdfs/hdi.pdf
4. High-Density Infrared Surface Treatments of Refractories fact sheet, Materials project factsheet website: **http://www.eere.energy.gov/industry/imf/completed_rd.html**
5. High-Density Infrared Transient Liquid Coatings fact sheet, Materials project factsheet website: **http://www.eere.energy.gov/industry/imf/pdfs/mri_hdi.pdf**
6. Infrared Heating of Forging Billets and Dies fact sheet, Materials projects factsheet website: **http://www.eere.energy.gov/industry/imf/pdfs/infraheatbillets.pdf**