

Technologies to Watch in 2007 and Beyond



Technology seems to be moving at light speed. The result is a future that always looks different from the past. Sometimes these changes result in a significant impact to an industry. Always they require us to remain viable by adapting to the changes. Several technologies are highlighted that may impact the future of the thermal-processing industry.

**Reed Miller, Editor –
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New technologies develop for various reasons. Sometimes they are the result of enterprising entrepreneurs with a vision and many times they are seeking continuous improvement – products that are faster, stronger, lighter, more energy efficient and less expensive. The products and processes highlighted below fall into one or more of these categories. In some cases, these technologies are not fully developed, commercialized or even fully realized, and their impact on our industry is, therefore, not yet fully understood.

Nanotechnology

We lead with this one because the scope and impact of this technology is potentially huge. In fact, in one form or another, nanotechnology plays a role in several of the highlighted technologies. Nanotechnology involves work with nanoparticles, which are about 100 nanometers in size. A nanoparticle is about one thousandth of the width of a human hair. Some refer to the practical application of this technology as molecular manufacturing.

A potential impact of this technology on thermal processing involves the development of new materials.

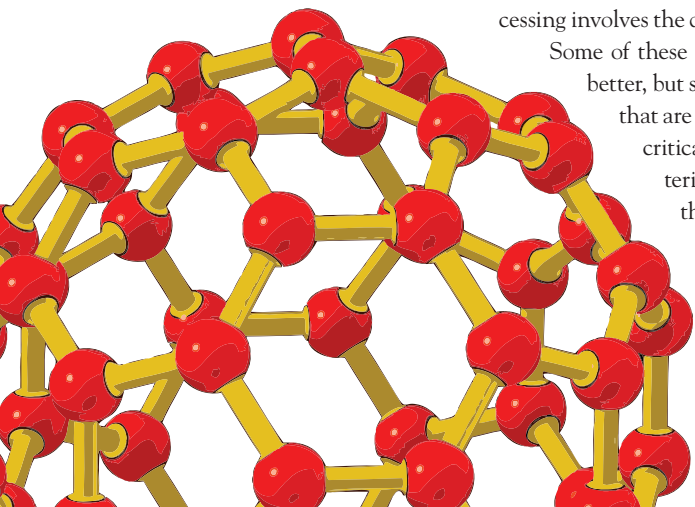
Some of these materials will make our lives better, but some will likely replace metals that are currently heat treated to meet critical properties. Many nanomaterials, however, may still require thermal processing, but this may look different than what we are accustomed to.

An example of one area under development is ballistic and armor applications. Previous work

resulted in the discovery of a new form of carbon called Fullerenes. Making use of this technology, new materials have been developed. Testing of the new Inorganic-Fullerenes material (IF), made from Tungsten Disulfide (WS_2), has shown it to have super-shock absorbing ability. The test impact was said to compare to dropping four diesel locomotives onto an area the size of a fingernail. The new IF material is up to twice as strong as the best impact-resistant material, currently used in armor, and it is over five times stronger than steel!

One company has developed a patent-protected thermomechanical process of forming and heat treatment, called Grain Boundary Engineering, which optimizes the internal structure of conventional metals and alloys at the nanoscale. Property enhancements of nanometals include weldability, resistance to intergranular corrosion and cracking, high-temperature creep, greater strength, optimum hardness and improved wear resistance.

Molecular manufacturing may soon significantly impact the global marketplace. Predictions claim the demand for goods and services using nanotechnologies will



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grow to \$1 trillion and employ two million workers by 2015. Many are concerned, however, the explosive growth of this technology brings with it potential health and environmental risks that are not yet well understood.

It will be important to keep an eye on this emerging technology to be certain we are participating wherever possible. The thermal-processing community needs to be certain we are not holding fast in the “buggy-whip business” at the dawn of the automobile era.

Composites

Composites are making inroads as replacements for conventional metals. Composite materials include glass, Kevlar, Spectra, Vectran and carbon fiber, which are all filled to shape by a hardened resin like epoxy or bismaleimide.

In addition to golf clubs, snowboards and medical devices, a practical example of this technology in action is the new Boeing 787 Dreamliner. It is the first commercial jet ever to have the majority of its primary structure – including the tail, wings and fuselage – made of advanced composite materials. Composites will make the Dreamliner 30,000–40,000 pounds lighter, which will enable the 787 to use 20% less fuel, resulting in 20% fewer emissions.

Metal matrix composites (MMCs) are cast materials that are cheaper, lighter and stronger than their original alloys. They are engineered by combining metal with a totally different class of material, such as ceramics and recycled waste. The metal functions as the matrix surrounding the reinforcing materials, resulting in physical properties not naturally attainable. One of the composites being developed embeds

nanoparticles that can provide self-lubrication, abrasion-resistance and energy-absorbing characteristics. A nanostructured aluminum, for example, can be 10 times stronger than conventional aluminum alloys. The cost of mass-producing this technology is reduced by the adaptation of a conventional foundry process. This may allow foundries to develop technologies to manufacture components from advanced lightweight materials.

Another example of composite technology in industrial-heating applications is nanostructured refractory materials. The Industrial Technologies Program of the U.S. Department of Energy has developed a low-cost nanoporous ceramic based on alumina, chromia and silica – referred to as ACS. This material will provide better insulation in high-temperature furnaces and substantially reduce energy loss.

High-Emissivity Coatings

The most widely known use of high-emissivity coatings is the black coating on the current space shuttle fleet. This coating protects tile on the shuttle bottom and leading edges from re-entry temperatures that exceed the service temperature of the tile. The aerospace uses of high-emissivity coatings generated considerable interest in using this technology in the late '80s and early '90s to save energy and improve the performance of industrial furnaces and kilns. Problems existed when trying to commercialize this technology for industrial furnaces.

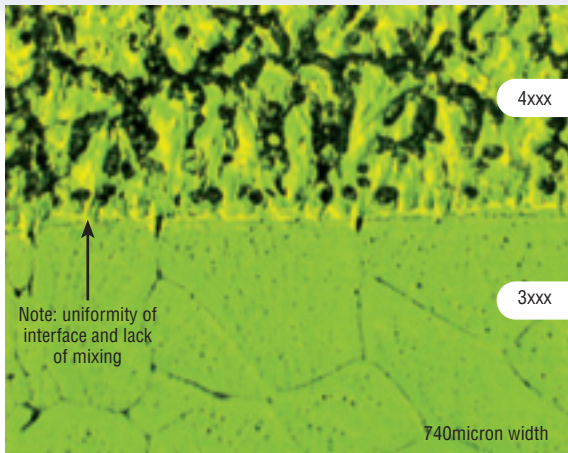
The latest technology in high-emissivity ceramic coatings, called EMISSHIELD[®], eliminates the previously experienced problems. The technology results in radiant and convective energy from the burners and hot furnace gases being absorbed at the surface of the coating. This energy is then re-radiated to the cooler furnace load. The most important benefit of using this technology in heat-treating furnaces is fuel savings. Energy savings are maximized when production is high. In the face-brick industry, 5%-15% fuel savings have been reported in lower-temperature tunnel kilns, with 10% fuel savings being typical. There are also indications that the use of EMISSHIELD[®] allows increased push rates and higher production. A highly monitored heat-treating furnace showed a fuel savings of 15% and greater productivity due to reduced cycle time.

Melting / Casting Technologies

Two technological developments in this area involve aluminum melting. The first of these is another under development by the Office of Industrial Technologies involving low-permeability ceramic and refractory components to improve low-pressure aluminum metal-casting processes. This technology, when fully realized, will provide significant energy benefits, improve uptime, reduce



Space shuttle with high-emissivity coating on the protective tiles. Photo courtesy of NASA



Novelis Fusion's perfect metallurgical bond.
Courtesy of Novelis.



Laser at work

defects and consequently reduce scrap/rework costs.

The second development casts multiple aluminum alloys into a single ingot. Called Novelis Fusion™, this technology allows for an ingot to be cast with one alloy at its center and one or more surrounding it. The ingot can then be rolled into a sheet or strip with different properties at different locations. This improved technology produces a “perfect metallurgical bond” between the alloy layers, resulting in material with both strength and improved formability or enhanced corrosion resistance without compromising strength.

Laser Surface Alloying or Hardening

The use of lasers to surface harden has been cost prohibitive because they are expensive relative to the alternative. Today's lasers are more affordable and are more necessary to address some challenging applications. Lasers accurately control the area of the workpiece heated and the amount of heat applied, thereby accomplishing what no other type of heat-treatment process can. There are a number of factors to consider before utilizing laser hardening as it is not a one-size-fits-all process. An example of an application where this thermal process could be utilized effectively is to improve the formability of the new ultrahigh-strength steel sheets that are so hard they have poor formability qualities. Laser heat treating can be used to soften the material only in the places where high formability is needed.

Another technology being developed by the Industrial Technologies Program of the Department of Energy is the development and implementation of advanced wear- and corrosion-resistant systems through laser surface alloying (LSA). With LSA, the surface properties of metals and ceramics can be modified. This involves the incorporation of hard particles (such as carbides, borides or nitrides) onto the surface of various materials for the purpose of improving wear and corrosion resistance. More work needs to be done on developing this technology, but the goal is to create advanced coatings consisting of hard particles alloyed with a corrosion-resistant matrix.

Furnace Atmospheres

Two recent developments are quite interesting. The first is a new carbon analysis technique. Called the C-Detect, it is a nondestructive measuring system that determines the carbon content in iron foils (shim stock) used for calibrating or monitoring carburizing atmospheres. The benefit of this technique is that it does not require specially trained personnel. It virtually eliminates the negative effects of surface imperfections, including finger

oils, on the final carbon reading.

On-site gas generation is becoming a well-accepted practice in our industry. An addition to this technology has the potential to save money by recycling hydrogen. Dubbed the Metallurgical Atmosphere Recycle System (MARS), this system can reduce the monthly hydrogen consumption of an annealing shop by up to 88%. This not only results in an obvious cost savings, but it also substantially reduces furnace vent-gas purging to atmosphere, thus eliminating regulated VOC emissions.

Conclusion

While we have just been able to scratch the surface of the possible up-and-coming technologies, it's clear that new technologies will affect what we do and how we do it. This may involve new thermal processes with lasers or revised thermal processing to address new material technologies such as nanomaterials. In either case, staying in tune with the developments will keep your business from becoming the next buggy-whip maker. *Industrial Heating* will do its part to keep you informed. **IH**

Additional related information may be found by searching for these (and other) key words/terms via BNP Media SEARCH at www.industrialheating.com: nanotechnology, composites, high emissivity, laser, shim stock, gas generation

Harbison-Walker Refractories Company/ North American Refractories Company

The EMISSHIELD® family of high-emissivity ceramic coatings has proven to be effective in saving process energy, increasing productivity and quality and prolonging refractory life. These products are manufactured using technology licensed from NASA. They maintain an emissivity of about 0.9 at all operating temperatures up to 3300°F. Under thermal cycling conditions, EMISSHIELD® coatings have remained strongly adhered to all substrates, including dense refractories, IFBs, refractory ceramic fibers and most ferrous and nonferrous metals.

In periodic and continuous furnaces used for firing ceramics, reheating metals and heat treating, the use of EMISSHIELD® coatings has reduced energy consumption by 6%-15%. If desired, faster heat-ups and cooldowns can be achieved, resulting in greater productivity. Refractory service life has been extended, particularly with RCF substrates where fiber shrinkage has been markedly decreased.

EMISSHIELD® coatings for metallic substrates can be used to protect metal furnace components exposed to excessive heating. When applied to boiler tubes, super-heater coils and radiant tubes, EMISSHIELD®

increases the amount of thermal energy transferred through the tubes while protecting them from corrosion.



Your Answer to Rising Energy Cost



- 6% to 15% Energy Savings
- More Even Heating
- Faster Heat-ups
- Quicker Furnace Recovery
- Increased Production
- Cooler Shell Temperatures
- Longer Refractory Life

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