INVESTING IN CERAMICS:

Manufacturing for Quality

Saint-Gobain's Carborundum Hexoloy® facility manufactures a unique product with a wide range of applications.

by **Susan Love,** Publisher

Saint-Gobain's Carborundum Hexoloy facility[1] in Niagara Falls, N.Y., brings to mind a high-tech Santa's workshop where bits of dark dust are miraculously turned into amazing and useful objects, some too secretive to even be discussed. And while the workshop analogy is accurate for this custom job shop, the technology is far beyond our friend from the North Pole, encompassing a wide range of state-of-the-art processes.

Hexoloy is a sintered SiC that is used to make corrosion-resistant, wear-resistant parts. It is hard and strong at high temperatures and has the additional advantages of being lightweight and wear-resistant. It has high thermal conductivity and can be manufactured into a wide range of complex shapes and sizes with minimal machining.

Typical Hexoloy applications include:

- automotive water pump seals—as-molded tolerances of ±0.4% (high precision parts)
- mechanical seals and bearings for the chemical process industry
- sliding friction and wear resistant parts (such as nozzles and valves)
- components for the semiconductor wafer processing industry
- thermal components—thermocouple protection tubes, heat exchanger tubing and kiln support beams/tiles
- armor for military personnel and vehicles

Hexoloy is used to make a variety of corrosion- and wear-resistant parts, as well as components for use in high temperatures up to 1650°C in air and to 2000°C in inert atmospheres.

But while the applications for the product are fascinating and diverse, it's the manufacturing process that makes Hexoloy unique. The transformation from raw material to finished goods starts with spray-dried premix powders manufactured at another facility at the Niagara Falls site. The premixes are alloys of one basic formula consisting of milled SiC grain and a propriety binder. According to John Bevilacqua, senior product specialist for the Structural Ceramics Group, "the sinterable premix is really the magic" in the process.

The sub-micron ultra-fine-grain powder is then processed by forming, finishing and firing into parts according to customer specifications and orders.

1 - The Hexoloy operation in Niagara Falls is part of the Structural Ceramics Group within Saint-Gobain's Ceramics and Plastics Branch headed by Ron Lambright. The Structural Group includes the Niagara Falls operations and a similar facility in Monchengladbach, Germany. Also included in this group are facilities in Sandborn, N.Y., for aluminum nitride products; Amherst, N.Y., for boron nitride products; and East Granby, Conn., Etrechy, France, and Robertsfors, Sweden, for silicon nitride products.

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Forming

Forming methods used in this plant range from dry press to wet bag to cold press to injection molding, with a small amount of slip casting. Small parts are formed via dry pressing and cold isostatic pressing. Some high-volume kiln furniture, including kiln beams, is extruded, as are thin-wall, 14-ft-long straight tubes used in heat exchangers and as thermocouple protection tubes.

Dry pressing to finished size is the most economical process for volume production, helping to justify the initial cost of tooling. Injection molding is used for the more complex parts made in volume.

In the pressing operation, a proprietary Hexoloy powder is used in a gravity-fed press. It is a sub-micron powder with lubricants and polymers—hollow spheres that flow nicely. Bevilacqua says the SiC premix is a "tremendous product unto itself" because of its ability to form high-precision, hard, wear-resistant parts.

Curing

Following forming, the parts are cured by heating in an inert atmosphere on shelves for six to eight hours. "Virtually everything is cured to increase green strength, optimize dimensional control and improve yield," Bevilacqua explains.

Green Machining

Prior to sintering, products are machined in the green state using diamond tooling and conventional, programmed CNC machines. Machining at this point helps control costs associated with expensive grinding of sintered goods and can be done faster than machining finished materials. Additionally, more complex geometries are possible by machining in the green state.

Firing/Sintering

Sintering furnaces operate above 2000°C, and both continuous and periodic kilns are used. A pressureless sintering process patented in the 1980s uses atmospheric pressure with sintering aids. This process is made possible by .4% boron in the mix. "That is the twinkle of the magic in the soup" that allows pressureless sintering to be used, explains Bevilacqua.

Sintered pieces exhibit ~18% linear shrinkage, so the initial forming and machining is critical to accurate finished parts. "Our emphasis on batch shrinkage, tool design, formed green size and green machine tolerances all improve the control of as-fired dimensions," Bevilacqua says.

Post Firing

St. Gobain uses a leading-edge vision system technology for sorting parts. Some of those parts will be shipped "as fired," while a small percentage of others will be sent for surface finishing, drilling or grinding. When surface finishes are critical, such as with some wear parts, lapping and honing may be used to further enhance the surface flatness. Costs for this final grinding with diamond tooling are directly related to blueprint tolerances for the parts.

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As the last step in the process, quality assurance testing includes a non-destructive final inspection for internal structures. Routine quality checks include dimensional conformance, density, strength, microstructure and grain size, chemistry, surface finish and flatness.

Future Growth

"We are, incredibly, all things to all people," says Bevilacqua. Driven by the material itself and by application solutions, the Niagara Falls operation is basically a large job shop, except for automotive seals, which represent a high volume core business. The material has "unique chemical and physical properties that will solve problems," and there are a "wide range of divergent applications and problems we can solve," says Bevilacqua.

Some of the more unusual products manufactured at the facility include:

- parts made into belts for sintering furnaces for silicon nitride at 1800°C
- nozzles for use in palm oil separators
- kiln furniture used to fire ceramics at temperatures above 1500°C
- hydrocyclone liners/valves for copper gold and nickel mines

Future growth is expected to come from the automotive industry for longer-life water pump seals, as well as extruded products and emerging technologies. Additionally, because Saint-Gobain's Hexoloy SA SiC product is light and tests well ballistically, it can be used to make armor and related military equipment lighter and more mobile.

The company is always looking for more applications that require Hexoloy's unique balance of properties including corrosion resistance, strength and stiffness in use, and high thermal conductivity. But the overall focus is on problem solving, rather than producing off-the-shelf products. "We see ourselves as an 'engineered solution company,' solving customer problems with unique ceramic materials applied with innovation," Bevilacqua says.

For more information about Saint-Gobain's Carborundum Hexoloy facility, contact John Bevilacqua, Saint-Gobain Industrial Ceramics & Plastics - Structural Ceramics Group, 23 Acheson Dr., Niagara Falls, NY 14303; (716) 278-6022; fax (716) 278-2373; or e-mail john.m.bevilacqua@sgcna.com.