LIKE other materials industries, powder metallurgy (PM) faces unprecedented challenges in the highly competitive international marketplace. Rising energy and raw materials costs, wounded OEM automakers, and customers rushing to Asia with manufacturing and assembly plants are changing the way PM companies are doing business. While growth in North America and Western Europe may be leveling off, Asia looks brighter than ever, especially China and India. For example, in the past several years more than 17 non-Chinese companies have invested in PM parts and metal powder plants in China. And more will follow. PM parts production in China is expected to increase at double-digit annual rates.

Automotive powder markets

The PM market softened in 2005. Iron, copper, and stainless steel powder shipments declined, impacted by production cuts at General Motors and Ford, and weakening sales of SUVs, which are traditionally heavy users of PM parts. The typical North American built vehicle in 2005 contained about 43 pounds of PM parts, while some SUV models have more than 70 pounds. GM’s new full-size SUVs, averaging 20 miles to the gallon, contain an estimated 68 pounds of PM parts. If the new models are successful, PM will benefit. For this reason, the market outlook could look brighter in 2006 and 2007.

GM is also targeting more PM parts in six-speed transmissions for rear-wheel drive vehicles. In this application, PM competes against gray iron casting, ferritic and pearlitic malleable iron casting, nodular iron, and machined steels. GM’s 4T80-E transmission contains the most PM parts, with a total of 26.1 pounds. In addition, the carmaker estimates a rise in PM usage in automatic transmissions through the 2009 model year. This article reports on the progress being made by several different powder and parts makers.

New technologies

For the future, PM companies are banking on new materials with improved properties that will open up new markets for higher-strength PM parts. More complex designs, automated production, and innovative processing techniques are other trends that will also fuel PM’s growth.

For example, Hoeganaes Corporation, Cinnaminson, New Jersey, has introduced a higher-density product, ANCORMAX-D, providing a density approaching 7.6 g/cm³, by double-pressing and double-sintering. This product offers new market opportunities for high-strength P/M gears in automatic transmissions. Höganäs AB, Sweden, and North American Höganäs (NAH), Hollsopple, Pennsylvania, have focused R&D on low-cost alloying elements, bonding technology, and high-density processes to improve the high-strength performance of PM parts and enhance tolerances. Surface densification by transverse rolling is a promising new technology to improve the performance of P/M parts and highly loaded gears, matching performance of wrought steels. Gears are more sensitive to bending and surface-contact fatigue, as well as wear. Because of this, they need high density at the surface and throughout the part. Pre-alloyed powders, optimized for surface densification, stretch these limits, and will increase P/M usage in automotive transmissions. A surface-densified material matches the rolling-contact-fatigue strength of a solid-steel reference material, Höganäs reports. Another program shows that a surface-densified PM planetary gear in a hub reduction unit of a heavy-truck application...
These are the Grand Prize Winners in the 2005 International Powder Metallurgy Design Competition, sponsored by the Metal Powder Industries Federation.

**Left, foreground:** A complex 316 stainless steel support cover won the grand prize in the stainless steel category. It is made by Webster-Hoff Corporation, Glendale Heights, Illinois, and is for a high-security military application.

**Right, foreground:** A highly complex electrical connector for a plug and adaptor won the grand prize in the injection molded category. The part is made by Advanced Materials Technologies Pte. Ltd., Singapore, for Eubiq Pte. Ltd., in Singapore. The complex part is made from copper powder to a density of 8.8 g/cm³ via metal injection molding.

**Middle:** Sinterstahl Füssen GmbH, Füssen, Germany, won the overseas grand prize for a camshaft sprocket in a 4.0L V-6 engine. The BorgWarner Engine Group Morse Tec Europe S.r.l., Milan, Italy, is the customer. The net-shape part is made with innovative tooling that consists of three lower and two upper punches.


**Background, right:** Burgess-Norton Mfg Co., Geneva, Illinois, won the grand prize for a free-wheel steering system axle assembly containing 16 PM parts weighing 5.9 pounds. Made for a snowblower, the assembly consists of a stamped steel frame, bronze and plastic bearings, and a wrought steel axle. It functions as an on-demand operator-controlled differential traction system.
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Ametek says that its pneumatic isostatic forging (PIF) process, an alternative to hot isostatic pressing, improves the density of metal injection molded (MIM) parts. The process offers high density with a fine grain size and improved fatigue properties.

**SMC Metal Products Inc.**, a Gibraltar Company, Research Triangle Park, N.C., reports on growth opportunities for new pastes in infiltration, sinter brazing, and brazing copper-brass heat exchangers. The company claims that infiltrant pastes can be deposited on parts in any shape (dot, line, circle, or square), which eliminates handling and placement problems associated with fragile compacted preforms. Sinter brazing paste allows simultaneous sintering and joining, and is designed to minimize infiltration into the part by remaining in the joint for a strong braze. Pastes for brazing copper-brass heat exchangers feature low-melting-point copper-tin-nickel-phosphorus powders as the filler material.

**Inco Special Products**, Wyckoff, N.J., reports that nickel can lead the way to higher-density P/M parts. Researchers at Inco, testing properties of PM steels made with Ti10D powder, report significant increases in strength and hardenability because of nickel diffusion at conventional sintering temperatures. The improved dispersion of admixed nickel reduces variability in properties, Inco claims.

**Hawk Precision Components Group**, Fremont, Ind., says that new growth opportunities will open up when PM parts makers strive for higher densities. Hawk is achieving single-pressed and single-sintered densities up to 7.5 g/cm³, and up to 7.65 g/cm³ with re-pressing by means of a proprietary densification process. Hawk reports that it can also produce complex part geometries with up to nine separate levels with net-shape compaction.

**Cloyes Gear & Products Inc.**, Fort Smith, Ark., sees the continued growth of variable valve timing (VVT) parts demanding sophisticated process-finish finishing equipment. Designing PM parts for VVT systems will require cleaner materials and closer tolerances. More high-tech secondary operations will be needed to meet this challenge.

**Capstan Atlantic**, Wrentham, Mass., focuses on gear-helix crowning via selective densification, rolling-contact-fatigue resistance equivalent to 8620 carburized wrought steel, precision shot peening, deburring, and CNC gear-inspection equipment for reverse engineering of custom gear-tooth forms. The company is working on methods to achieve AGMA 12 quality.

**FloMet LLC**, Deland, Fla., makes parts via metal injection molding. Magnets, solenoids, switches, and housings for battery and fuel markets offer opportunities for MIM parts. These potential applications represent tens of millions of parts-production runs. Nanotechnology also offers an exciting opportunity for MIM. However, it presents a serious question of how to protect alloy particles from oxidizing. Until this problem is solved, it will be difficult to sinter dense MIM parts from nanoparticles.

**Phillips Metal Injection Molding**, Menomonie, Wisconsin, sees cellular manufacturing taking hold in MIM, especially for high-volume parts. Cells with one molding machine feeding a single debinding-and-sintering furnace, and possibly a CNC machining center, will become the norm, the company predicts.

**Bodycote HIP Inc.**, Andover, predicts that P/M near-net shapes made via hot isostatic pressing (HIP) will continue gaining acceptance in offshore oil and gas components. HIPing provides large parts in 8 to 12 weeks, compared to forging deliveries, which can take up to one year or more. HIPed large selective net shapes are being developed for rocket-engine parts. The design concept controls selective dimensions very precisely in areas where machining is difficult, while allowing other dimensions to float. Aerospace, power turbine, HIP-clad and sputtering target markets are experiencing strong growth. HIP densification of ceramic powder is also growing.

**Extrude Hone/ProMetal**, a division of Ex-One Corp., Irwin, Pa., says that three-dimensional printing (3D printing) as a metal-forming process is in commercial production. The company licenses the process from MIT and produces parts by printing stainless steel powder, followed by light sintering and bronze infiltration. The composite material has a yield strength of 552 MPa (80,000 psi) and an elongation of 4.5%. Superalloy, tool steel, and precious metal parts can also be made by the novel process.