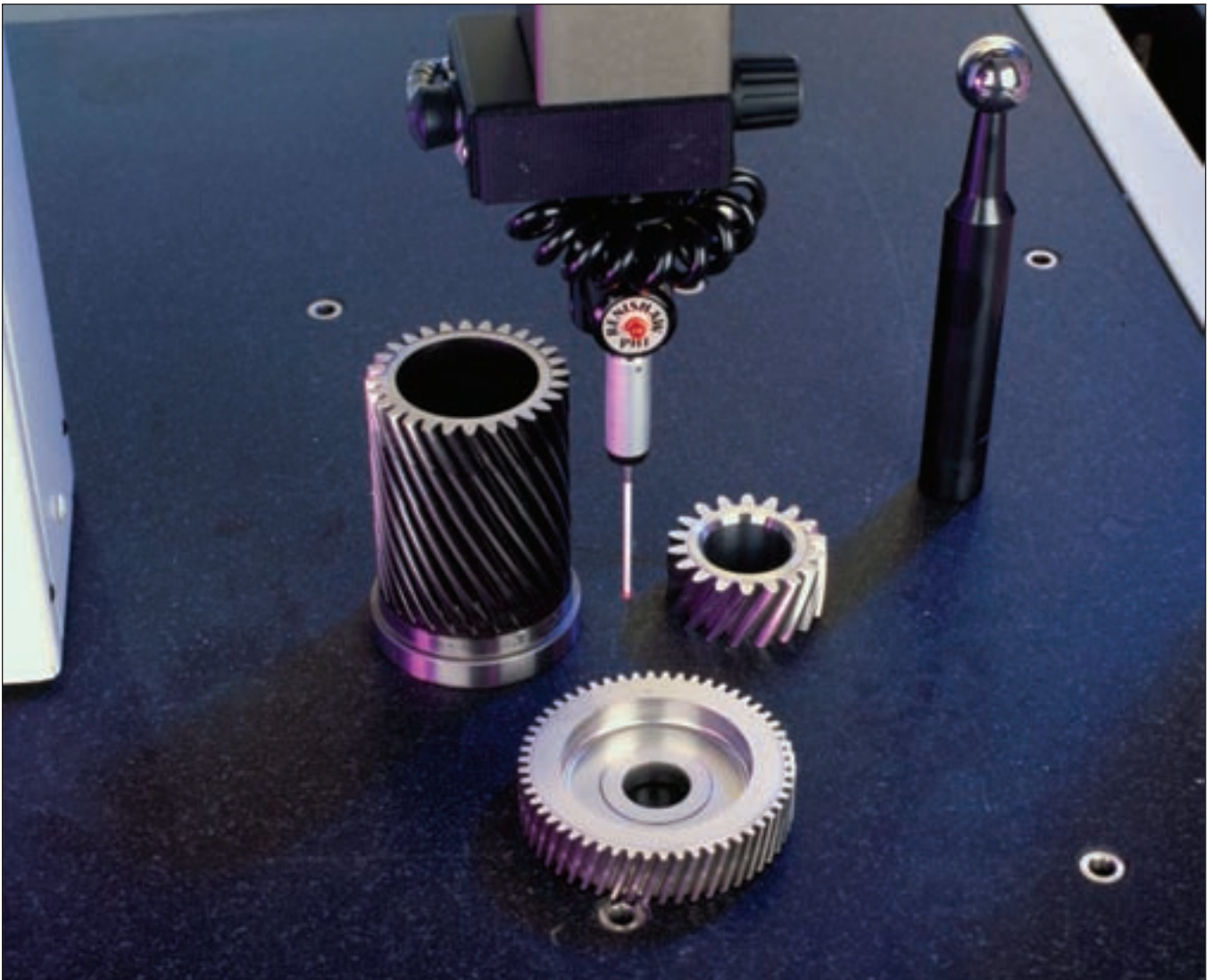


# The Powder Metal Method

DESPITE ECONOMIC UNCERTAINTY  
THE FUTURE LOOKS PROMISING FOR PM GEARS

Matthew Jaster, Associate Editor



A PM punch & PM helical gears on a CMM. Image provided by Capstan Atlantic.

There's no top-secret, powder metal technique that's going to eliminate the rather bleak outlook of the current automobile and housing markets; no business plan that will sweep declining powder shipments and PM parts usage under the rug; no triumphant declaration

that the PM industry is in the midst of a profitable and successful calendar year. In reality, you'll be hard-pressed to find anyone that's not a little concerned about where United States manufacturing is at, and where it's going.

It is nice to know, however,

there are people working to improve material properties, create innovative technologies and raise awareness of the PM industry in order to help get manufacturing back on its feet. If you submit to the notion that "the glass is half full," you may not only listen to

such optimism; you may start believing it.

**Getting the word out.** Due to its low-cost, high-performance characteristics and excellent response time, powder metallurgy remains a significant form of alternative gear manufacturing. Thanks to innovative technologies and improved material properties, domestic powder metals should continue to enjoy success for many years to come.

According to the Metal Powder Industries Federation (MPIF), the typical United States passenger car contains 43 pounds of powder metallurgy parts. More than 500 million PM hot forged connecting rods have been made for cars produced in the United States, Europe and Japan.

More importantly, there are other areas where powder metallurgy has yet to reach its full potential, including transaxles for recreational vehicles, business machines and lawn and garden equipment. These, along with automobiles, will eventually help push the industry forward.

"There are so many different areas the PM industry can be called upon for," says James Dale, vice president of the MPIF. "Problem is that it's difficult to assess the various needs of our customers. We're currently trying to increase visibility in the auto market by bringing some new ideas to the table."

Dale adds that the driving force in powder metallurgy in 2008 is going to be word of mouth. The key will be promoting the technical aspects of the industry and trying to get engineers to start thinking about different solutions during the design phase.

"The smartest thing an engineer can do at this stage in the game is to talk to potential suppliers early and often," Dale says. "Ask the right questions and find out what a supplier can do for you and what PM systems are available. You may be short-changing yourself if you don't know what the PM industry can provide in regards to mechanical properties and reduced component costs."

Dale describes the current state of the PM industry as "steady," though he admits to some recent drop-offs mainly due to the economy. Currently, the main objective of the MPIF is to get as much traffic as possible to its website and to

promote its members. By continuously adding and updating material, the site has become a focal point for PM in the United States as well as the global market.

"The MPIF operates with the Industry Development Board and tries to get involved in conferences and seminars relevant to powder metals," Dale says. "You'll find us at places like the National Design Engineering show and the SAE World Congress. It's important to get out there and talk about our breakthroughs in strength requirements and density."

The MPIF also publishes a series of material standards that serve the gear community with recognized standard alloys for designers and metallurgists to specify for their products. Wide distribution of these standards ensures the design community of up-to-date materials and properties for specifying their gear systems.

Howard Sanderow, president of Management & Engineering Technologies, a consulting firm, adds that there are a few other marketing thrusts currently in the industry.

"The Global PM Property Database—introduced two years ago—is a database that provides physical and mechanical property data for ferrous and non-ferrous structural materials, bearing grades and metal-injection-molded products. Free of charge, the database is available 24/7 at [www.pmdatabase.com](http://www.pmdatabase.com)," Sanderow says.

The website was created by a cooperative effort between the MPIF, the European Powder Metal Association (EPMA), and the Japan Powder Metallurgy Association (JPMA).

Sanderow is pleased with the collaborative efforts of these various global institutions, and as chairman of the AGMA Powder Metallurgy Gear Committee, believes there's a great opportunity for the PM industry and AGMA to collaborate on training programs for net-formed gear manufacturing technologies as well.

While there's PM business in the high-tech, medical and military fields, Sanderow believes it isn't enough for domestic manufacturers to offset the declines in dominant markets. According to Sanderow, the auto industry registered its first ever decline

in PM parts usage in 2007 as the shift to smaller vehicles impacted PM parts usage in light trucks and SUV's. The non-automotive segment of the PM industry has been affected by the sharp decline of new home purchases.

On a positive note, the domestic PM industry continues to enjoy a strong position in gear technology for power tools, lawn and garden transmissions, pumps and gear motors for a variety of industrial and consumer products.

"We believe gears are the single largest 'product' manufactured by the PM process, representing an annual sales volume of more than \$1 billion," Sanderow says. "The current soft economy in 2008 will impede the immediate growth of PM gear sales, but we should see a strong recovery in 2009/2010."

#### ***The rising cost of raw materials.***

According to a state-of-the-industry address at the PowderMet 2007 conference in Denver, the rising price of raw materials, especially copper and nickel, have forced a substitution trend in the industry.

Some stainless steel users are switching to lower-nickel 304 stainless or moving into non-nickel-containing stainless steels. Fabricators of bronze bearings are lowering the copper content in PM bearings with diluted bronze bearings or iron-graphite bearings. Observers expect the prices of nickel and copper to stay high until new mining capacity is targeted to hit the market in 2008.

The Hoeganaes Corporation, an iron powder manufacturer, strives for high-performing materials for its customer base, emphasizing a cost-effective alternative for PM parts makers.

"This has to be done within the context of the rapidly increasing material price environment that we live in," says Howard Rutz, vice president of research and development at Hoeganaes. "We deal with a wide range of markets in addition to our core 'press and sinter' business. When you come to work each day, you never know who is going to call with another unique application for iron powders."

The company has been working with gear maker Capstan Atlantic on the introduction of AncorMax 200, a

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warm compaction technology that takes advantage of the Ancordense process without the need to heat the powder. This process achieves a density of 7.5g/cm<sup>3</sup> by single pressing and sintering.

"This provides the ability to easily compact to the higher density levels that are necessary to meet gear requirements," Rutz says.

Combining this process with high-performance alloys such as Ancorsteel 4300 has opened up new applications for PM gears and sprockets in automotive transmissions and hand tools. Ancorsteel 4300 is the first in a line of engineered, high-performance, binder-treated products that stimulate wrought steel comparisons, and can be processed at conventional sintering temperatures. Good compaction, dimensional stability, and sintering conditions are just a few of the advantages of this alloy.

With large penetration in the industrial and automotive sectors, Rutz says there are many examples of different PM parts being manufactured for the gear industry.

"The advantage in near net shape production of gears is obvious, and the technology needed to compete in the highest levels of gear performance is on the horizon," Rutz says.

**An investment in technology.** While there's no breakthrough technology that's going to turn the industry upside-down, Capstan Atlantic is moving forward on several PM advancements. The company is aware of the global growth potential available to their customers, and it is seizing every opportunity to develop new techniques to jumpstart the market.

"With powder metallurgy, you can tailor the process to the application you've targeted and be very specific without over-engineering and creating a lot of waste," says Richard Slattery, vice president of engineering at Capstan. "People aren't fully aware of what's available to them and how flexible the PM process can be."

In 2007, Capstan targeted precise, high-performance, multi-level sprockets by launching an award-winning series of high-density, single-pressed sprockets for automotive applications. Recently, the company brought a selective densification process to the market and has the first PM-crowned gear in

## Precision Stock Bevel Gears From the Bevel Gear Specialists

Arrow Gear is widely known as a producer of high precision custom gears.

Arrow also offers a full line of spiral bevel gears from stock – including ground tooth gears. Stock gears are a cost-effective alternative to custom gearing – especially beneficial for low production volumes and prototype work.

Our state-of-the-art gear manufacturing facility is among the most advanced in the world. This capability allows us to provide high precision stock gears in matched sets that are carburized and hardened – meeting quality specifications from AGMA Q9 up to Q13 on ground tooth gears. Based on customer needs, our stock gears can often be modified to meet specific design requirements.

To learn more about Arrow's stock gear products, please visit our Website or contact our Design Engineering department.



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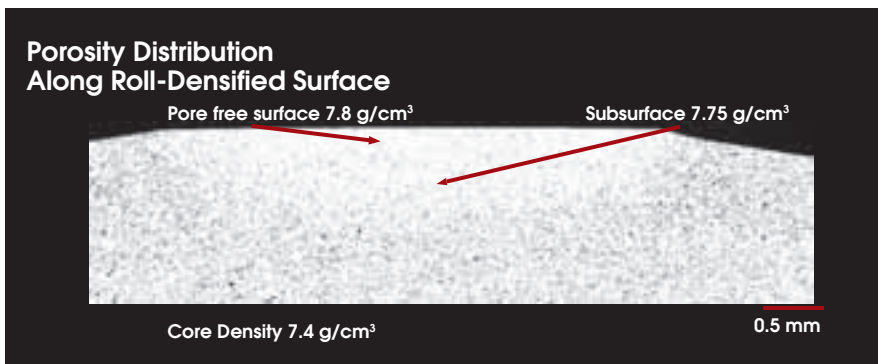
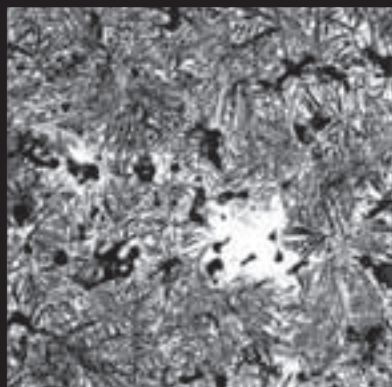


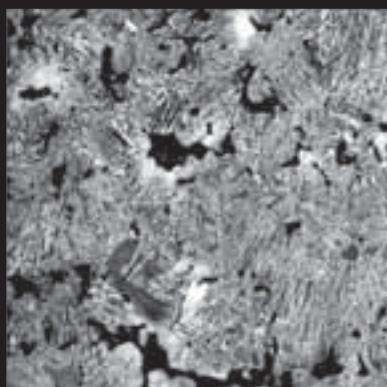
Image provided by Capstan Atlantic.

### Heat-Treatment/Surface Carburize

**Case: Acicular Martensite**



**Core: Lath Martensite**



Nital/Picral Etch, Orig. Mag. = 500x

Image provided by Capstan Atlantic.

production. The company will accept an award for its efforts at this year's PM World Congress in Washington.

Further progress has been made on the ability to produce gears with a custom involute profile for the purpose of noise reduction in service. Capstan has also produced a gear with a crowned helix for improved load distribution on the gear teeth. While maintaining the economic efficiencies of powder metallurgy, the company also is able to surface-densify and harden PM gear teeth to achieve rolling contact fatigue (RCF) properties equivalent to that of an 8620 carburized cut steel gear.

Other key areas of interest in research and development at Capstan include providing high dense, rolled combination gears and the ability to develop alloys to meet the specific needs of their customers.

Providing two gears as a single component with highly dense PM materials systems creates multi-level parts such as a gear with a flange, a sprocket with a pinion or a right-hand

helical gear and a left-hand helical gear. These combination gears, according to Slattery, are used in applications such as drive trains, laundry systems and high-volume printing machines.

Capstan also offers their customers the ability to reduce some of the alloys while maintaining the required physical properties.

"The cost of alloying elements such as nickel, molybdenum and copper have increased substantially, and the entire industry is dealing with a surge in raw material costs," Slattery says.

"Leaning out alloys and creating custom alloys can be less expensive to our customers."

In order to improve the quality and performance of PM gears, Sanderow highlights a few other advancements including:

- **Warm compaction.** A process to increase the density and thereby the strength and durability performance of PM gears. "This is a relatively inexpensive method to achieve

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properties approaching that of wrought steel," Sanderow says.

- **Surface densification.** A secondary process applied to the surface of gear teeth to completely densify the material and achieve properties equal to wrought steel. Several alternative methods are in production achieving greater than 99 percent density in the surface layer. The technique has been successfully applied to transmission sprockets and gears.

- **Gear rolling.** A secondary process, well known to wrought steel gear manufacturers as a means to improve the dimensional quality of gears. This is applied to PM gears to densify the surface of the gear tooth flank and root as well as improve gear accuracy. Both proprietary gear rolling technology and commercial techniques have been successfully applied to high-performance gears.

- **Microwave sintering.** A new technology under development for PM steels as a means to shorten the processing time and improve the response. This method has yet to be applied to the production processing of PM gears.

- **Fine powders.** A new technology which uses agglomerated fine powders to improve the sintering response of the PM steel, thereby achieving high mechanical performance.



A single pressed high dense combination gear featuring opposing helix angles by Capstan Atlantic.



Award-winning sprockets created by Capstan Atlantic in 2007.

- **Cr-Mn-Mo powders.** A recent development offered as a means to reduce the cost of the base steel powder (as compared to Ni-Mo PM steel grades) and still achieve high performance response. "The Cr-Mn PM steels require close control of the sintering conditions and vacuum heat treatments to maximize mechanical performance," Sanderow says.

**The PM perspective.** According to the MPIF, the PM parts market in China, Korea and India has seen outstanding growth rates. International OEMs are establishing production and procurement sites in these countries at alarming rates. In 2007, the MPIF urged Asia, Europe and the Americas to promote and grow PM worldwide, possibly through a global federation.

"We've definitely talked about it in the past, but I'm not sure a global federation is necessary at this point," Dale says. "The MPIF, EPMA and JPMA get together frequently to discuss the direction PM is heading, and a global federation might just mean more meetings."

Dale adds that they're all members of each other's organizations, and work well together as a group.

"For the time being, I think the various organizations are doing a great job of keeping everyone up-to-date on global issues in the PM industry. The World Congress is just one of the many examples of this."

Although this partnership has helped build up the reputation of the global PM market, the rise of the Asian markets has had a negative effect on some companies in the United States, according to Sanderow.

"The emerging markets in Asia have negatively impacted the domestic PM parts manufacturers as numerous consumer products are now entirely manufactured overseas (e.g., power tools), or the gear motor is imported as a complete sub-assembly for use in domestic equipment (e.g., copiers)," Sanderow says. "We believe this problem will continue to grow until the total costs of these products are better understood and appreciated by domestic purchasing and quality staffs."

While a global push is necessary, Sanderow believes the domestic market will thrive once again due to the

proximity between client and customer.

"While some may struggle with losses to offshore manufacturers, the high-quality gear requirements will be best served by domestic PM manufacturers who are located close to their customer, can react quickly to changing requirements and can provide the latest technical improvements—fast and efficiently," Sanderow says.

The 2008 World Congress on Powder Metallurgy and Particulate Materials will bring together the largest assembly of PM technologists, ever. The conference will feature special interest programs as well as new gear materials and continued progress in surface densification and gear-rolling technologies.

"Although most of the attention is focused on the billion dollar automotive transmission market, the non-automotive market is just as lucrative for the PM parts manufacturer," Sanderow says. "We see a strong, positive future for the domestic PM gear industry over the next 5–10 years and we've advised our clients accordingly."

Dale believes the breakthroughs in regards to strength requirements and maintaining gear profiles are only going to help drive the PM gear business.

"Gears and gearing are definitely a main entrée in powder metals, and I expect this aspect of the industry to continue to flourish in the future as we continue to work with the Big Three in Detroit," Dale says.

With limitless possibilities, a tremendous cost-saving potential and countless innovations in technology, you'd think an industry like PM could brush off the "alternative" gear manufacturing label. Regardless of their upside, plastic, injection molding and powder metallurgy will always be considered alternative manufacturing. It simply comes down to capabilities and available applications.

"PM gears will never be flying in helicopter transmissions or powering attack submarines," Sanderow says, "but for consumer products and industrial applications of less than eight inches in diameter, powder metal gears are definitely mainstream." 