Technology Tidbits

William R. Stott

New Technique for Forging Crowned Helical Gears

Createch Co. Ltd., a forging die manufacturer from Shizuoka, Japan, has developed a net-shape cold-forging process for forming helical gears and splines with crowned teeth.

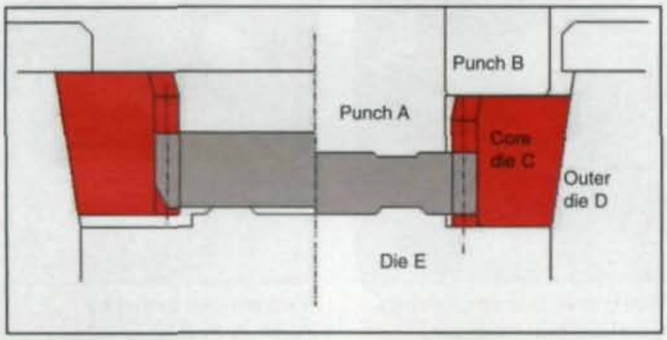
The process is being tested by Japanese automotive manufacturers to replace conventional forging and machining processes. Potential advantages include improvements in gear noise, pitting resistance and fatigue strength, says Hitoshi Ishida, Createch's president and founder. Also, there is the possibility of eliminating processes such as tooth shaving or tooth grinding.

The process is capable of forming gear teeth to JIS 2–3 quality for spacing error, tooth profile error, lead error with crowning, and runout, according to Ishida. That is similar to the quality level obtained by gears that have been cut and shaved or burnished, Ishida says.

Createch has created what Ishida refers to as a "dialog with molds," meaning that the interaction between the dies and the forged materials is so well understood and controlled, it's as if the mold is speaking with the material, Ishida says. This "dialog" allows a homogeneous distribution of inner stresses in the finished part, he adds.

According to Ishida, the secret to creating crowned teeth is radial force. With a conventional forging die, the material is forced into the mold with axial force. Essentially, the work material is pressed through a helical die from one end. Createch uses a conventional forging process to create rough helical gears without crowning. However, because crowned teeth are thicker in the middle than at the ends, they cannot be formed by such a process, nor could they be easily removed from the die.

To finish the gears, the Createch die sets include a tapered die case and a core die. The rough gear is placed inside the core die.



When the core die is forced into the tapered die case, the core die deforms elastically, shrinking inward as it's pushed through the die case. That inward force forms the crowning on the gear teeth. When the core die is removed from the die case, it returns to its original form, expanding away from the part and enabling the crowned teeth to be removed easily from the mold.

Another unique aspect of the Createch die sets is that they are equipped with a mechanism to rotate the core die during the crown forging process. The friction caused between the core die and the workpiece helps create a homogeneous stress distribution and symmetrical crowning of the tooth flanks, Ishida says. It also allows for continuous metallic fiber flows at the gear root, providing high fatigue strength and pitting resistance.

The Createch die sets are made for conventional forging presses, including hydraulic, knuckle, link motion and mechanical presses commonly used for forging operations. They are most applicable for high-precision gears, such as gears for planetary reducers and in some automotive applications, says Ishida.

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Japanese Companies Develop High-Strength Plastic Gears

Shin-Kobe Electric Machinery Co. Ltd. of Tokyo has developed plastic secondary balance shaft gears that greatly reduce the noise in four-cylinder automobile engines, according to the company.

Plastic gears have been used in automobile engines for many years—Shin-Kobe developed its first phenol resin balance shaft gear in 1955—but this is the first instance they have been used for the secondary gear, which rotates twice as fast as the primary balance shaft gear. Until now, steel gears were required for that application, according to Akikazu Tazawa, manager of overseas marketing and planning for Shin-Kobe.

The gears were developed in cooperation with Toyota Motor Corp. and are being used in the four-cylinder engines of the Estima, Harrier, Kluger, Ipusam and Camry models of Toyota vehicles, according to Tazawa. The company expects total sales of the gears to reach 3 billion yen (roughly $24 million) in 2002.

The new gears are made of KOBE LITE® KM-9000, an aramid-reinforced fiber and polyaminoamide resin, resulting in increased durability and heat resistance when compared to conventional plastic gears, such as phenolic resin with glass fibers. The gears also significantly reduce noise when compared with metal gears previously used. At 2,000 rpm, the noise can be reduced by at least 15 decibels, Tazawa says.

Shin-Kobe uses a special spun yarn to improve the adhesion of the aramid fiber, which normally doesn't have a good affinity with resin, Tazawa says. The fibers are arranged so that they radiate from the center of the gear, giving the gear added strength. Aramid also is less damaging to the mating gear teeth than glass or carbon fibers would be.

In addition, the plastic gears allowed designers to eliminate backlash shims, which were required with metal gears previously used. This saves assembly labor and complexity, Tazawa says.

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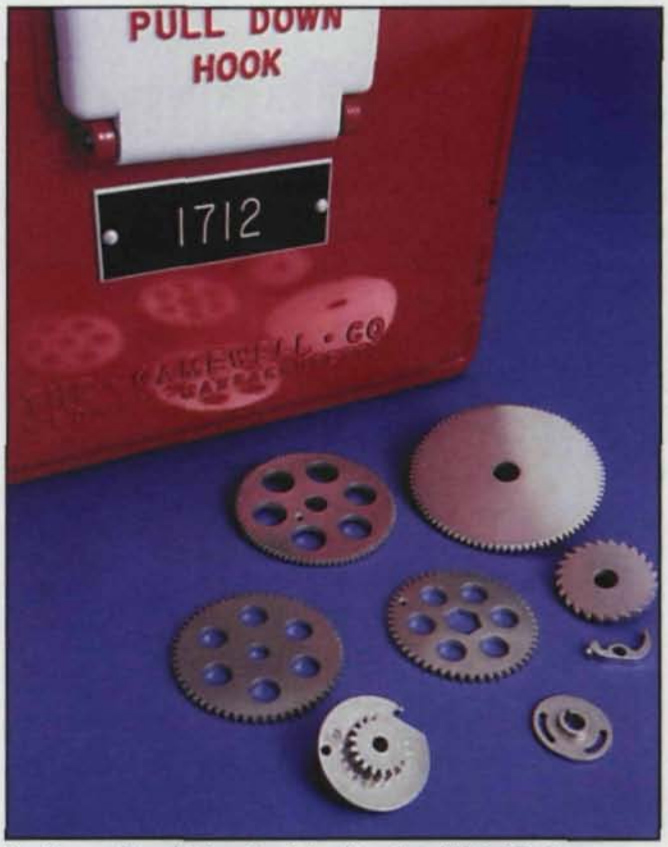
Gear Parts Win in P/M Competition

Each year, the Metal Powder Industries Federation (MPIF) holds a design competition to highlight the best uses of powder metal technology. The 2001 awards included many gears and gear-related items among the winners.

The Ferrous Grand Prize went to Stackpole Ltd. of Stratford, Ontario, Canada, for an intricate planetary gear carrier assembly made for GM Powertrain.

Ferrous Grand Prize: Stackpole Ltd.



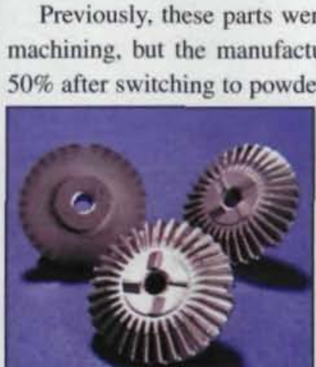
Nonferrous Grand Prize: Precision Powdered Metal Parts.

The carrier assembly replaces a cast iron carrier in GM's PT 4L60E heavy-duty transmission, which is used in 800 series vehicles, including the Sierra, Silverado, Suburban, Escalade and Corvette.

The assembly consists of a low-alloy steel spider and copper-steel clutch hub, which are sinter-brazed together into one unit. The multifunctional assembly combines the planetary carrier and clutch hub functions, a first for Stackpole. The new assembly reduces machining, reduces the part's weight and increases durability without secondary heat treatment of the splines.

The Nonferrous Grand Prize also went to companies working with gears. Eight nickel-silver parts, including five gears, won that prize. The parts were made by Precision Powdered Metal Parts of Pomona, CA, for a three-fold fire alarm box manufactured by Gamewell Worldwide of Ashland, MA.

Previously, these parts were manufactured by stamping and machining, but the manufacturer was able to reduce costs by 50% after switching to powder metal manufacturing.



Bevel gear indexing ratchets by Allied Sinterings Inc.

Transmission carrier by Keystone Powdered Metal Co.

Other gear-related parts that won awards were an automotive manual transmission synchronizer ring made by Sinterstahl GmbH of Fussen, Germany; a counter-shaft transmission hub with external involute spline teeth made by Caterpillar Inc.'s Advanced Compacting Technology Group of Rockwood, TN; a transmission carrier made by Keystone Powdered Metal Co. of St. Marys, PA; a bevel gear/indexing ratchet for a surgical stapler, made by Allied Sinterings Inc. of Danbury, CT; and a ratchet gear assembly for a cordless drill, made by Jenn Feng Industrial of Taiwan, R.O.C.

The annual design competition has awards for different categories of parts. The categories are injection-molded products, ferrous (iron, steel or iron-based), nonferrous (copper, copper-based, bronze, brass, nickel-silver or aluminum), advanced particulate materials, stainless steel and other high alloys (less than 50% iron). The organization also presents an overseas award, which is open to all materials.

Parts are reviewed by a panel of judges appointed by the MPIF's industry development board, and the criteria for awards are design configuration, engineering properties and promotional value.

The competition is open to MPIF member companies, and detailed rules can be obtained from MPIF by sending an e-mail message to *info@mpif.org*.

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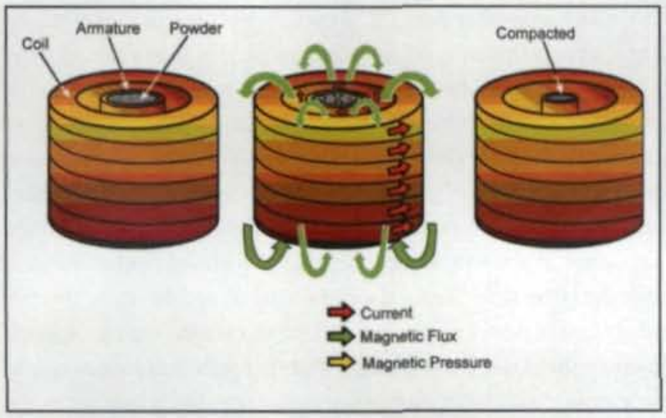

Magnetic Compaction of Powdered Metal

IAP Research Inc. of Dayton, OH, has a process that uses magnetic forces to form highly dense parts from powdered metal materials. Those parts may soon include automotive transmission ring gears.

IAP has been working with a major U.S. automotive manufacturer to adapt the process, called dynamic magnetic compaction (DMC), to produce the ring gears. Development testing has shown that the gears can be manufactured to AGMA 9 quality, with material density of 7.6 g/cm^3 in the gear tooth area, and material properties approaching those of machined parts, says Ed Knoth, senior research engineer for IAP. Although the parts meet design parameters, they need extensive laboratory testing to determine long-term fatigue life and other properties, Knoth says.

A container and die for making internal ring gears by magnetic compaction of powdered metal.

According to Knoth, DMC also is capable of manufacturing other parts with ring-type geometries and radially symmetric features. The process is targeted for parts requiring high density and material properties traditionally associated with wrought metals. Knoth is confident that the process is a viable alternative for many manufacturers. "I think it's ripe for production," he says, adding that the company is quoting jobs to use the process.

With the DMC process, the powdered metal is loaded into an electrically conductive container. For ring gears, the center of the container is a core tool with the negative pattern of the gear teeth to be formed. Outside the core tool is a ring made of electrically conductive material. End caps close off the faces of the container. When the container is placed within an induction coil, the magnetic field forces the outer ring to accelerate at the rate of several hundred meters per second toward the core tool, compacting the powder in between. The ring also decelerates quickly, causing a high pressure spike in the powder, which gives the material its high density, Knoth says.

The process is capable of pressing steel powder to 96% of full density, according to IAP literature.

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