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Powder progress
By Joseph Ogando, Senior Editor

Las Vegas, NV -- Powder metal technology, whose near-net-shape capabilities can cut scrap and machining steps, holds out the promise of big cost savings for mass-produced gears. But can it match cut-gear performance in the most demanding automotive transmission applications? Richard Slattery, engineering vice-president at gear maker Capstan Atlantic (Wrentham, MA) has evidence that it can.

At the recent Metal Powder Industries Federation conference Slattery described an ongoing, and so-far successful, research and development initiative to produce powder metal helical gears for automotive transmission pinions. The company has produced about 5000 of these 22.5 mm tall, 22-degree helix angle gears for a confidential Big Three automotive customer. "This is definitely not a lab run," says Slattery.

According to Slattery, these pinion gears have to meet some tough requirements: They need bending and rolling fatigue performance equal or better to the properties of the wrought materials they would replace-carburized AISI 8620 and 5120. They also require dimensional tolerances corresponding to AGMA 10 quality levels at a time when most powder metal gears only make it to AGMA 7. And these gears call for crowned teeth-something new for powder metal gears. "Until now, gears like this haven't been possible in powder metal," Slattery says. But Capstan engineers made them possible anyway by devising a system that overcomes three key manufacturing challenges.

MAKE THEM DENSE -- First, they focused on improving the core density of the gears in order to meet automotive requirements for tensile strength and bending stresses. "In an application like this, performance starts with density," notes Francis Hanejko, applications engineering manager for powder supplier Hoeganaes Corp., which has been working with Capstan in its gear improvement efforts. According to Slattery, Capstan has now achieved core densities of 7.45 g/cubic cm, or about a 0.15 g/cubic cm improvement over earlier parts, using relatively simple single press single sinter manufacturing methods. This density up tick may seem small, but it really pays off in terms of mechanical properties. Based on tests conducted in conjunction with his automaker customer, Slattery reports the increased density produces a 10% increase in yield and ultimate tensile strengths and a 5-10% improvement in bending fatigue resistance.

Slattery credits sintering know-how and material advances for the all-important density gain. He won't say too much about the sintering conditions. Proper sintering not only contributes to the density improvements but also helps create a microstructure up to the task of meeting contact fatigue requirements. "This is where it gets kind of secretive," he says. But he did disclose that Capstan used new Hoeganaes feedstocks (AncorMax D), which contain advanced binders and lubricants to promote better filling and compaction of the metal powder within the tool.

MAKE THEM ACCURATE -- The higher density may also plays a role in meeting the application's stringent dimensional tolerances, too. Slattery says the new gears don't shrink or distort as much during sintering because their start off with a higher density in their pre-sintered, or "green," state. This green density edge boosts their thermal conductivity, "So they simply sinter better," he says. And Hanejko adds that new feedstock promotes a more uniform density throughout the part, which can likewise help avert distortion during sintering operations. "The new binder and lubricant system makes it a lot easier to achieve a uniformly high density," he adds.

But even the best pressing and sintering methods only go so far. Slattery says that the as-sintered gears conform to AGMA 7 standards. Boosting them to higher levels requires a couple of secondary operations. The first is a soft-turning operation on the gear's ID, which improves concentricity and brings them into AGMA 9 territory, Slattery says. Capstan next performs a proprietary cold rolling operation that corrects tooth alignment to AGMA 10 levels. At the same time, this rolling operation imparts a mirror-like surface finish. More importantly, it selectively densifies the contact surfaces of the gear, improving the surface load capacity of the finished gear, Slattery notes.

CROWN THEM -- The rolling operation finally adds Capstan's crowning achievement: The new gears feature a 0.015-mm crown on the tooth profile and a 0.010 mm crown on the tooth lead. Both Slattery and Hanejko say that crowns mark a first for powder metal gears. "Until now it hasn't been done," says Slattery. The main reason: Crowns fatten up the middle of the tooth, preventing its removal from the tool. And Slattery adds that previous material systems suffered more from a tendency to have a lower-density region where the top and lower halves of the tool meet. This region tends to shrink more during sintering, and in gears it corresponds to the tooth profile. "You actually get a hollow where you want a crown," he explains.

Citing the influence of the crown and surface finish on NVH, Slattery predicts that the powder metal will produce "a quieter gear than wrought steel." He won't know for sure, though, until Capstan and its automotive customer complete their all testing on the gears. Right now, they're working on additional fatigue testing. "So far, we've very happy with the results," he says.