

At the “PEEK” of the Polymer Food Chain

Lindsey Snyder, Assistant Editor

In the hypercompetitive race to increase automobile efficiency, Metaldyne has been developing its balance shaft module line with Victrex PEEK polymer in place of metal gears. The collaborative product development resulted in significant reductions in inertia, weight and power consumption, as well as improvement in noise, vibration and harshness (NVH) performance.

“With our test data, we’ve shown that by switching from current iron gear to PEEK, we can save roughly 70 percent reduction in mass and almost 80 percent reduction in inertia. The combination results in a three to nine percent power consumption reduction,” says Allen Hale, product development engineer for Metaldyne.

“With less power consumption, the engine is using less energy to turn the part and reduces fuel economy. Another important item that OEMs look for is to reduce NVH. We’ve recorded that we’ve been able to reduce the system noise level by three decibels.”

Balance shaft modules help cancel the inherent shaking forces of an inline four-cylinder engine. Polymers are typically not used in a balance shaft module because of the high temperatures that the engine reaches—up around 155 degrees Celsius or 311 degrees Fahrenheit. PEEK is unique for its performance in extreme temperature environments, in which most plastics are not capable of surviving. PEEK features dynamic fatigue resistance at temperatures above 120 degrees Celsius (248 degrees Fahrenheit).

Other key properties include high strength and stiffness; low coefficient of thermal expansion; resistance to chemicals, solvents, lubricants and fuels; high PV values for use in demanding tribological environments; and low moisture absorption.

Frank Ferfecki, technical program leader at Victrex, explains some other benefits. “It has very good toughness and elongation properties. It can take the high contact stresses that can be seen in gear applications. Relative to polymers, it basically is at the top of the food chain. The other thing that is nice for gears about it is that relative to other polymers from a material performance standpoint, it doesn’t



Metaldyne balance shaft modules, featuring PEEK polymer gears, demonstrate reductions in inertia, weight and power consumption (All photos courtesy of Victrex).

need secondary operations like curing or annealing.”

Another benefit of using PEEK is the cost reduction there is in the overall production. “We save a lot of money on capital equipment by injection molding the part and not having to do the extra machining,” Hale says.

Metaldyne and Victrex began co-developing the gears using PEEK specifically for the balance shaft module line around 2002, according to Hale. “Basically, we contacted Victrex to see if they had some type of product that could withstand the operating environment. Metaldyne was looking for ways to reduce NVH and power consumption. We contacted Victrex, and they suggested PEEK. It has the chemical resistance, etc., that we need for the product because of the harsh operating environment.”

Metaldyne supplies balance shaft modules worldwide to automotive manufacturers including Hyundai, Mitsubishi, Chrysler and Nissan for both gas and diesel applications. The modules with PEEK gears are not currently being tested for the more extreme diesel engine applications. There aren’t yet any vehicles in production with this balance shaft module featuring PEEK polymer gears, as the focus thus far has been in developing and testing the product successfully. “Metaldyne did extensive testing of the modules. The next step is it needs to be validated by an OEM. Metaldyne is working with OEMs to date,” says Janice Grzywa, market development manager at Victrex.

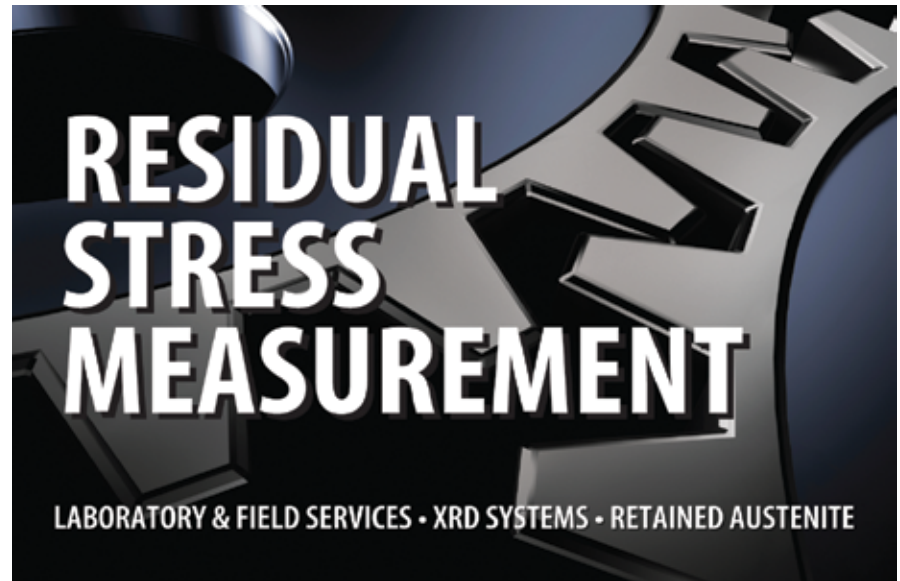
Hale describes the testing process used and the value there is in devoting the extensive time and resources to it. “We basically took traditional iron or steel gears and replaced them with PEEK gears. We did our testing in house, so we could go to customers with data that says, ‘this works.’ The customer doesn’t have to do as much development work.”

And although the product is not being rolled out on assembly lines despite being in development for a number of years, the time frame is pretty normal in the scope of these types of products for Metaldyne. “Typically, the products we are working on now are out another two or three years,” Hale says.

Victrex does all materials testing for any kind of application at its applied technology center in the U.K., which features a recently acquired gear test rig. The gear test rig features up to 6,000 rpm and a 40 Nm torque; adjustable center distance from 50 to 150 mm OD; flexible configuration for spur, helical and worm gears; dry and lubricated testing (oil temperatures up to 150 degrees Celsius/300 degrees Fahrenheit); torque transducers and incremental encoders on both input and

output shafts; dynamic loading of gear train; and measurement of composite error, efficiency, stiffness and backlash.

Victrex has been making a targeted effort at the gear industry with its PEEK polymer because it is a viable metal replacement material. “There’s been a commitment on the part of Victrex, probably five or six years ago, to understand our material in gear applications,” Grzywa says. “Not only **continued**



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The Victrex applied technology center in the U.K. features a gear test rig invested in as part of a targeted effort to appeal to the gear market in various applications.

in the gear test rig in the U.K., but in our commitment to various customer programs. We're putting our money where our mouth is.

"There were gear applications prior that, but in terms of financial and testing, there was a step up with the equipment set up in the U.K."

The Metaldyne collaboration is one of these customer programs in which Victrex recognized the opportunity in the gear industry and committed to a more active role. "Victrex changed our path and became almost a program manager and put quite a bit of money toward helping Metaldyne," Grzywa says.

Victrex is pursuing the gear market within various industry application areas, including medical, business machinery—such as printers and copy machines—and industrial machines, like textiles, weaving and knitting machines. "It's not so much the gear market as where do gears sit in some of these other markets we participate in because they lend themselves to metal replacement." ⚙️

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By switching from iron gears to PEEK, Metaldyne achieves roughly a 70 percent reduction in mass and almost 80 percent reduction in inertia in its balance shaft modules.