High-Performance Plastics

Custom PEEK Compounds have led to the development of transmission seals and thrust washers that offer lower wear, friction and temperature advantages

Matthew Jaster, Senior Editor

There's nothing wrong with off-the-shelf material solutions. They are readily available and provide proven application results. Look closer, however, and you'll find that off-the-shelf solutions are always compromising, according to Ray Szparagowski, technical director of automotive and high-performance plastics global fluid power division at Freudenberg-NOK Sealing Technologies.

"Customers are always making decisions on the validity of their product technologies," Szparagowski said. "Can I live with this amount of leakage? Can I live with this amount of tolerance? Can I live with this amount of clearance? But when it really comes down to making these products as efficient as possible, customization is probably a safer bet."

Material developers at Freudenberg have developed PEEK compounds that are precisely tailored to the respective application. The resulting transmission seals and thrust washers are characterized by lower wear, lower friction and lower temperature development. The company has spent years developing special filler packages for new high-performance plastics (HPP) that focus on sealing rings and thrust washers used in automatic transmissions.

Szparagowski uses a basic seal ring as an example. "Let's say I need a seal ring to fit in a groove and that groove is very large and oversized. The customer is going to pay more for the material I need to make the seal out of. They're also going to have a higher contact area on the sides of the running surfaces, so getting rid of friction is going to be an issue even with a low-friction material. However, if they let me go in and redesign the space needed, I can provide a cheaper part with less material that offers less surface contact and lower temperature. This customization gives you an opportunity to be much more efficient when it comes to cost and performance," he said.

A Custom Request

Several automotive customers had concerns about products that weren't optimized to match specific component and application needs. Szparagowski said that Freudenberg developed materials that can save the customer money and reduce friction and heat to be much more efficient than off-the-shelf solutions.

The new materials are based on precise knowledge of their application. To optimize the material properties, the experts at Freudenberg Sealing Technologies improve the base polymer with various ingredients. Fillers such as graphite or glass and carbon fibers, for example, can reinforce the material, reduce friction and wear, or produce conductivity. Additives such as pigments, waxes and stabilizers influence crystallization and flow behavior, while different colors enable the correct assembly of the component. The resulting HPP materials are precisely tailored to address current and even future application challenges.

"The biggest benefit here is the efficiency savings. These customized technologies can save money by not only providing lower hardness shafts, but rougher surfaces so the automotive customer doesn't have to machine to a precise tolerance on a finish. We can extend the envelope of the material to higher pressures and higher velocities without concerns of failure," Szparagowski said.

One example is the new material Quantix 55-14, which was developed on the basis of the high -performance polymer PEEK. This material is also known as "Low-Hardness PEEK" and reduces metal wear when it comes in contact with steel components. The engineers at Freudenberg Sealing Technologies in Findlay, Ohio, used the material to manufacture sealing rings that function as hydraulic rotary feedthroughs that contain the oil between the clutch and the interior of the transmission shaft in automatic transmissions. The lower incidence of system wear produced by Quantix 55-14 reduces hardness requirements for shafts and lowers customers' production costs.

Freudenberg's Levitorq thrust washers also use Quantix 55-14. The flat, disc-shaped components are used in torque converters and automatic transmissions where they absorb axial forces from rotating components. Friction needs to be as low as possible in these applications. When the shaft starts to rotate, Freudenberg's patented groove technology allows fluid to pass under the washer. This creates a hydrodynamic lubricating film that lowers friction and reduces wear in the application. If conditions prevent operation in

Freudenberg has developed PEEK compounds specifically tailored to an application.

The benefits of these custom components includes providing a database of how diferent seals and rings operate in the field.

the hydrodynamic range, the material's very low, dry friction will increase durability.

Both applications use a similar principle, according to Szparagowski. "Try to let the fluid do the work for you to lower the friction. In the example of our Levitorq thrust washers, we can reduce the friction of traditional designs by 7–10 times."

The result is a significant savings when it comes to energy efficiency and CO_2 in vehicles. Everybody is looking to improve gas mileage in 2019, so Freudenberg's automotive customers can take advantage of this technology to improve in these areas.

Material experts at Freudenberg Sealing Technologies have conducted comparative wear and friction testing on thrust washers made from Quantix 55-14 and those made from readily available, HPP materials designed for applications that require low friction and wear. Thrust washers made from Quantix 55-14 demonstrate a 95-percent reduction in wear, a 55 percent reduction in friction and a decrease in temperature at the interface by 35°C.

Gaining Knowledge & Experience

The obvious benefit to providing a customized solution for an automotive customer is the knowledge gained with each individual assignment.

"We've been involved with transmission seal rings for many years," said Szparagowski. This has provided us with different conditions and scenarios to learn more about how these products operate in the field. We're also significantly invested in testing and evaluation, building our own models for predicting fluid film generation, for example. We have set up very high standards for understanding when failure modes occur and if they do. We can offer analysis and evaluation of thrush washer applications to a high level because we understand how these things work and how to address any of our customers concerns."

More Opportunities for HPP

So, what's next for Freudenberg-NOK Sealing Technologies? Szparagowski said that the company will continue to push the envelope on how high they can take the pressure, velocity, and temperature ranges of their products.

"We expect to continue to move parts that are metal today into plastic. Over time, you're going to see less metal and more high-performance, highly engineered materials being used. This will occur because of all the weight, size and efficiency benefits," he said.

Additionally, the company's next generation of Levitorq is coming. Szparagowski said that certain customers have applications where lubrication is very sparse and hard to get fluid near the bearings, so they're developing patent-pending technology to collect that fluid and use it to pull it under the washer and allow this product to run at much higher velocities then could be traditionally done.

"We took a critical area of failure and improved it through our design," Szparagowski said. "I expect that we'll find several years from now we'll have the next generation of these bearings that will be able to take on even more aggressive conditions."

While the Levitorq is an axial thrust bearing, the company is trying to do some advanced work in radial bearings. Szparagowski said, however, that there a lot more complications in these designs and much more work to be done. They believe they will expand their portfolio to include radial bearings in the future.

The company is also looking into ultra-thin bearing applications. Many bearings today need many millimeters of space and Szparagowski thinks they can use these plastic materials and very thin cross sections (say less than a millimeter) and save space and still get the low friction and performance benefits.

"We have work to do in both those areas that could really change the nature of how a bearing looks in the future," Szparagowski said. "This could expand our opportunities to offer better customized solutions." **PTE**

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A Better Way to Measure High-Performance Plastics Means Performance

Dr. Sai Sundararaman, Freudenberg-NOK Sealing Technologies.

In today's manufacturing environment, and especially in the automotive industry, the benefits of high performance Plastics (HPPs) are driving an ongoing increase in their use. Use of these materials in design and engineering applications provide flexibility, a high strength-to-weight ratio, improved tribological performance and unique chemical formulas that meet a variety of performance requirements. Usage is further being driven by pressure on OEMs to reduce vehicle weights, cut CO_2 emissions, reduce system friction and heat, increase long-term material compatibility and control costs.

While the advantages of HPPs in manufacturing are clear and real, traditional standardized methods for testing the tribological performance of plastics as a measure of part performance in the end application are often less than reliable. Additionally, traditional test methodologies are slow — taking up to five days to yield results — and generally accommodate only four tests per month. This time limitation significantly slows the production development cycle for OEMs.

A challenge

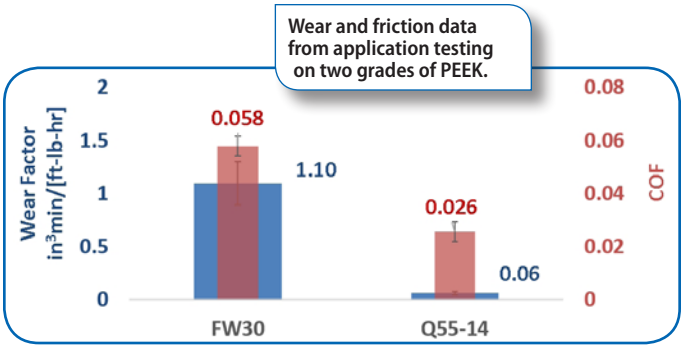
Consider the recent challenge faced by an automotive OEM that needed to reduce production time and costs in the manufacturing of its transmissions. To avoid regrinding the transmission shafts after outsourced heat treatment, the OEM chose to move to a softer metal for its shafts that didn't require these steps. The softer material also required a change to HPPs sealing elements with the correct tribological performance to prevent surface compatibility issues between the seals and the shaft. Using standard test methods to find the right plastic could have taken months. The OEM needed an accurate but faster solution.

A better way

In developing a new methodology, it was essential to increase the intensity of testing without altering failure mode — the accurate measure of the wear of the plastic. Many existing methods currently in use confuse wear failure with the creep, or melting, of plastic.

Freudenberg Sealing Technologies began work in 2016 on the development of new test methods for HPPs. The company's customers were exploring the use of HPPs in powertrain and hydraulic systems to solve a variety of environmental and performance challenges. Scientists worked closely with material engineers to study the test methods being used in the U.S., Germany and Japan. By extracting and combining critical processes from these methods, Freudenberg developed a new approach to test HPPs.

The methodology delivers reliable, accurate, real-world results in a fraction of the time normally required for traditional HPPs testing. When the automotive OEM working on transmissions approached the company about HPPs compatibility with softer metal shafts, the company was able to identify an optimal solution within a short period of time.



Why it's better

While faster is important — reducing testing time from five days to four hours, allowing for two tests per day — so is test accuracy. The HPPs test methodology that was developed generates extremely accurate performance data.

Wear and friction characterization of HPPs is complicated because they are dependent upon a number of system parameters including loads, speeds, temperatures, roughness/hardness, material geometry and others, which can change significantly based on application. Accurate evaluation of tribological performance of HPPs needs to account for these variables, as recommended in this innovative methodology, enabling it to be predictive of part performance.

Environmental advantages

This improved test methodology facilitates real environmental advantages as well. A recent study published by Holmberg and Erdemir (Ref. 2) on the effect of friction and wear on energy consumption, economic expenditure, and CO_2 emissions, concluded that 23 percent of the world's total energy consumption in the transportation, manufacturing, power generation and residential sectors results from tribological contacts.

Through the appropriate application of tribological technologies, CO_2 emissions and the related economic costs could be significantly reduced — with those improvements underpinned by more accurate testing and reliable results. As shown in the application example in the figure below, changing material essentially reduced friction by approximately 55 percent. This means that the Co_2 emissions are also proportionally reduced. Existing and commonly used tribological testing methodologies often fall short of the needs of OEMs and their customers. This innovative approach in testing saves manufacturers time through accelerated product development cycles, improved industry performance and numerous environmental improvements. It's good for manufacturers, good for the industry and good for the world. **PTE**

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