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Automotive Materials and Applications

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ON THE COVER:

Components made of PEEK are being used increasingly in automobiles, providing high performance at reduced weight. Courtesy of Victrex Polymer Solutions, West Conshohocken, Pa. www.victrex.com.

PEEK Parts Reduce Weight without Sacrificing Performance

Design engineers in the transportation and industrial markets are always trying to reduce weight without sacrificing performance. Because every pound counts when it comes to improving the fuel economy and efficiency of automobiles and airplanes, material selection is becoming more important. Material integrity is also crucial for medical devices that must hold tight tolerances and handle harsh conditions of sterilization to perform their desired tasks. In many instances, engineers are replacing metal parts with parts made of PEEK (polyetheretherketone) thermoplastics. While applications and key engineering requirements differ, PEEK must perform as well as traditional metal parts to be considered as a viable replacement solution.

Automotive bushings and thrust washers, aerospace clips and connectors, and electrical cable connectors for medical devices are just a few examples of applications where PEEK maintains its properties in extreme environments. This enables engineers to reduce costs while obtaining benefits such as less frequent maintenance, increased fuel efficiency, design freedom, and process flexibility. PEEK is a semicrystalline thermoplastic with a melting temperature of 343°C (649°F), and has a molecular structure that provides the necessary strength (Fig. 1) and stiffness (Fig. 2) together with wear, creep, and chemical and flame resistance required in today's automobiles, aircraft, and medical components.

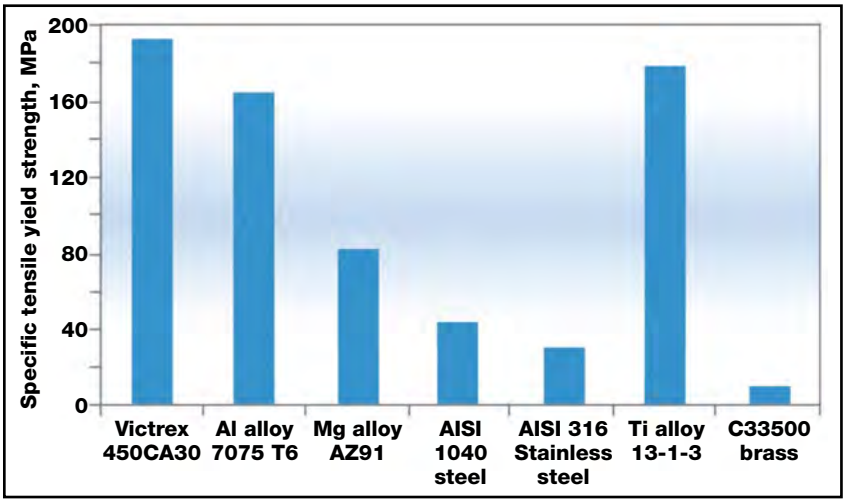

Fig. 1 — *PEEK polymers provide equivalent stiffness at lighter weights.*

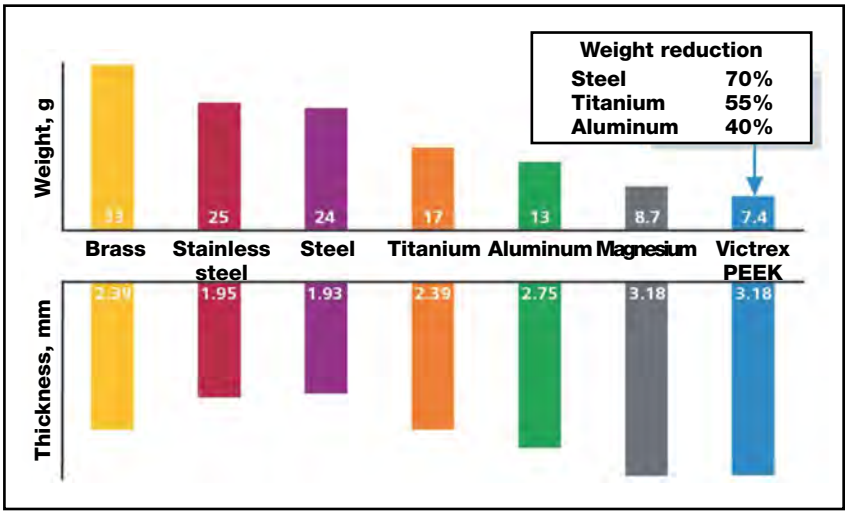

Fig. 2 — *Parts made of PEEK polymers weigh less than metal counterparts, but have higher specific strength.*

Efficient automotive powertrains

Recent studies show the government-mandated standards for the automotive industry will lead to conservation of natural resources and minimize the global carbon footprint. In addition, consumers can expect to save money in fuel costs over the lifetime of their vehicles once standards reach full effect. Automobile manufacturers are seeking innovative solutions to deliver better fuel economy and lower emissions, while consumers are looking for ways to pocket savings especially as gas prices remain high. One part of the solution is the design of smaller, higher output powertrains. The materials specified in the critical components of engines and transmissions (such as the thrust washers shown in Fig. 3) must be able to handle extremely aggressive, high-temperature environments. Lightweight PEEK polymers have a proven track record of successfully replacing metal parts in even the most demanding powertrain conditions.

PEEK-based wear grades provide the necessary durability and stability in today's engine systems. This is illustrated in bushings in electric water pumps designed by Melling do Brasil, San Paulo. The small sliding bushing that supports the pump's impeller previously failed when made of metal. Breakdown of water-pump components can result in costly maintenance and loss of use of the vehicle during repair.

The environment inside the pump includes water with chemical additives at high temperatures and pressures. PEEK wear grades tested in a 50/50 mix of water and ethylene glycol at

Fig. 3— *High-efficiency thrust washers made of PEEK for automobile powertrains.*

Fig. 4 — *Melling sliding bushing made from a proprietary PEEK wear grade for an automotive electric water pump.*

Fig. 5 — *PEEK electrical connector replaced stainless steel part on the ground block of an aircraft.*

150°C (300°F) had the required reliability to work in the cooling system, eliminating the possibility of a failure due to corrosion. Switching from a metal to a PEEK bushing (Fig. 4) eliminated up to 80% of the weight, which reduces frictional losses that affect the fuel efficiency.

Improvements in water pump design were possible by switching from metal to PEEK components. Producing PEEK parts using the injection molding process enabled design engineers to create a single system, making the pump smaller. Molded PEEK polymer components improved production cycle times because the material is easily processed with excellent part-to-part repeatability. PEEK wear grades provide reliability in demanding applications, and can be used to optimize designs and offer weight advantages for more efficient vehicles.

Fly lighter and save fuel

The lifetime costs of airplanes are affected by the speed of manufacture, material and assembly costs, fuel efficiency, and maintenance requirements. Replacing metal parts with PEEK components offers weight reduction that can lead to fuel savings worth millions of dollars annually. Injection-moldable polymers offer the freedom to consolidate parts through highly functional designs, which can ultimately result in faster assembly times and lower overall system costs. For example, several benefits are realized by replacing stainless steel retention clips with PEEK clips (Fig. 5) in electrical connectors, such as the new ground block, designed by Amphenol Pcd, Beverly, Mass.

With hundreds of connectors on each plane, the main driver for replacing metal retention clips with PEEK is that aircraft manufacturers can realize up to approximately 9% in weight savings with improved performance. Before engineers specified PEEK for the connectors, they had to be sure it would perform as well as the stainless steel it was replacing. The polymer was tested by soaking in 70°C (160°F) hydraulic fluid for 1000 hours, resulting in less than a 5% change in nominal properties, proving it was a reliable material for the application. Therefore, PEEK eliminated the need for an anti-corrosion treatment, which lowered overall costs and shortened product turn around. The thermoplastic polymer is also nonconductive, so it has greater electrical integrity in connectors, which is highly important as they secure and fasten critical electrical wiring in the aircraft.

After determining that PEEK was a viable replacement option, design engineers took advantage of the design freedom and processing flexibility available when using thermoplastics. Specifying PEEK for the connectors enabled consolidating parts, making manufacturing easier and more efficient. Instead of installing several steel retention clips separately, a one-piece PEEK retention clip is used.

Higher wear resistance at a lower cost for medical devices

Safety and reliability of medical devices are at risk when frequently used equipment cannot keep up with daily wear and deterioration. Connections for cables and wire in medical devices require not only wear resistance for frequent use, but also excellent chemical and hydrolysis resistance to withstand sterilization processes and maintain sterility. Engineers must find the right design and material to improve functionality, increase part life, and reduce maintenance.

Clinics and hospitals depend on lightweight durable digital imaging equipment and computers to make everyday repetitive tasks easier and more efficient. For example, the reliability of x-ray tablets depends on their electrical cable connections being secure and durable, and metal

connection clamps could not withstand the constant sliding and locking motions.

PEEK offers the required wear resistance and dielectric strength to insulate in electrical connector and cable applications in medical components and instrumentation. PEEK also maintains mechanical and chemical properties over 3000 hours in high-pressure steam. Selecting PEEK for the x-ray tablet clamps (Fig. 6) required only minor changes to the initial design of the machined metal part, which had a clearance issue that was not allowing it to grip the cable connector securely. The part was redesigned for injection molding and larger hook was added to the clamp to allow for more frequent use and a more secure fit of the cable. High-precision injection molding of PEEK parts also make it a low cost option compared with manufacturing a metal part.

Whether it is weight reduction or wear resistance, PEEK polymer enables OEMs to design with confidence when replacing materials such as stainless steel, titanium, aluminum, and glass in aerospace, automotive, medical, and other industry applications. When conditions including high temperatures and pressures, corrosive media, and sterile environments, extending equipment life and lowering overall costs is what can set apart a well-designed final product from another. PEEK can maintain the integrity and reliability expected for optimal performance in versatile applications. The inherent strength and thermal resistance of PEEK make it an ideal material for use in a wide variety of applications with lower processing costs via injection molding and extrusion.

Fig. 6 — *Clamp designs for x-ray tablet: (left to right) metal, machined PEEK, and injection-molded PEEK.*

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