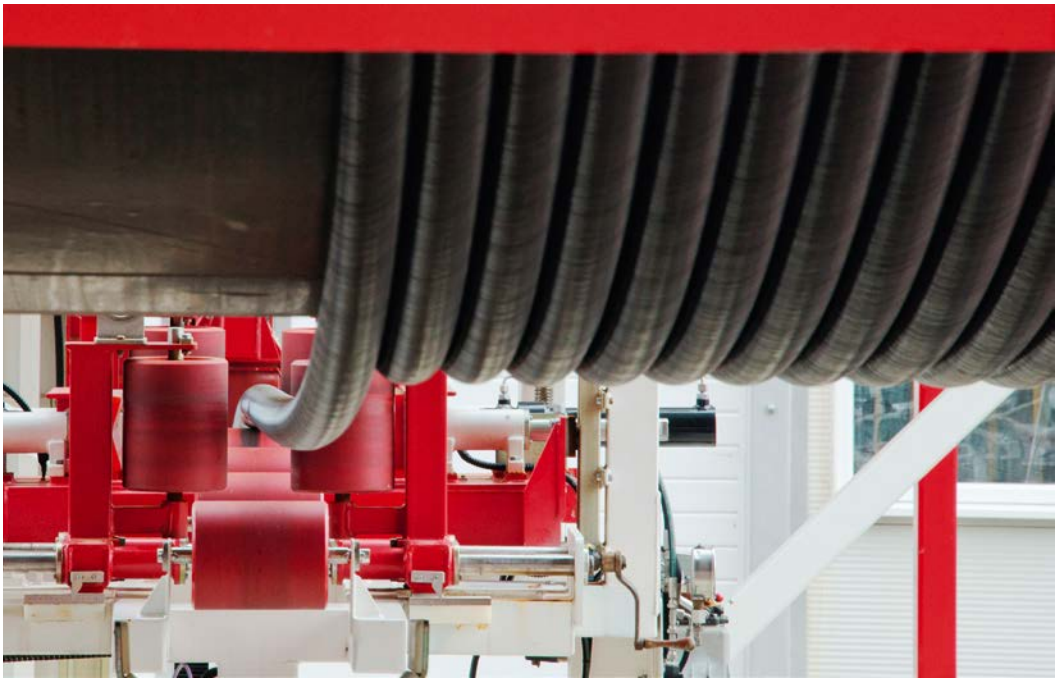
Polyaryletherketones (PAEK)

New Materials and Technologies Get Polyaryletherketones Moving

Advanced PAEK materials, production processes or integrated offerings are opening the door to increased efficiency and new potential uses. Translated to application level, this means greater productivity, performance and reliability with cost efficiency for applications in the automotive, aerospace, electronics, energy and medical industries, typically replacing traditionally used metals.



Developed by Magma and Victrex: m-pipe, a subsea intervention line
(© Magma Global)

Over 80 % of materials in the polyaryletherketone (PAEK) family are polyetheretherketones (PEEK), the largest group, with other members being PEK, PEKK and PEKEKK. Importantly, PEEK polymers are ideally suited to extreme and demanding environments, where alternative materials can meet specific individual needs. PEEK can support multiple requirements. It offers exceptional inherent properties such as chemical and wear resistance, very good dimensional stability and performance across extreme temperature ranges, e.g. withstanding continuous use in temperatures of up to 260 °C. Other features include high strength and stiffness, hydrolysis resistance, resistance to aggressive substances and excellent tribological properties.

Manufacturers, Capacities, Production

Across key markets, mega-trends support the use of PAEK materials. Victrex plc, Thornton-Cleveleys, United Kingdom, is a manufacturer of PEEK. At its headquarters, the production capacity exceeds 7000 t/a. Its PEEK products comprise granules, composites, coatings, films and pipes, and biomaterials from Victrex subsidiary Invibio Ltd, Thornton-Cleveleys, UK. Strategic investments and acquisitions show that the company is driving innovation not only with its high-performance polymers and material expertise, but also is a solution provider through the forward integration of its product portfolio. At the end of 2015, the company announced that it will invest up to GBP 15 million during 2016 in downstream production, including a new production plant for unidirectional (UD) tapes made from PEEK composites which are used in the oil and gas industry, and new facilities for the production of medical trauma plates. A few months before, Victrex acquired the US gear specialist Kleiss Gears Inc., Grantsburg, Wisconsin, in order to offer integrated polymer-based gear capabilities for the automotive industry, including design, prototyping, testing, inspection, tool design and manufacture of PEEK gears.

Solvay SA, Brussels, Belgium, manufactures PAEK in India and announced the construction of a production plant in the U.S. On completion of this facility (scheduled for 2016), the company's total production capacity is expected to be around 2500 t/a. Evonik AG, Essen, Germany, announced a capacity expansion of their Changchun PEEK facility in China.

Other active companies include regional PEEK manufacturers in China, such as Panjin Zhongrun Chemicals Co. Ltd. in Panjin, Jilin Zhongyan High Performance Engineering Plastic Co., Ltd. and Changchun Jilin University Special Plastic Engineering Research, both located in Changchun, and PEK or PEKK manufacturers such as Arkema Group, Colombes, France, Rallis India Limited and Gharda Chemicals in India.

New Applications in the Oil and Gas Industry

Use of PEEK-based polymers for seals and back-up rings in extreme ambient conditions can lead to longer service life and the prevention of costly downtimes. They can withstand, for example, temperatures of -196 °C to 260 °C and pressures up to 2000 bar during the exploration/production ("upstream"), processing/transport ("downstream") and in deep water ("subsea") systems. In addition, they are resistant to a large number of oil and gas media, as well as hydrogen sulfide (H_2S)/sour gas, and are tested beyond the current Norsok (a standard developed by the Norwegion oil industry) and ISO industry standards. Recently, Victrex CT 100 polymer has been introduced to offer a range of performance properties at temperatures from -196 °C to 200 °C, while the Victrex OGS 125 has been specifically developed to improve the compression molding of large seals.

The largest and longest structure based on Victrex PEEK is the lightweight, spoolable m-pipe from Magma Global Ltd., Portsmouth, UK (**Title figure**). The flexible composite pipe made of PEEK, carbon and glass fibers can be used in extreme conditions at depths of up to 3000 m (10,000 ft) and withstand pressures in excess of 1000 bar (15 ksi). Compared with steel pipe, the subsea production pipe shows low levels of fatigue, improved buoyancy and high corrosion resis- »

Fig. 1. A bracket/fitting for a door is the first primary structural component in an aircraft made from Victrex PEEK polymer. It is applied in the Airbus A350 XWB (© Airbus Helicopters)

Fig. 2. In the medical sector, implantable PEEK has been widely adopted. This femoral knee replacement is currently in development and evaluation (© Invibio Knee)

tance. The use of the complete system minimizes deployment times, maximizes vessel utilization through reduced hydraulic pumping times, and cuts intervention costs in subsea oil and gas extraction by up to 30 %.

Fulfilling the Needs of the Aircraft Industry

Competitive pressure among manufacturers and suppliers in the aerospace industry is fierce. It is estimated that more than 35,000 aircraft will be required worldwide over the next 20 years. Manufacturing costs are being reduced, production times shortened and weight lowered for environmental reasons accordingly.

In order to achieve these aims, Airbus S.A.S., Toulouse, France, for example, was the first to use a PEEK-based primary structural component (**Fig. 1**) in the door of the Airbus A350 XWB in 2015. The equivalent component is now being mass-produced from Victrex PEEK 90HMF40 and replaces aluminum. The Chinese aircraft manufacturer Commercial Aircraft Corporation of China (Comac), Shanghai, selected lightweight Victrex Pipes instead of metal pipes to protect high-voltage cables. Denroy Plastics Ltd, Bangor, UK, used Victrex ESD PEEK polymer in the design and manufacture of brackets suitable for use in hydraulic and fuel brackets for the wings, center box and fuel tanks for the Bombardier "C Series", Global and Learjet aircraft.

In October 2015, to support meeting the aerospace industry's needs, Victrex introduced new lower temperature processing PAEK composite materials. Just like metals, these composites can be formed into prepregs that can be over-molded with short fiber-reinforced Victrex PEEK polymers in the hybrid molding process. As a consequence brackets, clamps, clips and housings used in primary and secondary structures can be made in minutes, whereas the process for metal or thermosetting materials can take hours. Beyond production, quicker installation of brackets can also contribute to lower overall costs.

Advances in Medical Technology

In the medical sector, implantable PEEK grade has been widely adopted as an alternative to metal in spinal interbody fusion implants, for example PEEK-Optima from Invibio Ltd., which has been used clinically for more than 15 years. In September 2013 a new generation of implant materials for spinal interbody devices was launched. The combination of PEEK-Optima and hydroxyapatite, an osteo-conductive material, that enhances bone apposition, is fully integrated, not coated, into the polymer matrix, making it available on all surfaces of a finished device. The result is a strong, versatile and effective biomaterial for enhanced bone apposition. A number of companies have received FDA 510(k) clearance in the U.S. and CE mark approval in Europe for spinal interbody devices manufactured from this material, and launched new spinal fusion implants.

Further, PEEK-based options designed to improve clinical outcomes are under development. One example is trauma products, specifically trauma plates, made from the PEEK-Optima Ultra-Reinforced composite, a material with greater fatigue life that may extend the time before implant failure and increase the potential for healing.

A femoral knee replacement application is also currently in development, that uses PEEK instead of metal-based systems (**Fig. 2**). A pre-clinical study initiated by the collaboration partners Maxx Orthopedics, Plymouth Meeting, Pennsylvania, USA, and Invibio Knee Ltd., Thornton-Cleveleys, UK, is largely completed to evaluate outcome and benefits and collect data in support of the safety of the implant. Clinical trials are expected to be fully underway in 2017.

PEEK biomaterials are also growing in popularity in dental medicine. Initially confined to a few applications, the material is today used in high-end dental implants. In 2013 Juvora, an Invibio company, launched the Juvora dental disc, a dental device indicated for use in implant borne, fixed and removable prosthetic frameworks. The device is made entirely from PEEK-Optima, which is lightweight, has bone-like properties and low wear and contributes to deliver precision through CAD/CAM workflows. 99 % of patients rated the Juvora prosthetics high on comfort and 97 % rated high on overall satisfaction.

Combination of Material and Technology Can Open up Competitive Advantages

PAEK is being implemented in important key industries, and the outlook continues to be promising. Victrex for example is not only working on new PAEK materials such as developing grades for additive manufacturing processes (3D printing), but also on offerings beyond the polymer. These include the provision of new technology platforms, research and development resources and regulatory and manufacturing support. The reason: The overall PEEK space is changing – from developing and supplying a versatile material to offering complete technologies based on the high-performing thermoplastic. Customers are supported during the entire process up to production and beyond. By translating suitable integrated offerings, development times can be accelerated, costs lowered and customers can launch products quicker. ■

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