



IMAGE: SHUTTERSTOCK

# Engineering plastics speed ahead in automotive parts

*Using plastics to reduce weight and costs in vehicles is no longer enough. New materials need to meet increasingly more demanding under-the-hood applications. Mark Holmes reports*

Whether for conventional internal combustion engines or electric vehicle powertrains, the automotive industry is demanding increasing levels of performance from plastic components. OEMs are not only requiring lightweight solutions that can accelerate the replacement of metals, but these materials must be able to withstand a wide range of demanding environments involving extremes of temperature, water and chemical exposure.

Under-the-hood applications usually require enhanced temperature or media resistance, according to **Wittmann Battenfeld**. "This can be achieved by using today's high-performance thermoplastics," says Marco Moser, Application Engineer and product expert for lightweight technologies. "By combining these polymer materials with our lightweight technologies Cellmould and Airmould, manufacturers can reach the required material properties and additionally achieve a significant weight and

therefore cost reduction."

He continues: "Cellmould is a physical foaming technology used to produce automotive case parts such as foamed motor covers and car battery covers, as well as automotive structural parts, for example. With the technology you receive a foamed, closed-cell core surrounded by a compact outer layer. On the other hand, Airmould is a gas assisted injection moulding process to produce rod-shaped parts with a hollow inner section, for example automotive media ducts. With the whole transportation industry looking to minimise weight, these technologies can contribute to this and provide an overall environmental solution."

The Cellmould foaming process involves pressurised nitrogen gas, which is injected into the plastic melt inside the barrel of the Wittmann Battenfeld injection moulding machine during metering and is finely distributed. Due to the high

**Main image:  
Under-hood  
materials must  
deal with  
exposure to  
temperature  
extremes**

**Right: A car battery cover made with Cell-mould technology from Wittmann Battenfeld**

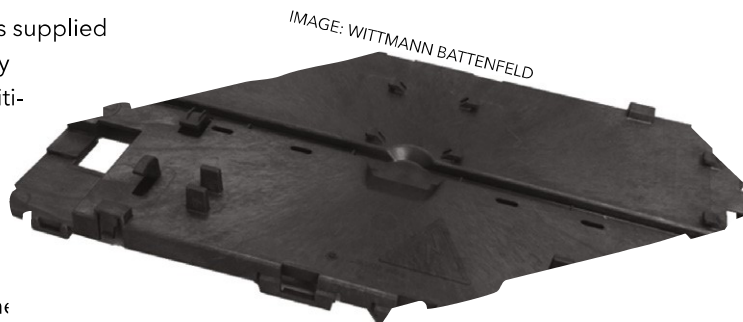
pressure of up to 330 bar, the nitrogen is supplied in a kind of liquid form and subsequently dissolves in the plastic melt as a supercritical fluid. When injected into the vented cavity of the mould, the pressure is released into the melt. The plastic/nitrogen blend separates again. Simultaneously, the supercritical fluid returns to its gaseous state, forming a fine structure based on its homogeneous distribution. Its actual structure depends on the conditions of the injection moulding process. These include the melt viscosity of the plastic material, injection speed – the higher the speed, the finer the foam structure – and finally the quantity of material – the less plastic, the more space is available for the formation of a foam structure with material reduction. The material quantity is achieved by either an appropriately lower dosing for a fixed cavity or completely filling the cavity and subsequently opening it by a pre-determined high-precision opening stroke.

The company says that as well as weight reduction, other advantages include elimination of sink marks, reduced warpage and part costs, and lower tolerances. The process also provides higher rigidity with the same weight, longer flow paths through reduced viscosity, new design options, and lower internal mould pressure and clamping force requirements.

Airmould is the internal gas pressure technology that is used in several different process variants, depending on the part geometry, plastic material used and the specific requirements for the product. A distinction is made between the partial filling process, and the spill-over cavity process for the production of hollow parts, and the shrinkage compensation process. These differ from each other by their specific mould technologies and the equipment and control system of the injection moulding machine. All three process variants can be achieved with the modular Airmould gas supply system.

According to Wittmann Battenfeld, advantages include an improvement in quality and the elimination of sink marks and warpage due to shrinkage. There is also a reduction of the required clamping force, cycle time and weight, as well as additional scope for design.

For exhausted engine vehicles, noise reduction, efficiency and weight reduction remain major trends, reports injection moulding machinery manufacturer **Sumitomo (SHI) Demag**. “Additionally, for hybrid vehicles there is a focus on improving and regulating the thermal management of the temperature to ensure the system can adapt to the



ambient temperature and maintain comfort for passengers,” says Nigel Flowers, UK Managing Director. “In all-electric vehicles, current trends are focused on improving the protection of the current. Materials like Duroplastics are experiencing a renaissance. Additionally, the vibration and resonance behaviour are totally different and consequently need a new selection of materials and part design.”

He says: “As more complexity is added into vehicle electronics, demand for connectors, micro-gears and micro-switches is rising. In the fibre optics market, this particular technology is adopted for moulding gears such as micro connectors, ceramic holders and optics housings. Other applications comprise micro engines, micro drive control systems and micromechanics rotators.”

**Materials selection**

Polyamide-based engineering plastics are widely preferred in under-the-hood applications across the automotive industry for their high heat, hydrolysis and oil resistance properties, according to **Eurotec** of Turkey. The properties of these materials should be enhanced and improved for resistance through special formulations so that they meet the required automotive specifications. With its recently developed ‘A’ series codes, the company says that it offers a material portfolio consistent with OEM specifications due the right-application-right-material selection principle.

Eurotec adds that superior mechanical properties, stipulated by OEM specifications for under-the-hood applications – such as motor cooling systems and drivetrains in conventional internal combustion vehicles – require the use of materials that are highly heat- and hydrolysis-resistant. These applications are functional components requiring consideration of their mechanical and thermal properties. For this reason, materials appropriate for long-term strength tests are preferred. The company says that it offers a wide range of technical polyamide engineering plastics with advanced mechanical and thermal properties intended for the automotive industry.

PA 66 30% glass fibre reinforced products are used in applications such as radiator end tanks and cooling pipes, for example, due to their high hydrolysis resistance. Eurotec adds that it continues to enhance the properties of products in its portfolio with high performance materials in accordance with OEM specifications that require hydrolysis resistance at high temperatures for cooling system applications. To analyse the hydrolysis performance of its products, the company collaborates with a German independent testing body that carries out hydrolysis resistance tests for many OEMs.

Ethylene glycol is used as a cooling medium for heat removal in applications such as radiator end tanks, cooling pipes, oil filters, throttle caps and expansion tanks. The most crucial parameter to consider when selecting the materials used in these critical components is ageing in the presence of ethylene glycol at temperatures of 120-140°C. Along with hydrolysis resistance, there are certain other OEM specifications where thermal ageing performance is critical for applications requiring resistance to high temperatures such as 150-170°C. Eurotec says that it can offer products specifically formulated for engine component applications that are exposed to high heat and oil resistance throughout their life.

For electric vehicles, the temperature gap in the battery pack should be kept to a minimum while driving, in particular for the cooling system. An electric motor is driven from control units powered by the battery. Maintaining the battery temperature within the defined minimum-maximum operating temperature range is one of the most critical points regarding battery lifetime. Therefore, efficient operation of an appropriate cooling system is essential for electric vehicles. The company adds that the design of complex components featured in cooling systems necessitate the use of water- or gas-assisted injection moulding, as well as conventional processes. The advantages of water-assisted injection (WIT) systems, such as reduced cycle times and wall thicknesses, as well as improved surface quality, provide ease of design even for thin-walled parts.

Eurotec adds that for use in battery cooling systems, it has developed a material compatible with WIT systems, which withstands a temperature of 130°C and has improved hydrolysis and glycol resistance. Tecomid NB60 KG30 BK005 HV 0B is a PA6, 30% glass fibre/glass bead reinforced, heat stabilised, black compound, which the company says is ideal for cooling pipe applications due to its good surface quality and dimensional stability. It

has passed both 120°C hydraulic oil tests required in OEM material specifications and the leakage, burst, cold impact and pressure pulse tests conducted on the final component.

**Teknor Apex Company** has introduced three halogen-free FR glass-reinforced PA compounds with UL-94 ratings of V-0, which provide high flow for injection moulding, good surface finish and improved property retention in comparison with standard glass-filled FR PA 66. Creamid grades A3H7G3, C3H2G4, and C3H2G6 are PA 66-based compounds with glass loadings of 15, 20 and 30%, respectively. Their non-halogen flame retardant formulations make possible compliance with European RoHS and WEEE directives as well as internal OEM requirements. Applications include under-the-hood automotive components requiring FR properties.

"Teknor Apex has drawn on semi-aromatic polyamide chemistry to enhance the ability of these compounds to retain tensile properties and stiffness upon exposure to moisture," says Mike Anderson, Commercial Director for the ETP Division. "The A3H7G3 product is currently in use for an automotive engine cover, having met an OEM specification for property retention after heat ageing at 170°C."

For the 20% glass-reinforced C3H2G4 grade, a comparison between dry-as-moulded and conditioned properties shows notched Izod impact strength increasing from 7 to 10 KJ/m<sup>2</sup>; tensile strength decreasing from 125 to 85 MPa; elongation at break increasing from 3.0 to 3.4%; and tensile modulus decreasing from 8,300 to 5,500 MPa.

"The new Creamid compounds enable engineers to meet increasingly stringent requirements for halogen-free FR formulations while finding new ways to consolidate parts," says Pratik Shah, Director of strategic initiatives. "Included are



IMAGE: EUROTEC

**Above: Eurotec says it is enhancing its PA materials in line with OEM specifications that require hydrolysis resistance at high temperatures**

Creamid® Polyamide Compounds				
Properties (Units)	Test Method	C3H2G6 .1FRS	C3H2G4 FRSE	A3H7G3 .2S HFFR
Glass Content, %	---	30	20	15
Density (g/cm <sup>3</sup> )	ISO 1183	1.43	1.36	1.30
Impact, Notched IZOD (KJ/m <sup>2</sup> )	ISO 180 / 1A	11	7	5.5
Tensile Strength (MPa)	ISO 527	155	125	105
Elongation at break (%)	ISO 527	4.0	3.0	3.0
Tensile Modulus (MPa)	ISO 527	10800	8300	6500
Flex Strength (MPa)	ISO 178	230	185	150
Flex Modulus (MPa)	ISO 178	9300	7300	5700
HDT @ 1.8 MPa (°C)	ISO 75-1	200	205	230
Flammability	UL 94	V0 (@ 0.8 mm)	V0 (@ 0.5 mm)	V0 * (@ 0.8 mm)

**Typical properties of three glass-reinforced polyamides from Teknor Apex Company**  
*Source: Teknor Apex*

grades with halide-free stabilisation that are designed for sensitive electronic applications, where ion migration can lead to failures of the electronic components. We continue to expand our portfolio of FR products in polyamides and other engineering plastics, such as PBT, PPA, and even PP, with several new grades in the final stages of commercialisation. Our vision is to have a polymer-neutral approach and provide an optimised solution to the individual customer problems.”

**RadiciGroup** has developed Radilon Mixloy, a new range of PA blends for applications including automotive. The matrix material is PA and the new range is made by blending other polymers readily available on the market through a compatibilisation technology developed by the group, which makes naturally immiscible raw materials miscible. Radilon Mixloy products feature high-performance properties including thermal and mechanical resistance, and surface appearance. They also have low density, dimensional stability and ease of processing. Other advantages of these blends are low water absorption, improved tribological properties and low permeability (barrier effect). The company says that there are many fields of application, including engine compartment parts.

In polyphthalamide (PPA) materials, **Solvay** has introduced Amodel Supreme, a new line of high-performance compounds. Target applications are high-temperature automotive components used in electric drive units, including e-motors, power electronics, housings for high-temperature electrical connectors, electric and electronic devices and telecommunication equipment components that need excellent heat resistance. The materials also offer stiffness and toughness to replace metal in more traditional and structural

applications such as clutch cylinders, shift forks and body in white.

Solvay says its new Amodel Supreme “features the PPA industry’s highest glass transition temperature (Tg) of 165°C which enables higher mechanical performance vs. traditional PA 4T and PA 6T based materials at elevated temperatures. There is also a greater Coefficient of Linear Thermal Expansion (CLTE) match to metals that allows for ease in designing overmolded components.”

The new PPA range features improved electrical properties, including volume resistivity and dielectric strength above 150°C. The materials also maintain electrical properties, like comparative tracking index (CTI), after exposure to high temperatures over time. The compounds were designed to ensure hydrolytic stability against new EV cooling fluids.

“Solvay continues to achieve new performance milestones for our Amodel PPA family of technologies to meet our customers’ increasingly stringent requirements,” says Brian Baleno, Head of Marketing-Transportation at Solvay Specialty Polymers. “Industries from automotive to electronics to telecommunications are raising the bar for properties such as heat resistance, strength, stiffness and electrical performance. Now, with the launch of Amodel Supreme PPA, we can meet or even surpass these high expectations and offer customers a new alternative to traditional metal and conventional polymers.”

**BASF** has expanded its Ultramid Advanced PPA portfolio with carbon-fibre reinforced grades with fillings of 20, 30 and 40%. The company says that these new materials make lightweight parts and can safely replace aluminium and magnesium without loss in stiffness and strength and are electrically conductive. The new grades combine these properties with the advantages of Ultramid Advanced N (PA 9T), which provides high dimensional stability due to low water uptake, good chemical and hydrolysis resistance, high strength and modulus. The new carbon-fibre reinforced grades can be used to manufacture automotive structural parts for body, chassis and powertrain. With this offering, BASF complements its PPA portfolio of more than 50 grades already available on the market.

The mechanical performance of the new carbon-fibre reinforced PPA grades can be tuned by the choice and the content of the carbon fibre, as well as by the additive technology. Ultramid Advanced N3HC8 with 40% carbon fibre filling shows a better strength and modulus at 80°C (conditioned) than magnesium or aluminium. “Our new PPA compounds with carbon fibres are the ideal metal

replacement," says Michael Pilarski from PPA business management at BASF.

BASF has also introduced a heat stabilised Ultramid with heat resistance of up to 190°C for demanding environments. The PA 6 GF30 compound meets requirements for use in hybrid and electric powertrains. The company adds that engineering plastics must not only withstand high temperatures over a long period of time, but also prevent galvanic corrosion of electrical components. Heat resistance, good long-term use properties and weld resistance are the basic pre-requisites for components in current and future powertrains, whether in the internal combustion engine or hybrid and electric vehicles. With the development of heat-stabilised Ultramid B3PG6 BK23238, BASF is expanding its product portfolio of polyamides for the high-temperature range. The new P-stabilisation offers heat resistance of up to 190°C and prevents galvanic corrosion on electrical components due to its halogenide- and metal-free stabilisation, with a halogenide content of less than 50 ppm. The polyamide, reinforced with 30% glass fibres, also has good thermal ageing performance, as well as



vibration and hot gas welding properties.

**Tisan Engineering Plastics** says that EV designers have turned to advanced polymers for electric insulation that do not compromise mechanical and dimensional properties. For EV parts, specialty compounds with lower initial mould-shrink and warpage tolerances are preferred. They also have lower moisture absorption for dimensional stability and come in UL 94 V-0 grades for flame resistance.

Tisan supports these efforts by formulating

**Above: BASF has expanded its PPA portfolio of Ultramid Advanced with new carbon-fibre reinforced grades**

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engineering materials that provide strength, performance, lighter weight, flame retardancy, better efficiency and cost reduction for parts that are used in EVs. The company produces PA 6 and 66 compounds under the Tislamid brand name with standard and modified formulations for customer requirements. PA 6 compounds with short glass fibre reinforcement are used for EVs: Tislamid 66 with 30% glass fibre, hydrolysis- and heat-stabilised, and improved flame-retardant product – Tislamid 30D03 F01 K02 K06 R02 – is an example for an ion battery application in EVs.

The company offers a wide range of FR plastics that deliver the required electrical performance – Comparative Tracking Index (CTI), dielectric strength and a Relative Temperature Index (RTI). It has developed a new generation of FR compounds based on PA 66. Tislamid B 30D03 F01 Y01 HS R01 is a FR PA 66 with 30% glass fibre which is used in battery packs and drive assistant sensors. Tisan says it shows “excellent” mechanical strength, offers flame resistance classified as UL94 V0 up to 0.8 mm, and also maximum glow wire performance at 960°C.

In addition to PA materials, Tisan produces PBT materials for automotive parts used in very harsh environments where compounds need to have resistance to those environments. Its Tisester PBT compounds have low water absorption rates and possess the characteristic of maintaining insulation properties even in harsh environments, so they are used in many high voltage parts. To meet market needs such as these, Tisan developed Tisester PBT F 30D03 F01 K02 HS R01 (FR PBT, 30% glass fibre, heat-stabilised) which is used in thermal management systems and electric motor parts.

**Avient** has launched two new materials based on polyketone that can deliver comparable performance and lower production-related CO<sub>2</sub> levels than PA 66, PA 6 and acetal (POM), it says. Developed in response to current PA supply constraints, the company says that the new Edgetek PKE and LubriOne PKE series provide performance similar to PA 66 and PA 6. The speciality formulations combine good chemical and hydrolysis resistance to meet the challenges of harsh applications, such as those found in chemical, fuel contact or high-moisture environments. The new materials also offer sustainability benefits over the product lifecycle through carbon footprint reductions compared to competitive materials. Avient says polyketone base resin production emits up to 61% less CO<sub>2</sub> than PA and POM. Additionally, the new grades are formaldehyde-free, addressing VOC concerns in manufacturing compared to POM.

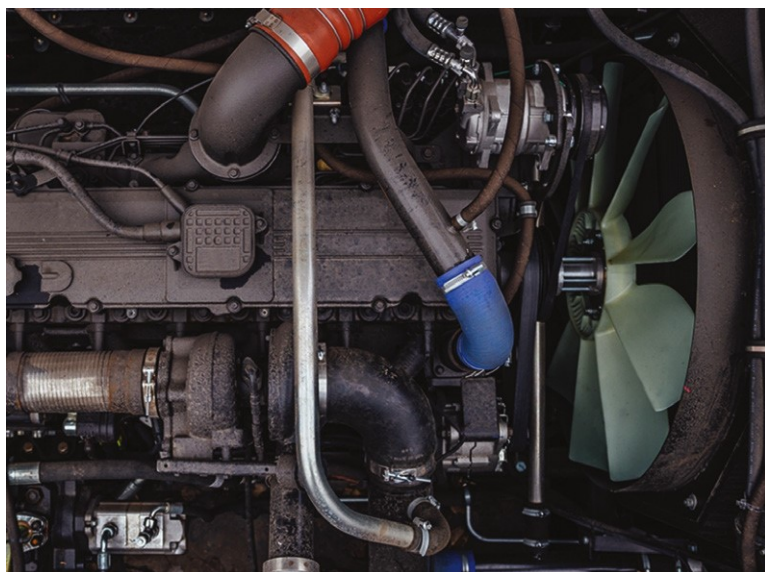
The Edgetek PKE series includes short glass-reinforced formulations with 10-40% short glass fibre. These materials provide good chemical resistance and dimensional stability, low moisture uptake, and high impact and wear resistance. The reinforced grades are targeted at applications in the industrial, electronics and transportation markets like electrical battery components and under-the-hood components in contact with fuel or chemicals.

**Lanxess** has developed the Pocan XHR (Xtreme Hydrolysis-Resistant) range of PBT materials offering good resistance to hydrolytic degradation in hot and humid conditions. In internal testing with standardised test specimens based on the stringent SAE/USCAR2 Rev. 6 long-term hydrolysis tests of the US Society of Automotive Engineers (SAE), the compounds reached Class 4 or Class 5 – the top two ratings.

The company adds that many electrical and electronic devices are exposed to ever-higher thermal loads for reasons including confined installation spaces or elevated operating temperatures. When used in dry environments, the plastics for these devices need to be able to withstand long periods in hot air. The impact strength of most product types in the Pocan XHR series remain virtually unchanged even after 3,000 hours of being stored in air at 150°C. This makes the compounds ideal for parts in engine compartments, such as connectors, or for power electronics components.

The compounds are also ideal for overmoulding of metal parts, says Lanxess. Rapid and extreme changes in temperature often cause stress cracks in components with overmoulded metal areas because of the differences between metal and plastic in terms

IMAGE: AVIENT



**Avient has launched two new materials based on polyketone that it says can deliver comparable performance and lower production-related CO<sub>2</sub> levels than PA 66, PA 6 and acetal for use in under-the-hood applications**

of thermal expansion. The Pocan XHR series has an elongation at break of up to 4.7% (ISO 527-1,-2), which counteracts the formation of stress cracks. Moreover, the improved long-term temperature stability and hydrolysis resistance reduce susceptibility to stress cracks. Stress crack resistance is tested under extremely harsh conditions in heat shock tests. This involves subjecting the overmoulded components to abrupt changes in temperature from -40°C to 125°C and back in several hundred cycles and keeping them at the various temperatures for extended periods (30 minutes). Lanxess says in heat shock tests, components with Pocan XHR metal overmoulding exhibit no stress cracks or, if they do, the cracks do not appear until after many multiples of the usual number of test cycles. That makes the XHR products well suited to overmoulding metal parts, such as bus bars, connectors, power strips and main supporting frames.

The melt viscosity of all Pocan XHR variants remains constant for a long time at the injection

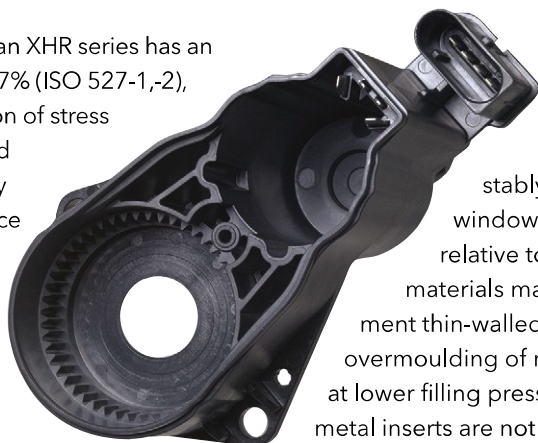


IMAGE: LANXESS

moulding temperatures customary for PBT. The materials can therefore be injection moulded stably within a wide processing window. The improved flowability relative to comparable standard PBT materials makes it possible to implement thin-walled geometries. Furthermore, overmoulding of metal parts can take place at lower filling pressures, which means that the metal inserts are not distorted or pushed out of position in the tool by the molten material.

Pocan XHR also offers good resistance to strong alkalis. This reduces elongation at break by around only 40% when the material is stored at 55°C in 1-molar sodium hydroxide solution for 100 hours. This is a significant improvement over standard PBT. On vehicle underbodies in particular, a combination of road salt, cast iron, and moisture can cause a mildly alkaline environment to build up. Lanxess says that XHR compounds are therefore ideal for electrical and electronic components such as sensors, housings and connectors.

The company is also introducing flame-retardant

**Left: One of the potential applications of Pocan XHR from Lanxess is housings for automatic parking brakes**

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**Right: Husco variable oil pump control technologies made from SABIC's Ultem resin**

XHR compounds. They are particularly well suited to live components in hot and humid conditions, which have to exhibit good hydrolysis stability and fire resistance at the same time. The flame-retardant compounds are reinforced with glass fibres at 15, 25, and 30wt%, and are also available in unreinforced versions. All materials are equipped with a halogenated FR package and achieve the top classification of V-0 with low specimen thicknesses, according to UL 94 flammability tests. The classification is required for many plastic components in batteries of electric and hybrid vehicles, for example.

**SABIC** is collaborating with component supplier Husco to develop next generation automotive applications for Ultem polyetherimide (PEI) resins. Husco has been using unfilled and glass-reinforced grades for 12 years and is now looking to find new solutions for drivetrain and braking systems in future vehicles. Typical applications currently include components for electro-hydraulic control valves in variable valve timing (VVT), variable displacement oil pump control (VDOP) and cylinder de-activation control (CDA), all of which enhance fuel efficiency and vehicle performance. Cam phasing and VVT technologies are low-cost and lightweight and enable engines to maximise performance for specific loads and speeds. VDOP technologies improve efficiency by allowing engines to scale their oil usage in response to driving conditions. Husco has also been developing and producing solenoid valves for a wide range of cylinder deactivation applications. These valves control engine systems that turn specific cylinders on and off in order to maximise efficiency and performance.

According to SABIC, the range of Ultem PEI resins offer elevated temperature resistance, high strength and stiffness and broad chemical resist-



ance. They provide a good balance between mechanical properties and processability. Key benefits of Ultem resins include: long-term heat resistance up to 180°C; good strength and stiffness up to 200°C; dimensional stability over a wide temperature range;

strength retention over long periods; and inherent flame resistance without additives.

Husco says that it values Ultem because of its ease of use in injection moulding and the absence of any requirement for such secondary operations as annealing. Low creep is valuable in applications under virtually constant stress, and it provides freedom for designers to create complicated parts. The company says that it requires precision and micron-level dimensional stability across a broad temperature range that starts at -40°C and goes up to well over +150°C in applications like engine valve components, which need to survive sometimes as many as 700m cycles over their lifetimes and constant vibration loads. Ultem is also amorphous, which reduces impacts from process settings that may be seen with other high temperature rated semi-crystalline materials.

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