Electronically controlled water pump

Polyphenylene Sulphide (PPS)

High Growth Rates. Polyphenylene sulphide has only been firmly established on the market for 15 years. Because of its special property profile, innovative new applications are being constantly found, not just in the classic field of metal substitution. Opportunities are also opening up in new market segments such as aircraft construction and power supply systems. This additional potential is bringing strong growth to the PPS market.

Poly(thio-1,4-phenylene) is the only polymer from the class of polyarylenethioethers to have attained any commercial importance. It is normally known by its trivial name, polyphenylene sulphide (PPS). It is a thermoplastic, semi-crystalline polymer produced from dichlorobenzene and a sulphur source. A distinction is made between crosslinked PPS and linear PPS. With both the crosslinked and the linear PPS grades, the synthesis process results in products in powder form.

The technology for producing crosslinked PPS was developed in 1953. The linear PPS process is based on the same technology but results in products with improved technical performance. Both products are semi-crystalline and have a melting point of around 285 °C. They have comparable glass transition temperatures (85–100 °C) and post-crystallisation temperatures (110–135 °C).

PPS, which has now been on the market for around half a century, initially found it rather difficult to become established despite its outstanding range of properties. It had a kind of "outsider" image and tended to live in the shadow, being used only for a few high-temperature applications. Its popularity started to increase about 15 years ago, with the result that this high-performance polymer has now become almost indispensable in many areas of application. The growth of the market and its fields of application have meant that PPS has matured from a speciality niche product to a major high-performance plastic. It has thus become established as a key industry standard for demanding applications.

Mechanical Properties

Linear PPS has a lower proportion of inorganic impurities, higher tensile strength and elongation at break as well as higher flexural resistance and notched impact strength than the crosslinked variety. Reinforcement of the polymer with glass fibres – also in combination with mineral fillers – results in products that have outstanding mechanical properties even at very high temperatures. Their HDT/A rises to 270 °C. Such compounds can have a long-term service temperature of 240 °C.

Among the commercial products, two grades in particular – one reinforced with 40 % glass fibre and the other filled with 65 % glass and mineral – have evolved as the industry standards. Moulded parts made of PPS compounds are noted for their characteristic metallic sound, which is rather unusual for plastics. A wide variety of compounds are also marketed with different reinforcing fibres and fillers. Because of its chemical resistance, PPS is compatible with many such additives and also allows the formulation of unusual products such as polymer-bound magnets.

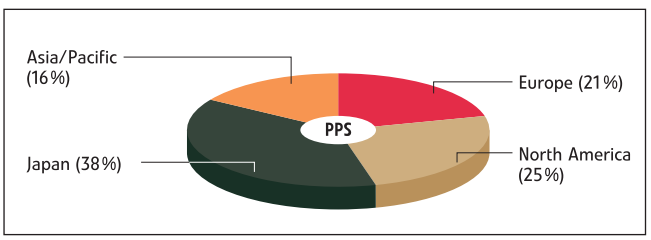

Fig. 1. PPS consumption by region

Chemical Properties

PPS and its compounds have very high chemical resistance. Only at temperatures above 180 °C can PPS be dissolved in suitable solvents. The normal fuels and oils used in combustion engines have no influence on the stability of PPS and, even at elevated temperatures, do not produce any significant dimensional changes due to swelling. PPS does not absorb water, which means that the use of products made of PPS is completely unrestricted even in a moist and hot environment. The only limitation to the use of PPS is in permanent contact with heavily oxidising substances. PPS is inherently flame-retardant and self-extinguishing even without the normal additives.

Capacities and Manufacturers

In recent years, PPS has developed as a high-performance plastic with significant and continuous volume growth. ▶

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The market for the linear grade in particular has expanded considerably. The rate of growth for the crosslinked PPS market is probably somewhat below that of the linear PPS, because this grade is used primarily for traditional PPS applications and less for parts that have to comply with maximum mechanical requirements.

Global sales of PPS compounds are expected to exceed 58 000 t in 2004. The estimated annual growth rates are currently between 7 and 11 %. With an average filler content of around 50 %, polymer consumption is thus equivalent to around 29 000 t/a. Conservative forecasts talk of a consumption of over 65 000 t/a PPS compounds in a few years, while more optimistic estimates put the figure at more than 70 000 t/a.

The industrial region of Asia-Pacific, including Japan, is the biggest market for PPS because of the concentration of the electrical and electronics industry there. It accounts for 54 % of total consumption (Fig. 1). Alongside Japan, PPS consumption in Taiwan and South Korea is becoming increasingly important. The North American PPS market (25 %) is the second-largest individual market after Japan (38 %). The European share (21 %) is currently still lower than that of other regions, although volumes have risen considerably in recent years.

The PPS manufacturers, product names and capacities are listed in Tables 1 and 2. The facility with the most modern technology was built by Fortron Industries (joint venture between Kureha Chemical Industry Co. Ltd. and Ticona) in Wilmington, North Carolina/USA in 1994. The plant has a capacity of approx. 7500 t/a and operates according to a process developed Kureha Chemical Industry Co. Ltd. It supplies a linear PPS with the trade name Fortron.

Chevron Phillips has been operating a production facility for crosslinked PPS with the trade name Ryton since 1972 in Borger, Texas/USA. This plant has a capacity of around 10 000 t/a. Chevron Phillips markets primarily the crosslinked PPS of the first generation. No figures have been published about capacities of linear PPS.

Japan has a large number of PPS manufacturers. Toray Industries Inc. has two production lines, one for crosslinked and one for linear PPS. Toso Susteel, Dainippon lnk (DIC) and Idemitsu (pilot plant) also have production facilities. A certain consolidation took place in Japan when Dainippon Ink acquired the PPS activities of Tohpren and thus became a leading manufacturer of PPS in Japan.

Fortron Industries and Kureha have the world's biggest PPS polymer capacities for linear polymer. There are at present no polymerisation plants for PPS In Europe. The market leaders for both crosslinked and linear PPS have their production sites in the USA.

The main market volume consists of reinforced compounds, which typically have a reinforcement content of between 30 and 65 %. The prices for this product extend from 5–15 EUR/kg. The proportion of non-reinforced grades is increasing at an above-average rate. The vast majority are straight linear grades with prices currently between 15 and 25 EUR/kg.

The highly filled glass and mineral-based grades tend to be at the lower end of the price scale, while the high-performance, straight glass fibre-reinforced grades are at the upper end. The price structures for PPS are currently in a state of flux. The increasing capacity utilisation and the mounting feedstock costs will be reflected in rising prices for PPS and its compounds.

Region	Manufacturer	Capacity in t/a	
		linear PPS	branched PPS
USA	Phillips Petroleum		10 000
	Fortron Industries	7500*	
Japan	Toray	2900	2800
	Kureha Chemical Ind.	5000*	
	Dainippon Ink + Tohpren	6000	
	Toso Susteel		2000
	Idemitsu Petrochemical		150
Total		36 350	

*Capacity increase announced

Table 1. PPS polymer manufacturers (status 2004)

Region	Supplier	Trade name
Europe	Albis Plastic Chevron Phililips Solvay Ticona	Tedur Ryton Primef Fortron
North America	Albis Plastic Chevron Phililips Ticona	Tedur Ryton Fortron
Asia	Asahi Glass Dainippon Polyplastics/Kureha Toray Industries Toso Susteel	Asahi PPS DIC PPS Fortron Torelina Susteel

Table 2. Suppliers of PPS compounds and trade names (a number of compounders offer customised PPS compounds under their own trade names)

Examples of Application

Unmodified linear PPS is being used in increasing quantities for the extrusion of film and fibres. PPS compounds are used for the production of a wide variety of functional components for which a very high long-term service temperature and optimum chemical resistance are specified. The main customers are the automotive industry and the electrical and electronics sector, where PPS is playing an important role in the substitution of metal. Non-reinforced PPS grades are used predominantly for the production of film, filaments and fibres. PPS powder is also used as a heat-resistant binder for coatings.

The automotive industry – the biggest market for PPS – uses the product predominantly for injection moulded applications in the engine compartment, for components for the cooling water system, fuel systems and similar parts where very stringent specifications exist on heat resistance and chemical resistance. The title picture shows an electrical water circulation pump for a car. The pump head and housing are made of PPS compounds. The pump wheel is a PPS polymer-bound magnet.

Composites incorporating PPS as the polymer matrix are being increasingly preferred for structural parts in the aviation industry. Where such components are used for parts of the wings or tailplanes and other supporting parts, the aircraft becomes lighter and thus more economical.

Electrical and electronic system units in the fields of engine management, transmissions and lighting are other typical fields of application. The electrical industry uses PPS for a large number of components in motors and switches (especially for domestic applications), con-

nector plugs, microswitches for telecom applications, and chip carriers. Wherever derivatives from polystyrene, polyamides, polyester and similar engineering polymers come up against their limitations, the move to high-performance polymers like PPS will not be very far away.

Outlook

The wide variety of technical possibilities offered by PPS is illustrated by its use in many new applications in all sectors of industry.

Because of its special property profile, innovative applications are constantly emerging – not just in the classic field of metal substitution. Opportunities are also opening up for PPS in new market segments such as aircraft construction and power supply systems. This additional potential is bringing strong growth to the PPS market. The outlook for PPS over the next few years is therefore very positive. ■

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