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A STUDY CONCERNING MECHANICAL RESISTANCE AND DOMAINS OF USAGE OF THE ULTRADUR POLYBUTYLENE TEREPHTHALATE (PBT)

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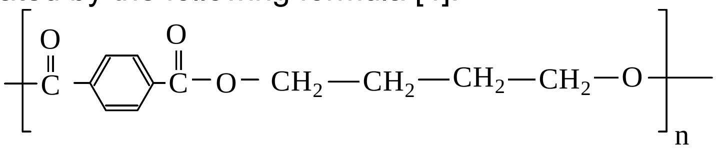
Summary:
PBT are thermoplastic polymers that are part of the saturated polyester category and they are characterized through high mechanical resistance, they offer a high rigidity within a vast interval of temperatures and a good resistance to shock and lassitude. The most important applications of PBT are automotive engineering, electrical engineering, electronics and telecommunications as well as precision engineering and general mechanical engineering.

1. INTRODUCTION

Ultradur Polybutylene terephthalate (PBT), Ultradur is BASF`s trade name for partially crystalline, thermoplastic, saturated polyesters based on polybutylene terephthalate (PBT). Its structure is illustrated by the following formula [4]:



Ultradur is produced by polycondensation of terephthalic acid or dimethyl terephthalate (DMP) with 1,4-butanediol using special catalysts. Terephthalic acid, dimethyl terephthalate and 1,4-butanediol are obtained from petrochemical feedstocks, such as xylene and acetylene.

PBT is outstanding for its high rigidity and strength, very good dimensional stability, low water absorption and high resistance to many chemicals. Moreover, PBT exhibits exceptional resistance to weathering and excellent heat aging behavior.

Ultradur PBT is classified in three groups [5]: Ultradur PBT unreinforced grades, Ultradur PBT impact modified and Ultradur PBT reinforced grades.

Unreinforced grades:

B 4500 – Medium-viscosity grade for extrusion or injection molding,

B 4520 – Standard injection-molding grade for manufacture of industrial functional parts.

Impact modified:

KR 4071 – Impact-modified injection-molding grade with high toughness, predominantly for automotive components.

Reinforced grades:

B 4300 G2, B 4300 G4, B 4300 G6, B 4300 G10 – Injection-molding grade containing 10-50% of glass fibers, for industrial parts, rigid, tough and dimensionally stable, for example for program switches, thermostat parts, small-motor housings for vehicles, headlamp frames, cams, automotive windscreen wiper arms, housings, consoles, contact mounts and covers.

S 4090 G2, S 4090 G4, S 4090 G6 – Low-warpage, free-flowing standard injection-molding grade containing 10-30% of glass fibers for industrial parts with high dimensional stability requirements, for examole plug connectors, housings and sunroof frames.

B 4040 G2, B 4040 G4, B 4040 G6, B 4040 G10 – Injection-molding grade containing 10-50% of glass fibers, for industrial parts with excellent surface quality, for example external door handles in vehicles, visible sunroof frames, oven door handles, toaster casings, external mirrors, rear screen wiper arms in vehicles and sunroff wind deflectors.

2. MECHANICAL PROPERTIES

The Ultradur PBT product range includes grades with the most varied mechanical properties such as rigidity, strength and impact-resistance (Table 1) [2,5].

Table 1. Mechanical properties – PBT

Typical values at 23˚C	Unit	B 4520	KR 4071	B 4300 G2	S 4090 G2	B 4040 G2
Tensile modulus of elasticity	MPa	2500	1700	4500	4500	5000
Tensile stress at yield (v=50mm/min)	MPa	60	35	90	75	96
Strain at yield (v=50mm/min)	%	3,7	4,2			
Strain at break (v=50mm/min)	%	>50	>50	3,5	2,9	2,9
Flexural strength	MPa	85	60	140	119	
Charpy impact strength	kJ/m^2	No break	No break	40	45	26

Unreinforced Ultradur is distinguished by a balanced combination of rigidity and strength with good impact-resistance, thermostability and sliding friction properties and excellent dimensional stability.

The strength and rigidity of glass-fibre reinforced Ultradur grades are substantially higher than those of the unreinforced Ultradur grades. Fig.1 shows the dependence of the modulus of elasticity on the glass fibre content.

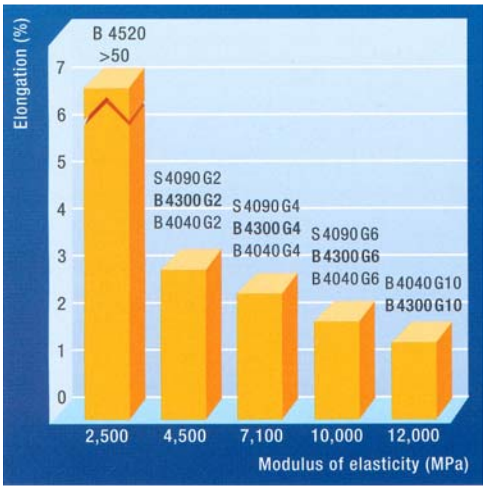


Fig.1. Modulus of elasticity and elongation

The shear modulus and damping values (Figs.2 and 3) measured in torsion pendulum tests in accordance with ISO 6721-2 as a function of temperature [3] provide useful insight into the temperature-dependence of the properties of the unreinforced and reinforced Ultradur grades.

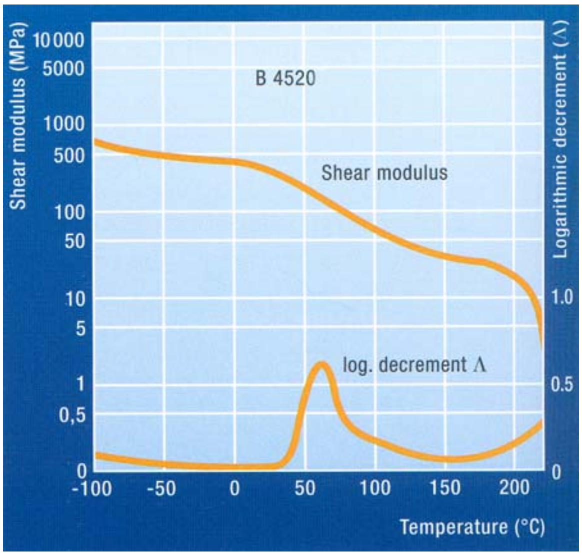


Fig.2. Shear modulus and logarithmic decrement of unreinforced Ultradur as a function of temperature (in accordance with ISO 6721-2)

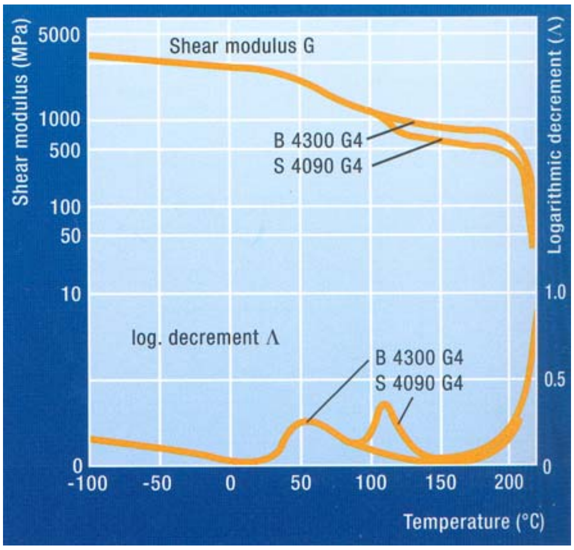


Fig.3. Shear modulus and logarithmic decrement of glass-fiber reinforced Ultradur as a function of temperature (in accordance with ISO 6721-2)

The pronounced maximum in the logarithmic decrement at +50˚C identifies the softening range of the amorphous fractions while the crystalline fractions soften only above +220˚C and thus ensure dimensional stability and strength over a wide range of temperature.

The good strength caracteristics of the unreinforced and glass-fibre reinforced Ultradur grades permit high mechanical loads even at elevated temperatures (Figs.4 and 5).

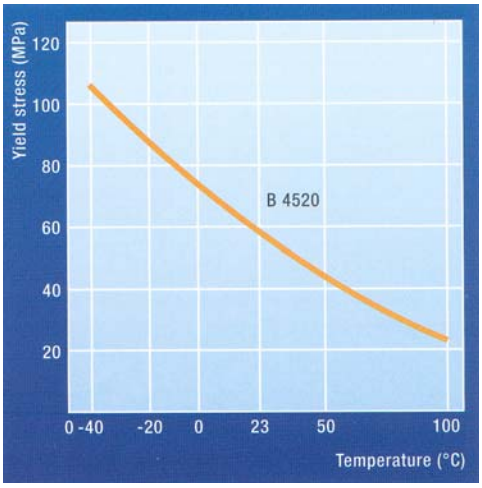


Fig.4. Yield stress of unreinforced Ultradur as a function of temperature (in accordance with ISO 527, take-off speed: 50mm/min)

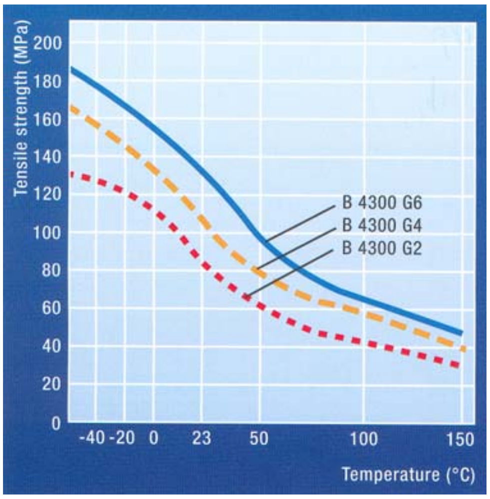


Fig.5. Tensile strength of glass-fiber reinforced Ultradur B as a function of temperature (in accordance with ISO 527, take-off speed: 50mm/min)

The behavior under short, uniaxial tensile loads is demonstrated by stress-strain diagrams. Fig.6 shows the stress-strain diagram for unreinforced Ultradur B 4520 and Fig.7 shows that for glass-fibre reinforced grades as a function of temperature. In the latter diagram the effect of the increasing glass fibre content is apparent.

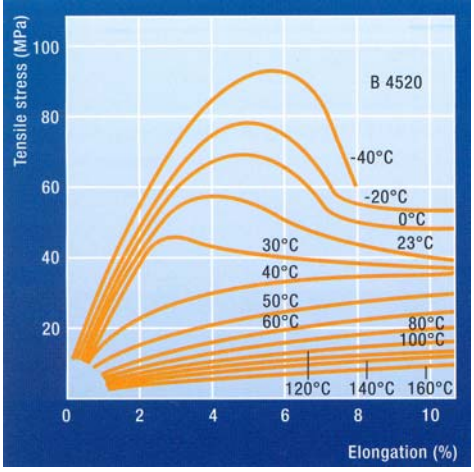


Fig.6. Stress-strain diagrams for unreinforced Ultradur at different temperatures

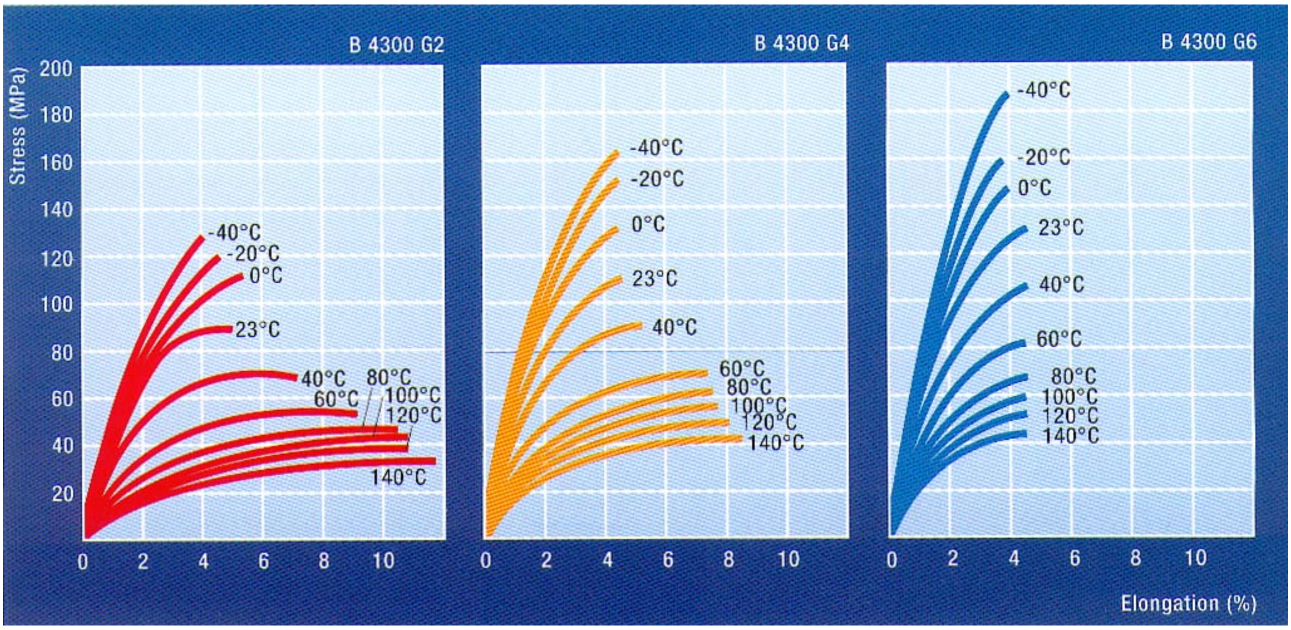


Fig.7. Stress-strain diagrams for glass-fiber reinforced Ultradur at different temperatures

Impact strength may simply be specified, for example the stress-strain diagram, as the deformation energy at failure (see Figs.6 and 7).

A further criterion for toughness is the impact resistance of unnotched test rods in accordance with ISO 179/1eU. According to Table 2 the impact resistance of unreinforced Ultradur B 4520 is higher than that of glass-fibre reinforced Ultradur grades.

Table 2 Dependence of impact strength (ISO 179/1eU) and impact failure energy (E50)(DIN 53443) on the glass fiber content

Property	Unit	B 4520	B 4300 G2	B 4300 G4	B 4300 G6	B 4300 G10
Glass content	Wt.-%	0	10	20	30	50
Impact-failure energy (E50)	J	>140	12	5	1,6	0,8
Impact strength +23˚C	kJ/m^2	290	40	58	67	55

Comparative values closer to practical conditions for the impact properties of the materials under impact loads can be measured by impact tests or falling weight tests in accordance with DIN 53443. Based on this standard the 50% impact-failure energy (E50), i.e. the falling energy at which 50% of the parts are damaged, was determined for test boxes having a wall thickness of 1,5 mm (see Table 2). The failure energy is dependent on the dimensions, the thickness of the walls, the reinforcement on the moldings and on the processing conditions. If the highest possible notched or low-temperature impact strengths are required impact-modified grades must be employed. In this case the best low-temperature toughness is achieved by Ultradur KR 4071.

3. APPLICATIONS

The most important applications of Ultradur PBT are automotive engineering, electrical engineering, electronics and telecommunications as wel as precision engineering and general mechanical engineering.

Ultradur PBT demonstrates its strengths wherever high-quality and above all heavy-duty parts are required – as is the case for example in the automotive industry. Ultradur PBT is rigid, impact-resistant, dimensionally stable, heatproof, weather-resistant and resistant to fuels and lubricants. These properties have made Ultradur PBT an indispensable material in many applications in modern automotive engineering. Ultradur is employed in housings and functional parts in electric drives, housings and mountings for various electrical and electronic components, in windscreen wiper arms, door handles, headlamp structures, mirror systems, connectors, sun-roff components, in housings for locking systems and in many other applications.

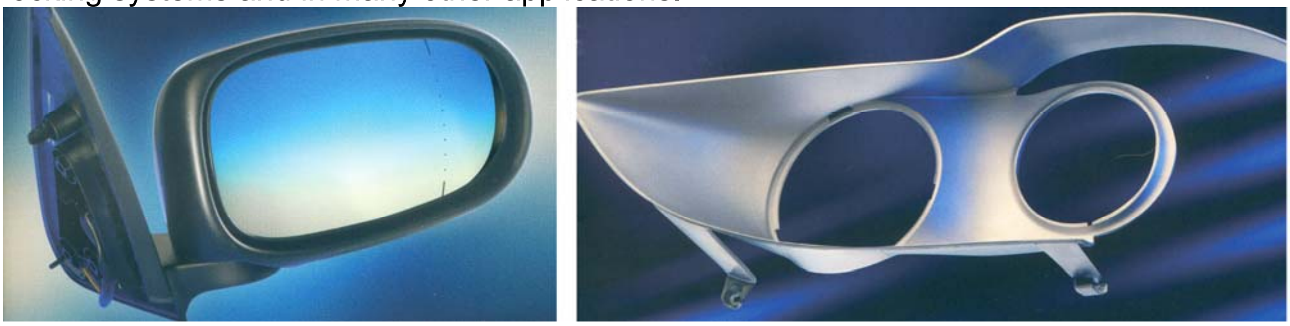


Fig.8. Automotive: bezel and rear mirror housing

Parts which are becoming ever smaller and more complex and offer steadily increasing functionality are typical of the high demands imposed on the materials used in electrical engeneering and electronics. This is no problem for Ultradur PBT. It is rigid, flame-resistant, heat resistant and it exhibits good dimensional stability and outstanding long-term electrical and thermal performance. Ultradur PBT is used in plug-in connectors, connector strips, switching systems, housings for automatic cutouts, capacitor pots, in coil formers, lamp parts, PC fans, power supply components, parts for electric drives, sheathing for waveguides and many other products and not least in vehicle electrical systems (ignition coil housing).

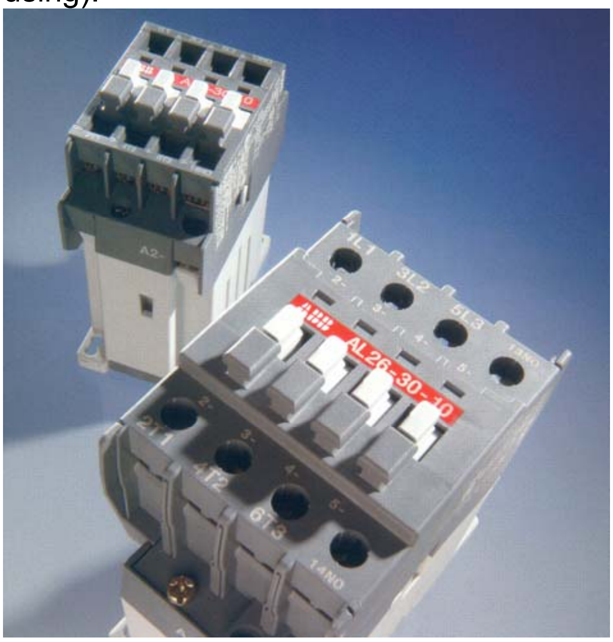


Fig.9. Electrical engineering: motor circuit breakers

Long service life, perfect operation and dimensional accuracy are properties which turn a modern component into a first-class product. Ultradur PBT contributes to this. It affords good surface quality and dimensional stability, high rigidity and compressive strength and it has particularly low warpage. Ultradur PBT is employed in functional parts for printers, copying equipment, cameras and optical devices, gas meter housings [1] and housings for valves, pumps and a wide variety of other applications.

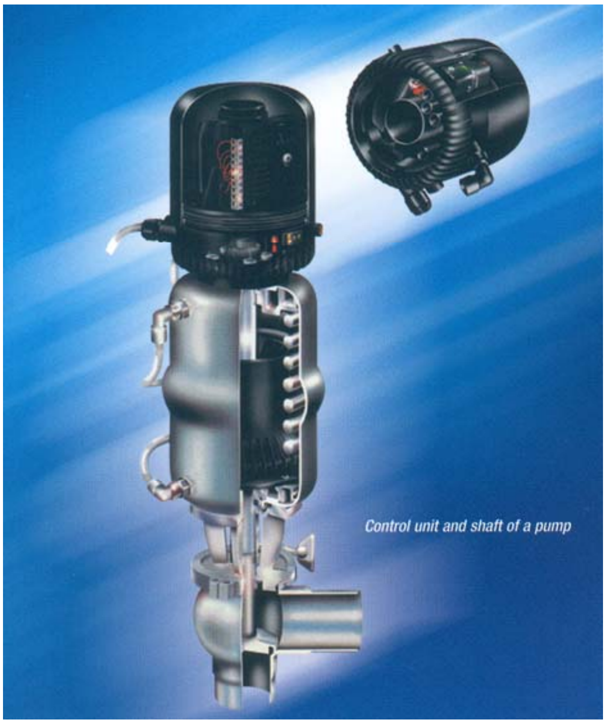


Fig.10. Precision engineering and mechanical engineering: control unit and shaft of a pump

4. CONCLUSIONS

Ultradur PBT are thermoplastic polymers caracterised through high mechanical resistance which directly influences the temperature. Reinforcing the PBT with glass-fiber leads to the rising of the material`s rigidity. The unreinforced PBT`s shock resistance is much higher than the shock resistance of PBT reinforced with glass-fiber, no matter of the percentage of reinforcement. The most important applications of PBT are automotive engineering and electrical engineering.

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