Dimensional Stability and Impact Strength

(PC+ASA) Blends for Automotive Body Panels

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Blends based on polycarbonate (PC) and acrylonitrile-styrene-acrylic ester (ASA) are noted for their good weatherability and processing stability. A new product with improved flowability and toughness has been developed for the field of automotive body panels.

Applications in the field of automotive body panels (title photo) constitute a particular challenge for thermoplastics on account of the complex requirements profile involved. Apart from good processing properties (high flowability, good melt stability) and mechanical characteristic values (stiffness, toughness and strength), a key role is also played by dimensional stability (Fig. 1). If metal and plastic parts are used alongside each other, then their dissimilar thermal expansion (CTE; Table 1) can lead to serious problems in respect of dimensional stability and accuracy of fit [1]. Although a design approach can also be adopted to these problems [2], the material selection is also of major importance.

As can be seen from Table 1, the different plastics vary considerably in terms of their thermal expansion in some cases. Amorphous plastics with a high glass transition temperature, such as polycarbonate (PC) or polyphenylene ether (PPE) have particularly low CTE values. These two types of plastic are thus used primarily as amorphous components in blends with semi-crystalline polymers, such as polyamide (PA) or polybutylene terephthalate (PBT). Corresponding polymer blends, such as (PC+PBT+MBS) or (PA+PPE+SEBS) (MBS: (methylmethacrylate+butadiene+styrene) rubber, SEBS: styrene-ethylene-butylene-styrene-block copolymer) display a good combination of dimensional stability, flowability and low-temperature impact strength [3, 4].

Attractive automotive body materials can additionally be created by combining amorphous plastics, such as in (PC+styrene copolymer) blends – (PC+ASA). Key aspects of product development for applications involving automotive body parts are discussed below, taking the example of (PC+ASA) blends (e.g. grade: Luran S KR 2868 C, manufacturer: BASF).

Dimensional Stability

In the field of off-line painted body parts, use has so far been made primarily of (PC+PBT+MBS) and (PC+ABS) blends, while (PPE+PA) blends are used for on-line painting [5]. Compared with blends containing semi-crystalline components,

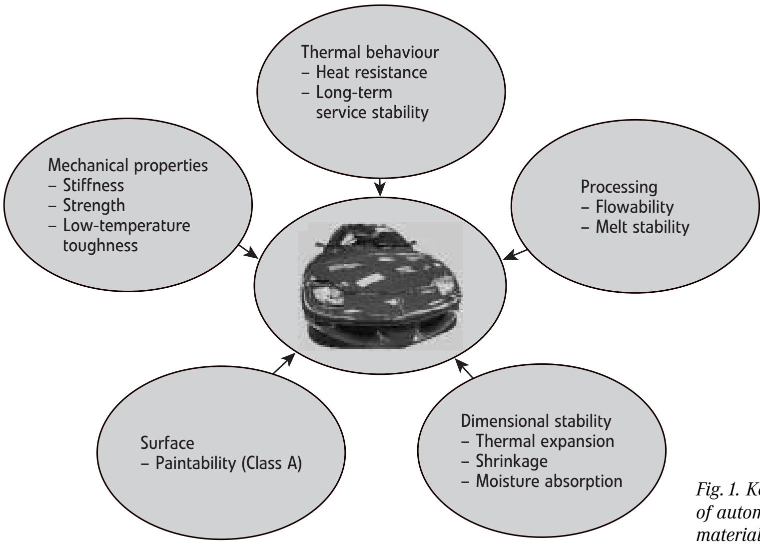

Fig. 1. Key properties of automotive body materials

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Material	CTE at 25 °C $10^{-6}\,K^{-1}$
Steel	11
Aluminium	20
Polycarbonate	70
Polyphenylene ether	65
Polyamide 6	80
Polybutylene terephthalate	120
Polypropylene	160
PC+PBT+MBS	90–95
PA+PPE+SEBS	90–100
PC+ASA	75–80

Table 1. Coefficient of thermal expansion (CTE) for different materials at 25 °C

amorphous PC blends display not only a lower CTE value at room temperature but also a lower temperature dependence for their CTE value (Fig. 2).

The reason for this behaviour is the low increase in their specific volume with temperature increasing below the glass transition point, which, in the case of the (PC+styrene copolymer) blends is approx. 110 °C (SAN phase) or 149 °C (PC phase) [6]. The more pronounced temperature dependence of the CTE value for the blend with a semi-crystalline component is attributable to the glass transition of the crystalline phase. On account of the relatively low glass transition temperature of the PBT phase, a massive increase in the CTE value is already evident in (PC+PBT+MBS) blends at just above room temperature.

With off-line painting, which is generally conducted at temperatures of 80 to 90 °C, the CTE value of a (PC+PBT+MBS) blend is around 60 % higher than for a (PC+ASA) blend. Even at a temperature of 70 °C, which can also be attained in the operating state, the CTE value of a (PC+PBT+MBS) blend is more than 50 % higher than that of a (PC+ASA) blend, Luran S KR 2868 C. With a part of 1 m in length, the difference in the CTE value leads to additional expansion of 2 mm for a temperature increase of 50 K (from room temperature to 70 °C).

Toughness

The toughness and fracture behaviour are key criteria for deployment as an automotive body panel. In order to assess these properties, use is made not only of standard tests, such as notched impact strength and puncture behaviour, but also of finished part tests, since design and fastening also play a decisive role in a component's fracture behaviour, in addition to the material properties.

The low-temperature toughness of (PC+ASA) blends can be considerably improved by a commercial rubber with a polysiloxane component, for example (Fig. 3). Adding just 6 % by weight of this modifier (while keeping the same amount of rubber in the blend) will produce a significant improvement in notched impact strength at – 30 °C. The improvement in toughness in this system, however, is obtained at the expense of flowability. A similar property level (Table 2) in respect of low-temperature toughness and flowability, but with considerably lower input material costs, can also be achieved through optimisation of the blend composition in respect of the PC and rubber component (Luran S KR 2868 C).

Thermal Stability

Apart from short-time heat resistance to withstand painting processes, good stability during long-term service is also essential. In order to assess this property, puncture tests were conducted at room temperature (ISO 6603-1) on specimens that had undergone storage at 90 °C (see Fig. 4). The high basic strength of polybutadiene rubber means that both (PC+PBT+MBS) and (PC+ABS) blends have a somewhat higher toughness than (PC+ASA) blends in the starting condition.

While with (PC+ABS) and (PC+PBT+MBS) blends, there is already a clear reduction in the energy absorbed in the puncture test after a storage duration of 3000 h, 85 % of the toughness level of (PC+ASA) blends is retained, even after a storage period of 10,000 h. The reason for this massive loss of toughness in (PC+PBT+MBS) and (PC+ABS) blends is the embrittlement of the polybutadiene rubber through thermo-oxidative processes.

UV-Resistance

Although the majority of automotive body components have so far been painted in the colour of the car employing a top coat, the concept of giving pigmented plastic parts a coat of clear varnish is gaining ground on account of the cost advantages that can be achieved [5]. For this concept to be implemented, it is necessary to have good colour stability and UV-resistance in the matrix material.

With weathering tests (to DIN 53387) on white or blue-coloured (PC+PBT+MBS) and Luran S KR 2868 C, the Luran S KR 2868 C shows a considerably better colour stability after UV storage than the comparison sample.

With this test too, the excellent weatherability of the acrylate rubber is decisive for the colour stability of the (PC+ASA) blend.

Processing Stability

The good thermal resistance of (PC+ASA) blends enables them to be processed over a wide range of temperatures. Whereas, with the (PC+PBT+MBS) blend, a massive fall in the melt viscosity is observed, a comparatively small change is seen with Luran S KR 2868 C. With the (PC+PBT+MBS) blends, ester interchanges occur in the melt, giving rise to copolyester carbonates as well as to short-chain degradation products that are responsible for the fall in viscosity [7]. Reactions of this type do not occur in (PC+ASA) blends, which is why the viscosity profile is only determined by thermally or mechanically (shear) initiated degradation products.

Comparison of Automotive Body Materials

Table 2 compares the essential properties of different automotive body materials. The moisture absorption of Luran S KR 2868 C is of the same order of magnitude as that of (PC+PBT+MBS) blends, and is thus considerably lower than for

Properties		PA+PPE	PC+PBT+MBS	PC+ASA Luran S KR 2868 C
Water absorption (23 °C, saturation)	%	3.5	0.5	0.7
Young's modulus (dry/moist)	MPa	2000/1400	2200	2400
Tensile strength	MPa	50	55	60
Elongation at break	%	30	> 50	> 50
Charpy notched impact strength	kJ/m²			
at + 23 °C		45	45	100
at – 30 °C		20	18	15
Heat distortion temperature (HDT B)	°C	170	100	120
CTE	$10^{-6}K^{-1}$	95	95	75
Shrinkage	%	1.7–2.0	0.9–1.2	0.3–0.7

Table 2. Comparison of the properties of different automotive body materials

(PA+PPE) blends. Luran S KR 2868 C has the highest Young's modulus and the highest notched impact strength at room temperature of all the materials in this series. At –30 °C, this (PC+ASA) blend almost attains the notched impact strength of (PC+PBT+MBS) blends. The low CTE value at room temperature and the low temperature dependence of the CTE have already been discussed. The low shrinkage of Luran S KR 2868 C is also an advantage when it comes to the processing and the dimensional accuracy of corresponding parts.

On account of these properties and the advantages that have already been discussed in respect of UV and thermo-oxidation resistance, the (PC+ASA) blend of Luran S KR 2868 C is eminently suitable as a material for large automotive body parts.

Fig. 2. Temperature dependence of the CTE value for different plastic blends (measurement to DIN 53752, Method A)
Thermische Ausdehnung = Thermal expansion; Temperatur = Temperature

Fig. 3 Notched impact strength at –30 °C (ISO 179 1eA) and flowability (DIN 53735 at 260 °C/5 kg) for (PC+ASA) siloxane rubber blends as a function of the siloxane rubber component
Kerbschlagzähigkeit bei –30 °C = Notched impact strength at –30 °C; Anteil Siloxan-Rubber Gew. % = Siloxane rubber component, % by wt.; Schmelzindex MVI = Melt flow index MVI

Fig. 4. Thermal stability of different plastic blends at 90 °C (characterised by energy absorption in the puncture test at room temperature)
Bruchenergie = Fracture energy; Zeit = Time