

# TOP TEN DESIGN TIPS

By Jürgen Hasenauer, Dieter Küper, Jost E. Laumeyer and Ian Welsh

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## 2. Material selection

# The right choice

**Material selection** – There is no such thing as a bad material-just the wrong material for a particular application. It is therefore essential for designers to know the properties of the competing materials inside out and to test them all carefully in relation to the factors affecting the injection moulded part.

### Conventional thermoplastics

The materials most frequently used in injection-moulding are thermoplastics. These may be subdivided into amorphous and semi-crystalline plastics (Fig.1).

These two groups differ in molecular structure and in all the properties that are influenced by crystallization (Fig. 2).

As a broad generalization, semi-crystalline thermoplastics are used mainly for components that are exposed to high mechanical stresses, while amorphous thermoplastics are more often employed in housings because of their lower tendency to warp.

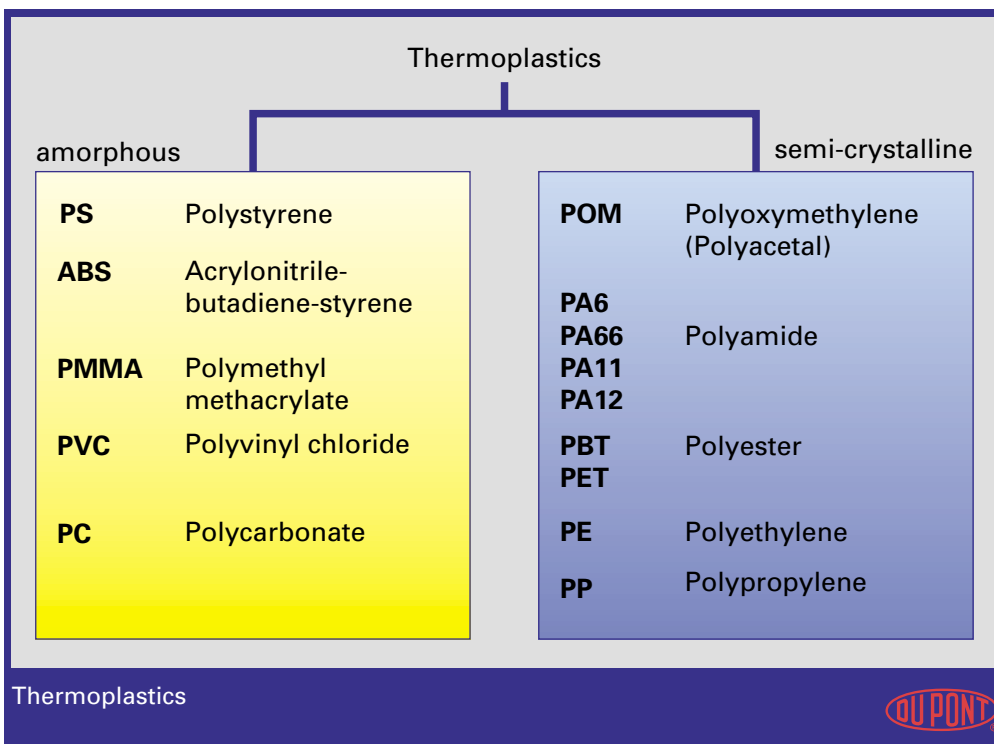


Fig. 1

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## Fillers and reinforcing materials

Thermoplastics are supplied in unreinforced, glass-fibre-reinforced and mineral- and glass-sphere-filled forms. Glass fibres are used primarily to increase strength, rigidity and service temperature; minerals and glass spheres have a lower reinforcing effect and are employed mainly to reduce warpage.

Glass fibres affect processing, particularly a parts shrinkage and warpage behaviour. Fibre-reinforced materials cannot therefore be replaced by unreinforced thermoplastics or materials with low reinforcement content without dimensional changes occurring (Fig. 3). The orientation of the glass fibres is determined by the flow direction. This produces a change in mechanical strength.

	amorphous	semi-crystalline
Mechanical properties	O	+
Tendency to creep	+	O
Chemical resistance	-	+
Flexural fatigue strength	-	+
Critical strain	0,4%-0,8%	0,5%-8%
Notch sensitivity	-	O
Service temperature	O	+
Onset of melting	Softening range	Precise melting point
Shrinkage	0,3% - 0,8%	1,0%-3%

+ favourable   O satisfactory   - unsatisfactory


Property comparison of thermoplastics 

Fig. 2

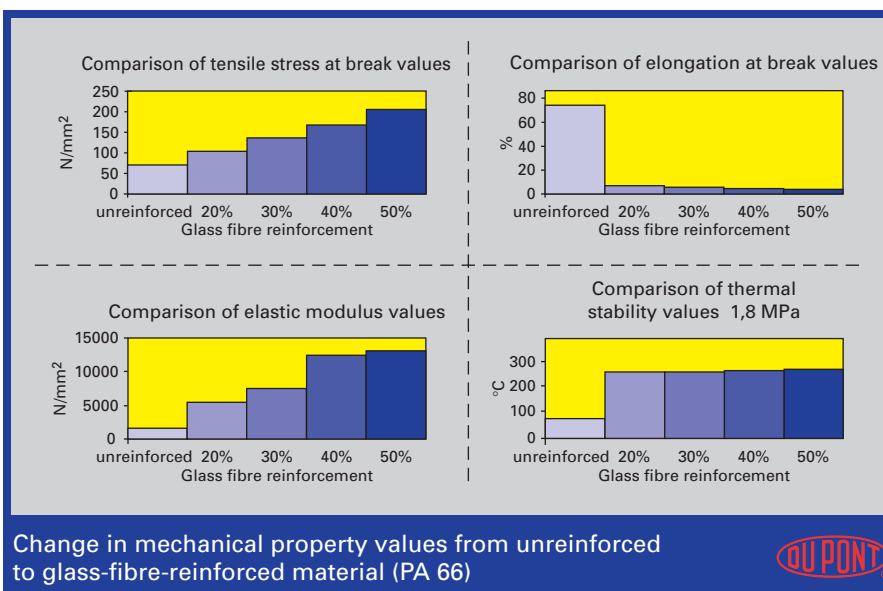


Fig. 3

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To demonstrate these effects, test bars were milled from injection moulded sheets in the longitudinal and transverse directions and their mechanical property values were compared in a tensile testing machine (Fig. 4).

In the case of 30% glass-fibre-reinforced PET, there was a strength loss transverse to the direction of flow of 32% for tensile strength, 43% for flexural modulus and 53% for impact strength. These losses must be taken into account in strength calculation by incorporating safety factors. A wide variety of reinforcing materials, fillers and modifiers are added to many different thermoplastics to alter their property profiles. In material selection, the changes in properties produced by these additives must be checked very carefully in brochures or databases (e.g. Campus) or, better still, technical advice should be sought from specialists employed by the raw material manufacturers (Fig. 5).

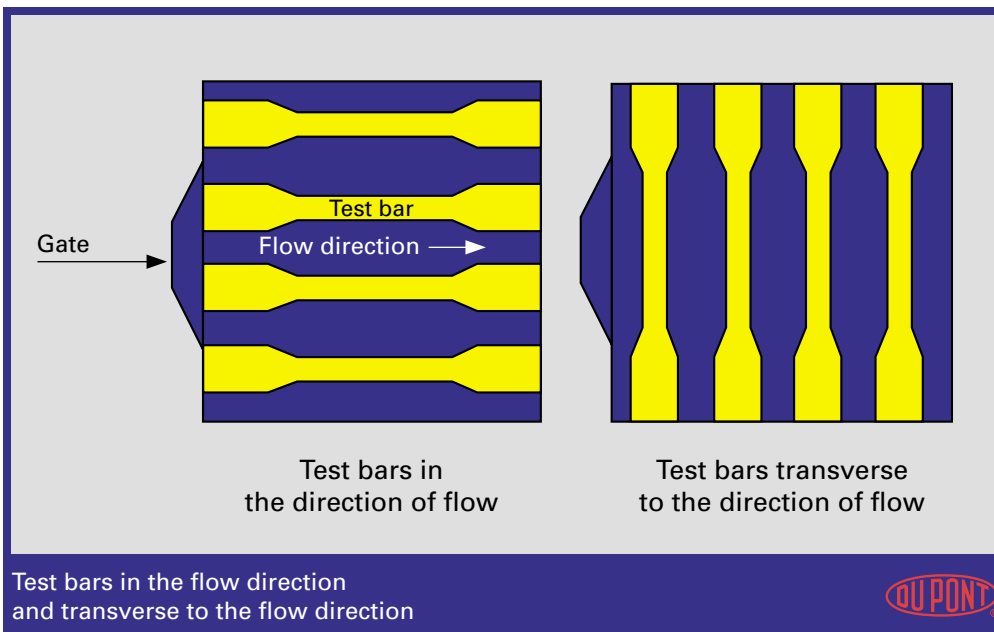


Fig. 4

Additive	Max. content (% w/w)	Elastic modulus	Strain	Impact strength	Dimensional stability	Flame retardancy
Glass fibres	60	↑↑↑	↓↓	↓	↓	↑
Minerals	40	↑	↓	↓	↑↑	↑
Aramid fibres	20	↑	↓	↓	↓	↑
Elastomers	15	↓	↑↑	↑↑↑	↓	↓
UV stabilizers	1	↓	↓	↓	—	—
Flame retardants organic	20	↓	↓↓	↓↓	↑	↑↑↑
inorganic	40	↓	↓↓	↓↓↓	↑	↑↑↑↑
Antistatic agents	5	↓	↓↓	↓↓	—	—

Fig. 5

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## Effect of moisture

Some thermoplastics, especially PA6 and PA66, absorb moisture. This may have considerable effect on their mechanical properties and dimensional stability. Particular attention should be paid to this property in material selection (Fig. 6-7).

## Other selection criteria

Other requirements relate to processing considerations and assembly. It is also important to investigate the possibility of integrating several functions in one component so saving costly assembly operations. This measure can have a very beneficial effect on production costs. It can be seen that in price calculations, it is not only the raw material price that is important. It should also be noted that materials with higher rigidity permit thinner walls and so result in faster cycles.

It is important to list all the criteria for material selection and evaluate them systematically. A rough material selection flow chart is shown in Fig. 8.

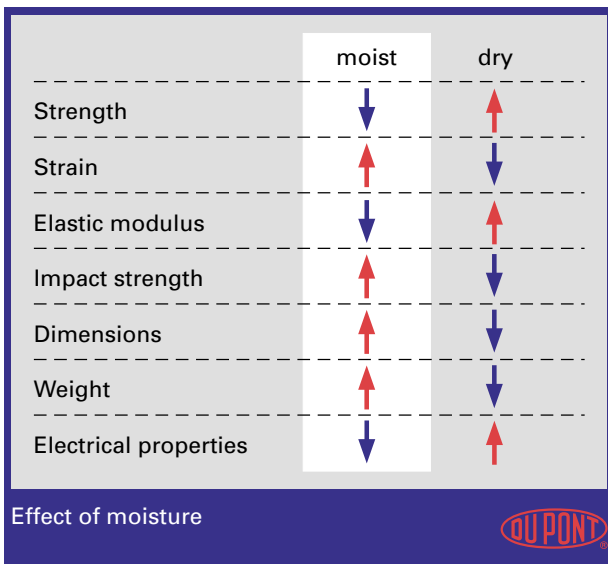


Fig. 6

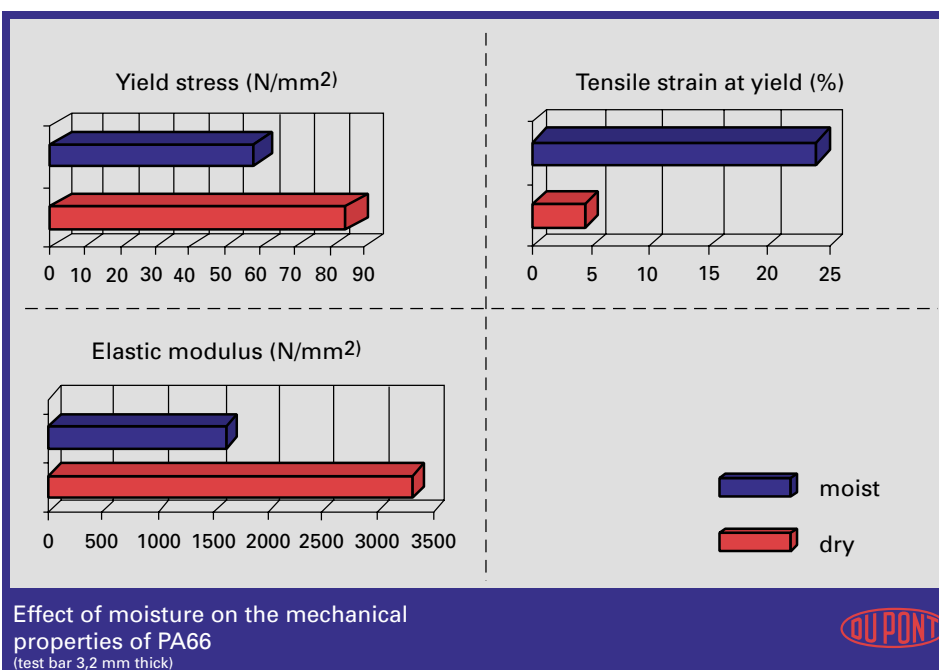


Fig. 7

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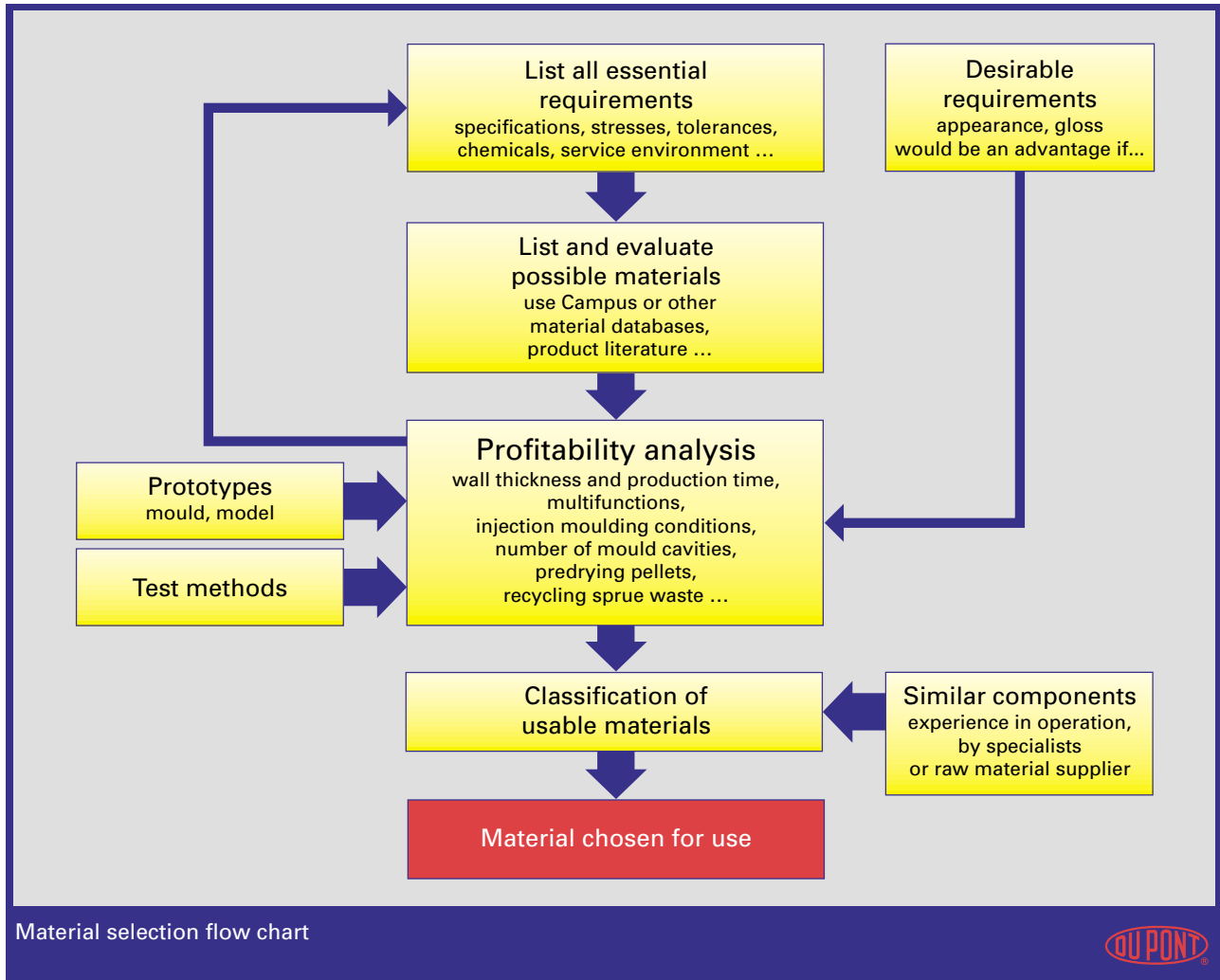


Fig. 8

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