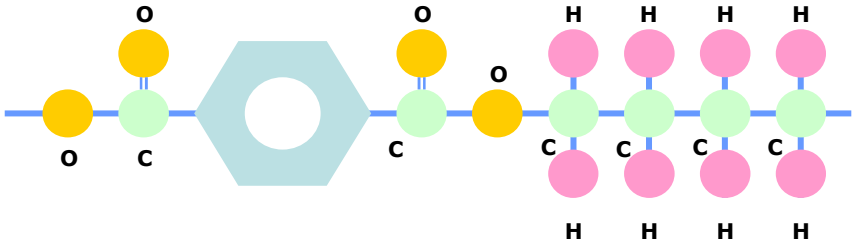
PBT AND ITS ADVANTAGES

Polybutylene terephthalates (PBT) are semi-crystalline engineering plastic materials with outstanding properties. The product range covers from high impact with very low stiffness to highly filled grades with enhanced stiffness and strength.



PBT is produced by transesterification of terephthalic acid and 1,4-butanediol. Being a polycondensation polymerisation water is also obtained as by product.

Key properties of PBT are given below;

- Melting Temperature : 225 °C
- Glass Transition Temperature : 50 °C
- Density : 1,31 g/cm^3
- Oxygen Index : 21%
- Long-term Use Temperature : 120 - 140 °C
- Short-term Use Temperature : 200 – 220 °C
- Crytallinity Ratio : 40 – 60%
- Crystallization Rate : High
- Cooling Rate : High
- Moisture Saturation Level : 0.2 – 0.5%

PBT has high crytallinity ratio and the crystallization rate is fast during cooling. Its thermal properties like melting temperature and glass transition temperature are similar to Polyamide 6 (PA 6). On the other hand due to its chemical nature PBT is not hygroscopic; therefore do not absorb moisture from environment as polyamides.

Important properties that makes PBT as a unique polymer are listed below;

- Low moisture absorption
- Good dimensional stability
- Very good thermal and color stability
- Excellent stiffness and hardness
- Good mechanical strength
- High wear resistance and low friction
- Good creep and fatigue behaviour
- Good electrical properties
- Very good chemical resistance
- Excellent flammability characteristics
- Excellent flow and processing properties
- Very good surface finish

As PBT do not absorb moisture like PA, properties are kept nearly the same in every humid condition. Comparison for un-reinforced PBT, PA are shown in Figure 1.

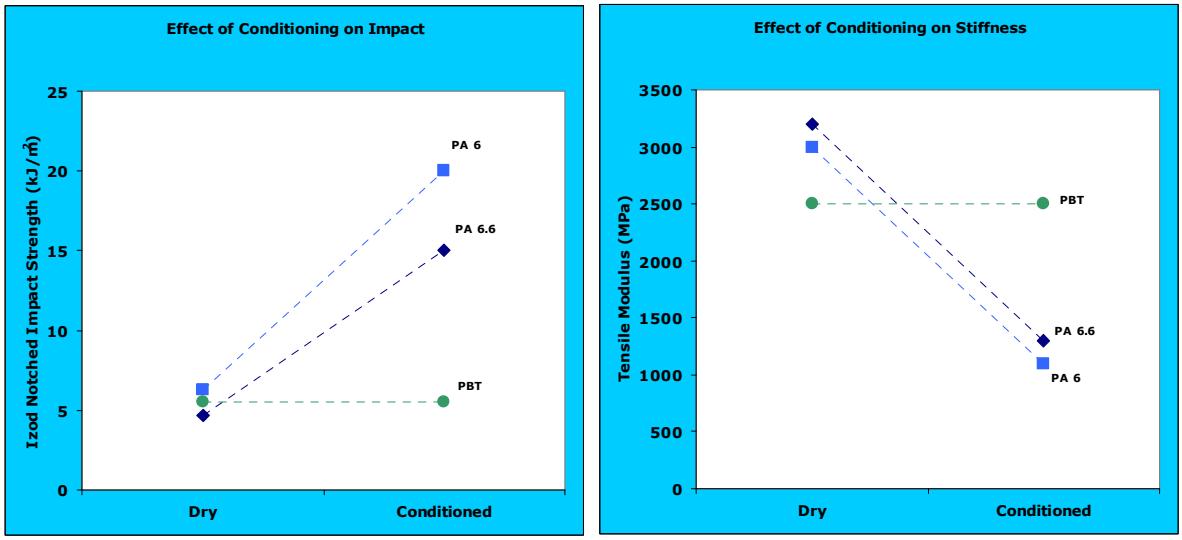


Figure 1. Effect of conditioning on mechanical properties of un-reinforced PBT, PA 6 and PA 6.6.

It is clearly seen from the graphics that moisture conditioning do not have any effect in the mechanical properties of PBT, where in PA flexibility and impact strength increase but stiffness decrease. As PBT is not affected from moisture it is one of the main polymers used in electrics & electronics industry. Electrical resistivity of various polymers are shown in Figure 2.

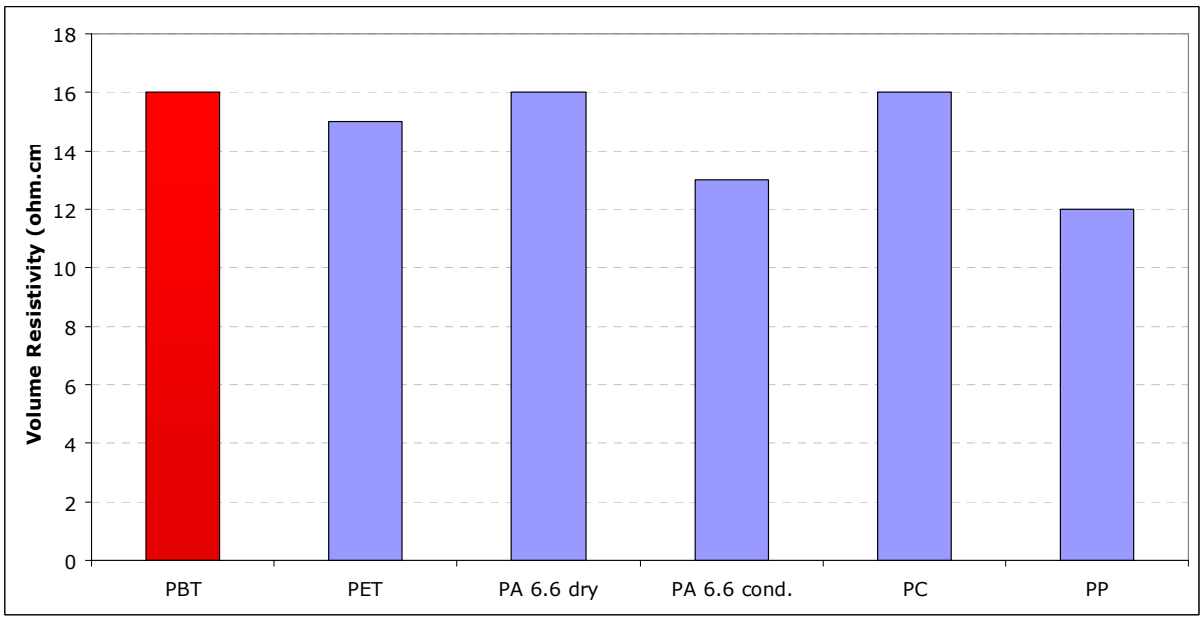


Figure 2. Electrical resistivity of various polymers.

Based on their melting temperature and molecular structure PBT offer excellent thermal properties. Reinforced compounds have increased heat deformation temperature (HDT) in proportion to their mechanical strength and use temperature. Figure 3 presents use temperature and heat deformation temperature values for various polymers that contain 30% glass fiber.

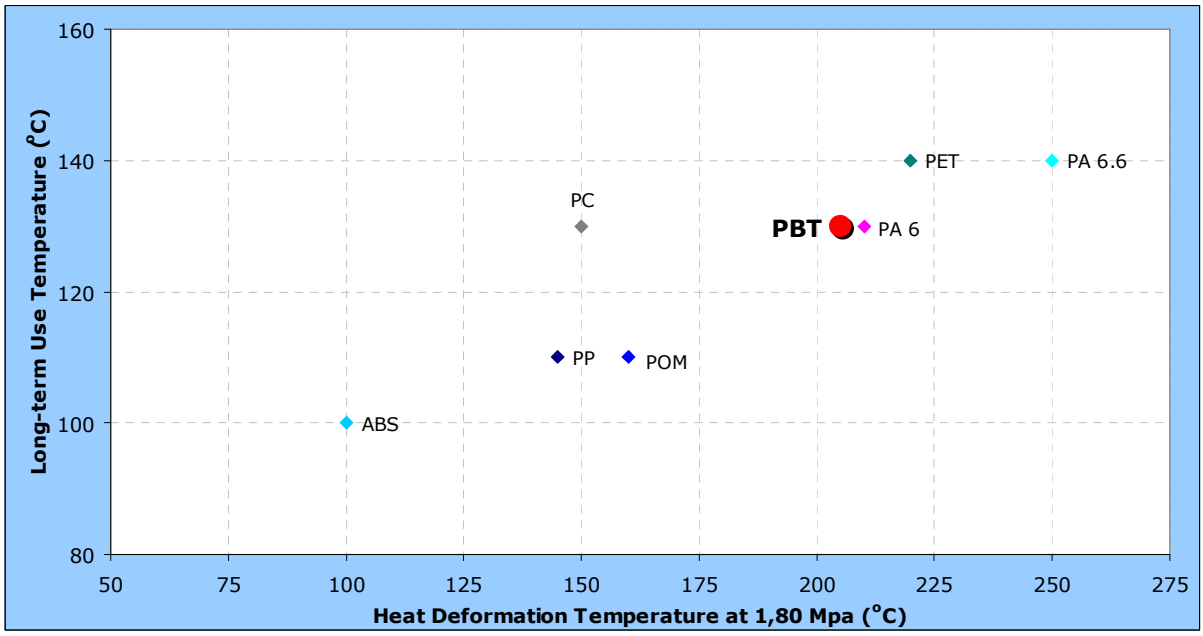


Figure 3. Continuous use temperature and HDT for 30% glass fiber reinforced polymers

Reinforced and thermally stabilized types of PBT can be continuosly used in temperatures below 130 °C, where for short term PBT can resist upto 220 °C. The thermal performance of PBT's are comparable to that of PA 6.

Other important characteristics are mechanical properties, especially strength and stiffness. Comparison data for 30% glass fiber reinforced polymers can be seen in Figure 4.

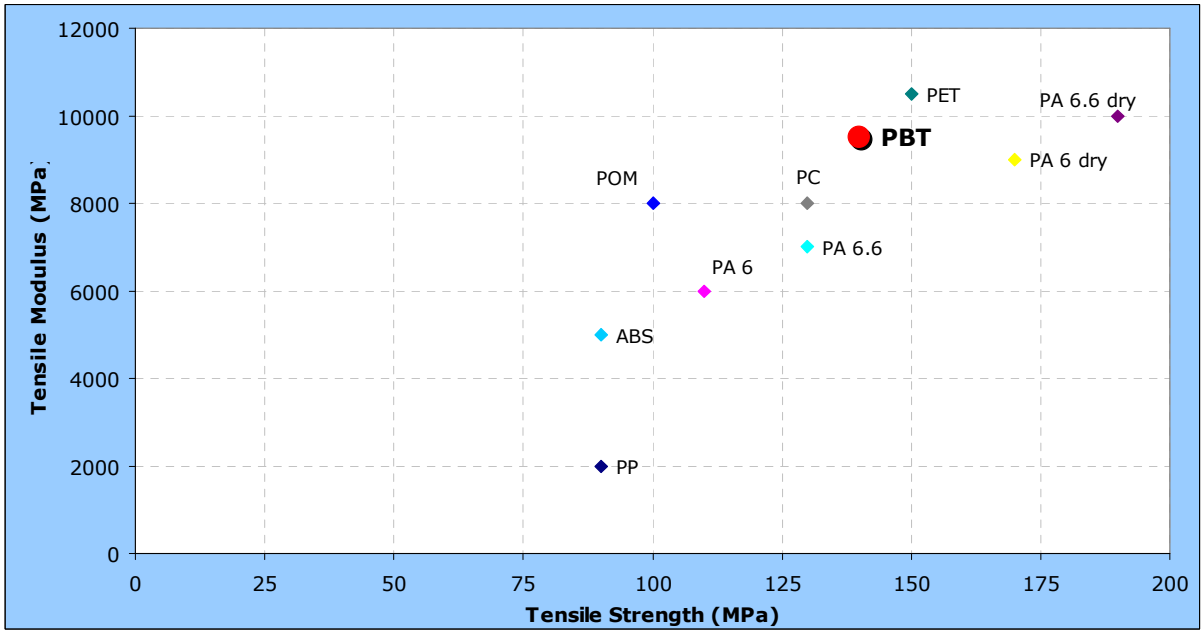


Figure 4. Strength – Stiffness ratio for 30% glass fiber reinforced polymers.

The strength and stiffness of PBT is lower than PA under dry conditions, where under normal conditions that PA's absorb moisture, PBT has higher stiffness and strength properties compared to PA.

Color stability is another key advantage of PBT over PA. Below Figure shows a comparison of color change after thermal aging for heat stabilized un-reinforced PA 6.6 and PBT.

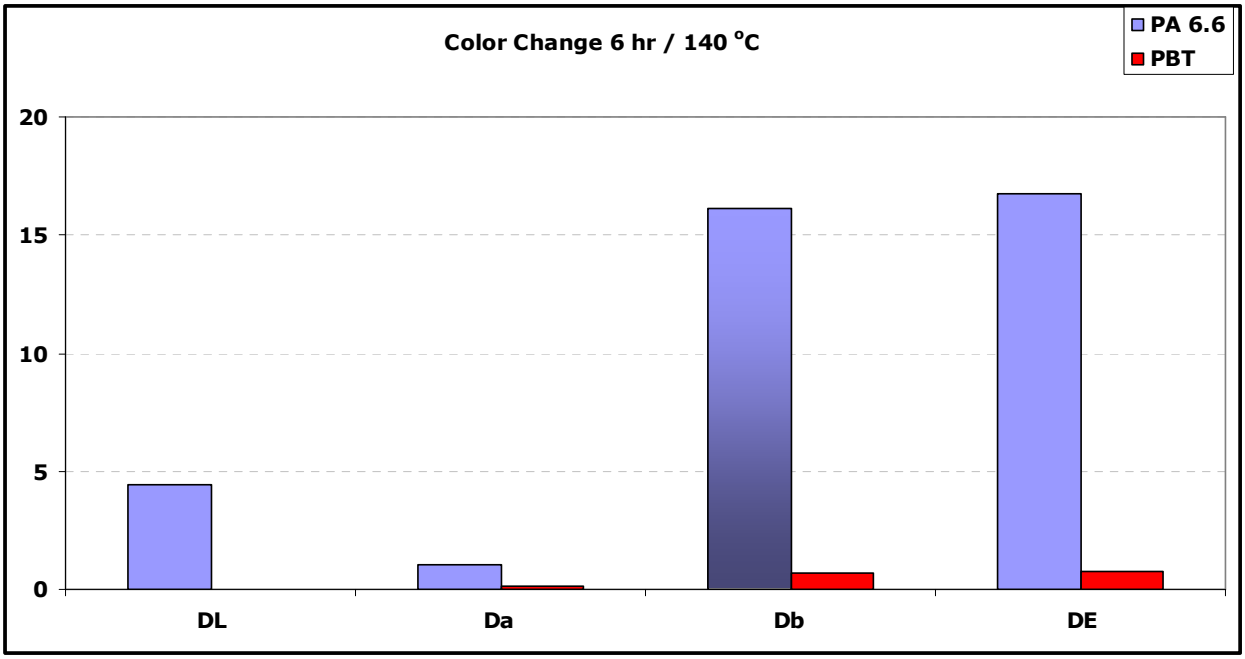


Figure 5. Color change for PA 6.6 and PBT after thermal aging.

It is clear that after 140 °C and 6 hours PA has a darker (DL), slightly red (Da) and considerably high yellowish color (Db). Wheras in PBT overall color change is close to DE zero and yellowness is more than 15 times less compared to PA. As a result visual and colored parts that are used under temperature should be produced from PBT's rather than PA. A nice example can be given as lamp holders and iron bases.

Thermoplastics in general have low resistance to fire and tend to burn in case the fire source is not removed away. To improve the fire resistance of thermoplastics and to make them flame retardant certain additives are in use. PBTs having high oxygen index and proper chemical structure are excellent materials to be used as flame retardant with optimum costs. Especially in glass fiber reinforced types PBT have competitive advantages. Comparison of key properties for 15% glass fiber reinforced, flame retardant (UL94 V0) PBT and PA 6 are shown in Figure 6.

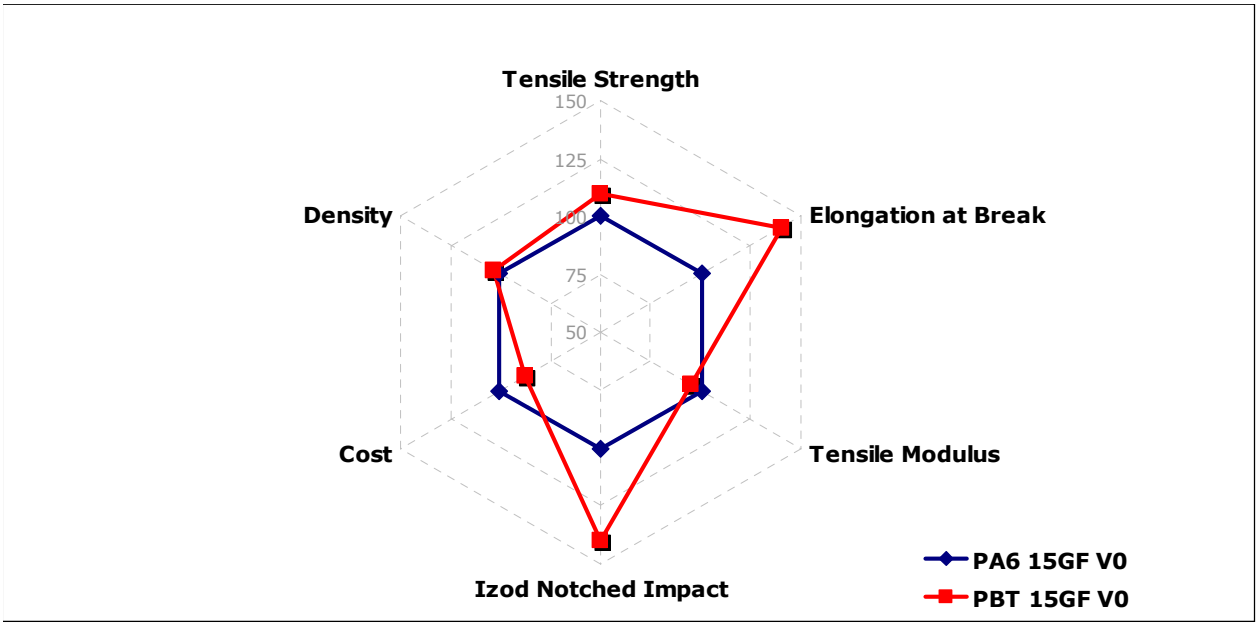


Figure 6. Comparison for PA 6 and PBT, 15% glass fiber reinforced, flame retardant types. Values for PA 6 is taken as reference in %

In flame retardant and glass fiber reinforced types PBT has below advantages compared to PA;

- ✓ Better mechanical properties
- ✓ Lower material cost
- ✓ Higher flow ⇨ Faster molding cycles ⇨ Lower process cost
- ✓ Consistent electrical properties independent from environmental conditions
- ✓ Dimensional stability due to low moisture absorption
- ✓ Color stability under high temperature
- ✓ Excellent flame resistivity
- ✓ Better gloss and surface aspects

Although PBT has various competitive advantages compared to many other polymers, it also has some disadvantages that are listed below;

- Low flexibility
- Hor water resistance (< 60 - 70 °C)
- Pre-drying prior to use
- Density

Density and impact resistance data for 30% glass reinforced polymers are presented in Figure 7.

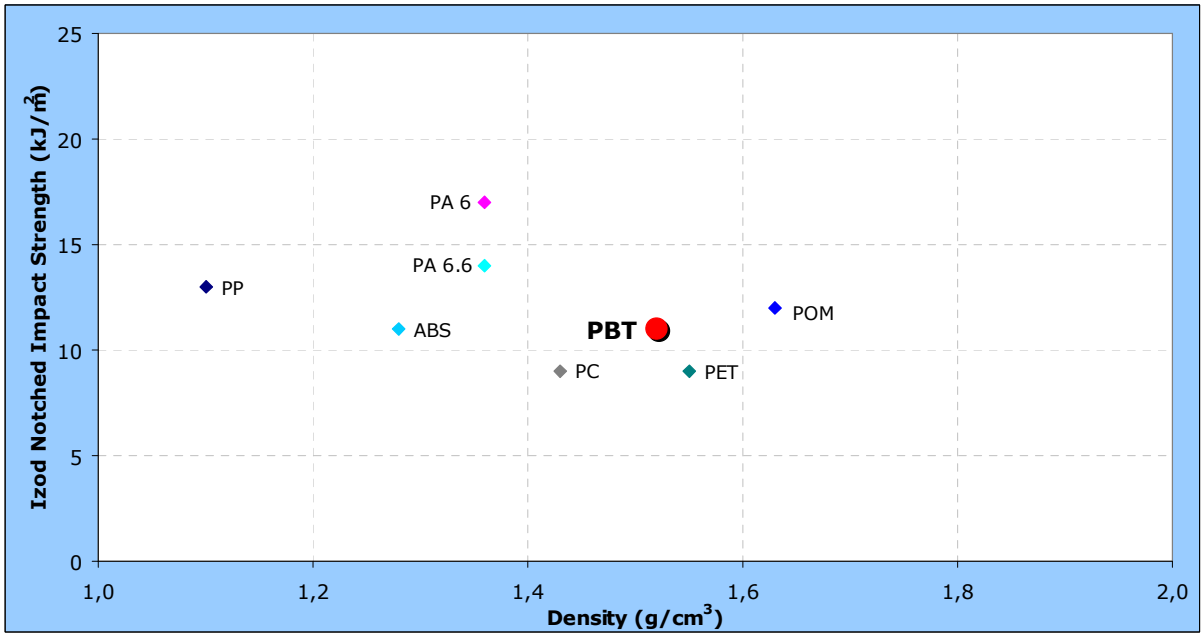


Figure 7. Density – Impact Strength ratio for 30% glass fiber reinforced polymers.

It is clear from graph that PBT, together with PC, PET and POM have higher density and lower impact compared to other materials. This ratio can be improved by incorporation of elastomeric additives during compounding especially to increase flexibility and impact resistance.

Due to excellent balance of properties, PBT grades are suitable for an extensive range of industries like;

Automotive; mirrors and mirror mechanisms, lightening systems, lock mechanisms, door handles, wiper arms, cable connectors, caps and closures

Electrics and Electronics; connectors, relays, lamp holders, lamp housings, circuit breakers, drive housings, power switches, telecom parts, bobbins, various sockets and switches

Appliances; iron bases, oven knobs, oven handles, ventilation systems, keybord buttons, varios housings

In addition PBT is used in industrial applications like gears, bearings, conveyor elements that need high strength and long term consistent properties.

PBT can be processed in all commercial injection molding machinery. In general standard 3 zone screws are used. Drying is the most important parameter prior to use as moisture causes immediate hydrolytic degradation during process which causes molecular weight reduction and thus reduction in resistance. Moisture content should be less than 0.04% before processing. When there is a blend with PET or PC moisture content should not exceed 0.02%. Figure 8

presents the effect of proper drying on short-term properties for PBT 30% glass fiber reinforced.

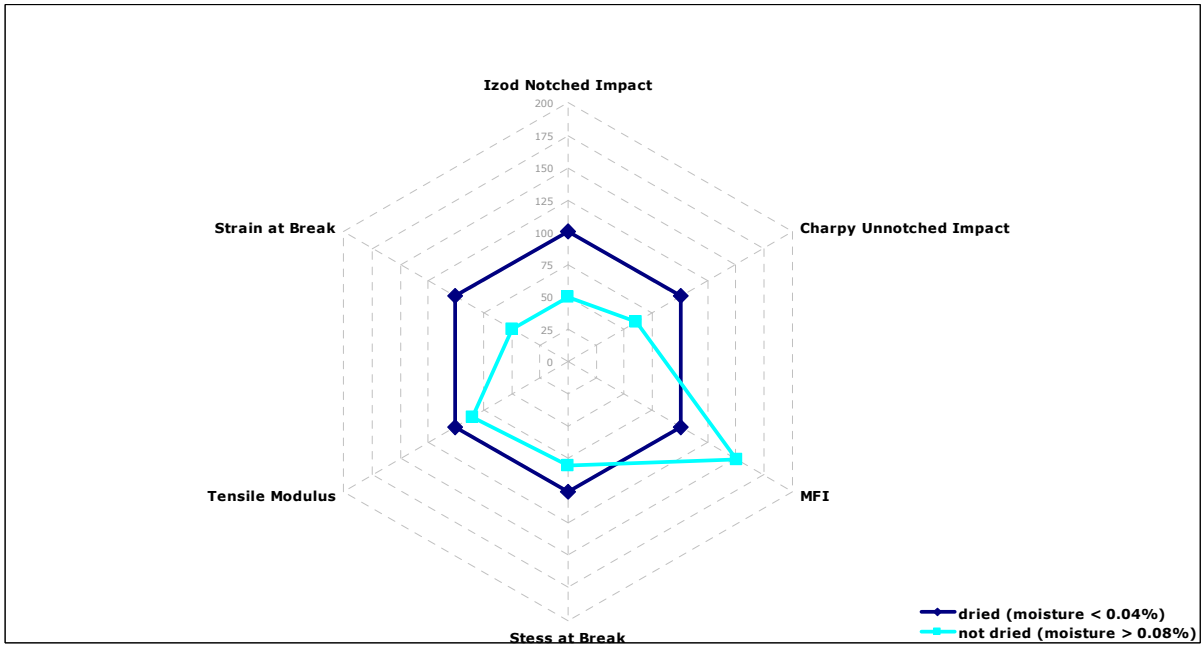


Figure 8. Effect of proper drying on short-term properties for PBT 30% glass fiber reinforced. Values for dry is taken as reference in %.

If material is not dried under required conditions mechanical properties decrease by 10 – 50% where material flow increases 2 times. It is important to note that no surface defects are observed with unproper drying.

Suggested processing conditions are given below;

- Drying : 120 °C / 2-4 hr
- Process Temperature : 240 – 270 °C
- Feed Throat Temperature : 50 – 70 °C
- Mold Temperature : 60 – 100 °C
- Barrel / Part Volume : 2 – 4
- Residence Time : max 4 – 5 min.
- Shrinkage - unreinforced : ⊥ % 1,6 and // % 1,6
- Shrinkage – 30% GF : ⊥ % 0,3 and // % 1,0

Being a fast cooling material, for thin wall parts, high injection speeds are suggested for proper molding.

In order to improve some properties it is possible to make blends of PBT with some other materials;

- For stiffer, more glossy and high temperature requests, PBT/PET blends
- For flexible, impact resistant and better dimensional stability, PBT/PC blends
- For improved UV resistance and dimensional stability, PBT/ASA blends are used