Design with Makrolon®
Thermally Conductive Polymers

The last few years have seen significant development of injection moldable thermally conductive polymers. Electronic and lighting manufacturers are realizing new-found freedom in both design and assembly with these materials. Traditional die cast processes limit shape, add weight and, due to high processing temperatures, restrict electronic component integration. On the other hand, thermally conductive polymers such as Makrolon® TC8030 polycarbonate from Covestro and the injection molding process increase packaging freedom while reducing mass and enable in-mold electronics integration not possible with die casting.

All the advantages of Makrolon® TC8030 polycarbonate are of no value if the design is poor. A poor design can affect thermal performance and long-term durability of the product. Fortunately, there are well established guidelines for designing with polycarbonate materials, and many of them apply to Makrolon® TC8030 polycarbonate as well.

The mechanical strength of Makrolon® TC8030 polycarbonate needs to be kept in mind in the design process. The filler content necessary to achieve high thermal conductivity alters some properties, such as impact strength and elongation to break vs. an unfilled polycarbonate.

Features, such as radii, and the avoidance of sudden wall thickness changes, are important to maximize the impact performance of a part. Typically a radius-to-wall thickness ratio of 0.2–0.25 should be considered for applications where impact is a concern. Thickness transitions should be tapered or have radius rather than a sharp, stress increasing corner.

Many publications suggest 0.5° per side is an adequate minimum draft for unfilled polycarbonate. This can be debated, and in fact experienced molders often suggest a minimum 1° per side. Parts have been successfully molded of Makrolon® TC8030 polycarbonate with 1° of draft, however experience suggests a minimum draft angle of 1.25° per side with 1.5° per side preferred for improved de-molding.

Generally, increased conductivity is a benefit to a heat sink in service. It is less helpful in molding. High thermal conductivity means the part will lose heat to the mold steel more quickly, potentially reducing flow length. Spiral flow data indicates that a nominal wall thickness of 2.5 mm provides a flow length of 10–11" at a melt temperature of 630 °F (ISO for EMLA: tested at 2 mm thickness = ca. 70 mm at a melt temperature of 310 °C) yielding a good compromise between part weight and flow. However, cooling fins that become as thin as 1 mm due to draft have been successfully molded.

One advantage of the rapid heat loss of Makrolon® TC8030 polycarbonate is the ability to mold thicker-than-standard sections with less risk of sink marks. Normally sink is a concern with rib-to-wall thickness ratios greater than 0.4 – 0.5 with the risk increasing with the ratio. Parts have been made with minimal sink with ratios as high as 0.8.

Thermally conductive plastics generally use large percentages of additives to achieve their high thermal conductivity. In many cases the additive levels are near the maximum limit for physical property retention. Coloring materials is also done with additives, which leaves little room to pre-color thermally conductive plastics without seriously lowering mechanical properties. In the case of most thermally conductive plastics: "You can have any color you want, as long as it is charcoal gray."

To overcome the lack of styling afforded by charcoal gray, Makrolon® TC8030 polycarbonate has been tested for paintability using both solvent and waterborne paint systems. The resulting adhesion is very good. A specialized, low-temperature powder coating system has also been trialed with good success. In many applications, the lack of visibility of the part makes the need for coloring questionable. If, however, part appearance is critical in service, these techniques can achieve the desired aesthetic.

Assembly techniques should be decided-on early in the design. Attachment locations, number and method can be dictated by the material selection. The mechanical behavior of the material may require more support or may preclude the use of a particular type of fastener.

Makrolon® TC8030 polycarbonate has been tested with several joining techniques. Tests show that adhesive bonding provides good joint strength and is the simplest assembly method. Once bonded, the assembly is generally tamper proof and will usually require permanently damaging the assembly to access components. Automated application equipment makes the process very clean, repeatable and precise.

The higher filler content of Makrolon® TC8030 polycarbonate means special consideration when using threaded fasteners. Threaded fasteners that bite into Makrolon® TC8030 polycarbonate with standard screw boss designs have limited tightening torque and pull-out force compared to an unfilled polycarbonate. Designs which use threaded metal inserts or bolts that pass through the Makrolon® TC8030 polycarbonate and sandwich it between a nut/washer and the mating part are better options.

Threaded metal inserts are also a possible option. Shrinkage stress can be a concern with molded-in inserts. They are often preheated before over-molding. Heating causes the inserts to expand allowing the insert and over-molded material to shrink more uniformly. The residual heat in the threaded insert also helps mitigate some of the stress at the interface, acting as a localized "annealing" process.

Snap-fit designs can be successfully used with Makrolon® TC8030 polycarbonate provided it serves as the female half of the joint. The strain to break of the material makes it impractical to use as a cantilever snap arm feature.

The same high conductivity that makes Makrolon® TC8030 polycarbonate a good heat sink material makes it a challenge for welding. Thermal energy generated for hot plate or ultrasonic welding is dissipated quickly making it difficult to achieve a good bond.

Although it may be possible to achieve some level of bond using hot plate welding, the dynamic forces necessary in ultrasonic welding make that technique unlikely. As the frequency and amplitude are adjusted to increase the thermal energy and therefore the melting, the forces on the material tend to cause cracking of the parts before a weld is achieved.

Generally, adhesive bonding, pass through bolt joints, twist-lock features and snap fits are good techniques for joining Makrolon® TC8030 polycarbonate.

A properly designed part using Makrolon® TC8030 polycarbonate that takes advantage of opportunities for part consolidation and reduction in assembly steps can be a cost effective alternative to traditional heat sink materials.

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