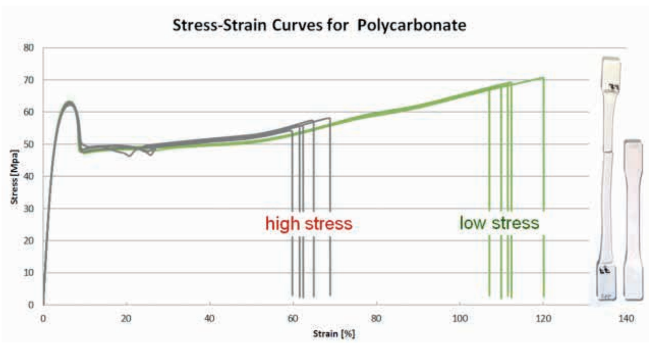
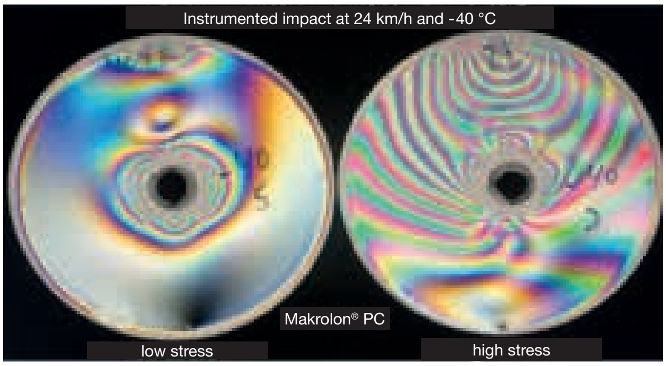
Addressing Molded-In Stresses and Part Durability

The polymer chains that make up a thermoplastic can be thought of as springs that can be stretched or compressed. As plastic flows into a mold cavity, the polymer “springs” tend to stretch as fountain flow pulls them out of the melt to form a frozen layer at the mold surface. Some of this stretch can be frozen in at the mold surface resulting in molded-in stress. Molded-in stresses can also develop as the thermoplastic shrinks during solidification. Covestro has conducted studies to address how these stresses affect part durability.

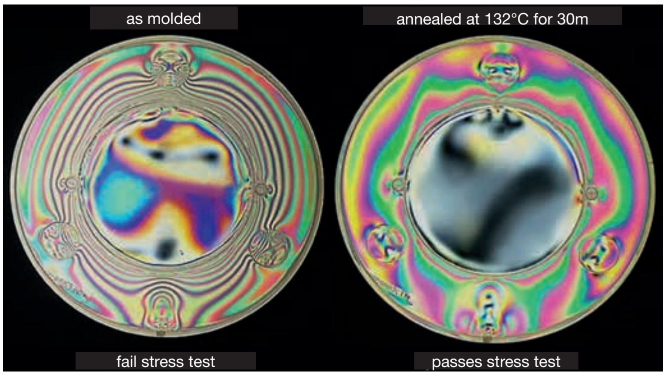
Makrolon® PC tensile bars and impact testing disks were intentionally processed with high and low levels of molded-in stress as verified by polarized light techniques. Consistent with the spring analogy, the highly stressed tensile bars exhibited a reduction in elongation to break. The already stretched (stressed) polymer springs reach their elongation limit sooner.



In instrumented impact testing at 24 km/h and – 40 °C, the highly stressed PC disks required 7 % less energy to puncture. In PC, the reduction in elongation to break occurred well after the onset of necking, and in impact the material remained ductile during impact. The high levels of molded-in stress did not diminish PC mechanical performance in a significant way, but such levels of stress could be a serious issue for materials which lack the toughness of PC. In less tough materials, elevated stresses could lead to brittle behavior or a loss of mechanical performance at stress and strain levels required by the application.



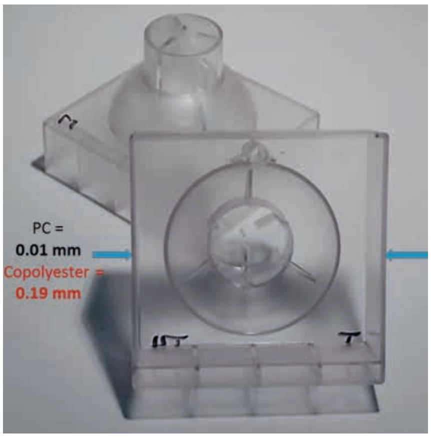
Chemical resistance testing at various levels of applied strain revealed little if any reduction in performance for the PC tensile bars molded at high stress levels. Annealing of the parts before testing produced a modest improvement in chemical resistance. Annealing of the bars while under applied strain generated a dramatic improvement in chemical resistance. Likewise, annealing of insert molded PC parts greatly improved resistance to environmental stress cracking and chemical attack.



Samples of a medical test part were molded in Makrolon® PC and medical grade copolyester to see the effect of molded-in stresses on dimensional stability. The parts were processed at appropriate conditions for each material. After molding, key dimensions of the part were measured and recorded.

The parts were then placed in an oven at 82 °C to simulate temperatures the parts might see during shipping. The side-walls of the copolyester part distorted inwards 0.19 mm vs 0.01 mm on the PC part. The much higher distortion in the copolyester is due to a combination of molded-in stress and low modulus, particularly at elevated temperatures.

This distortion at shipping temperatures can have serious implications in parts for which a change in dimension or tightness of fit can lead to functional problems such as misalignment or leaks.



Stresses in molded thermoplastics can come from a variety of causes such as the way the part fills, shrinks or ejects from the mold. They can manifest as surface stresses or bulk stress in the plastic. The polarized light technique for stress analysis shows the sum of the tensile and compressive stresses through the plastic thickness. It reflects bulk stresses and is most relevant to bulk mechanical properties such as tensile and impact performance. Solvent stress testing detects surface stresses and is more relevant when evaluating surface phenomena such as demolding stresses and chemical resistance.

Bulk molded-in stress levels were found to be generally lower when molding at higher mold and melt temperatures, and at an optimum filling speed for the part. Packing time and pressure can also be optimized to minimize bulk stresses. The effect of molding conditions on surface stresses is more complicated. A recent study indicated that in some instances, cold mold temperatures can induce beneficial compressive stresses on the surface and thereby improve chemical resistance. In this study, parts molded in a hot mold performed about the same or perhaps slightly better in solvent stress testing than parts molded in a cold mold. Adherence to good molding practice with regard to wall thickness variations, sharp inside corners, molding draft, gate design mold cooling etc. can perhaps do more than processing to minimize stresses and improve part performance.

covestro

Covestro Deutschland AG
Business Unit Polycarbonates
D-51365 Leverkusen

plastics@covestro.com
www.plastics.covestro.com