

## Reduction of Residual Stress by Variothermal Processing and Validation via Birefringence Measurement Technique on Injection Molded Polycarbonate Samples

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**Abstract :** Injection molding is one of the most commonly used techniques in the industrial polymer processing. In the conventional process of injection molding, the liquid polymer is injected into the cavity of the mold, where the polymer directly starts hardening at the cooled walls. To compensate the shrinkage, which is caused predominantly by the immediate cooling, holding pressure is applied. Through that whole process, residual stresses are produced by the temperature difference of the polymer melt and the injection mold and the relocation of the polymer chains, which were oriented by the high process pressures and injection speeds. These residual stresses often weaken or change the structural behavior of the parts or lead to deformation of components. One solution to reduce the residual stresses is the use of variothermal processing. Hereby the mold is heated - i.e. near/over the glass transition temperature of the polymer - the polymer is injected and before opening the mold and ejecting the part the mold is cooled. For the next cycle, the mold gets heated again and the procedure repeats. The rapid heating and cooling of the mold are realized indirectly by convection of heated and cooled liquid (here: water) which is pumped through fluid channels underneath the mold surface. In this paper, the influences of variothermal processing on the residual stresses are analyzed with samples in a larger scale (500 mm x 250 mm x 4 mm). In addition, the influence on functional elements, such as abrupt changes in wall thickness, bosses, and ribs, on the residual stress is examined. Therefore the polycarbonate samples are produced by variothermal and isothermal processing. The melt is injected into a heated mold, which has in our case a temperature varying between 70 °C and 160 °C. After the filling of the cavity, the closed mold is cooled down varying from 70 °C to 100 °C. The pressure and temperature inside the mold are monitored and evaluated with cavity sensors. The residual stresses of the produced samples are illustrated by birefringence where the effect on the refractive index on the polymer under stress is used. The colorful spectrum can be uncovered by placing the sample between a polarized light source and a second polarization filter. To show the achievement and processing effects on the reduction of residual stress the birefringence images of the isothermal and variothermal produced samples are compared and evaluated. In this comparison to the variothermal produced samples have a lower amount of maxima of each color spectrum than the isothermal produced samples, which concludes that the residual stress of the variothermal produced samples is lower.

**Keywords :** birefringence, injection molding, polycarbonate, residual stress, variothermal processing

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