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Visualization Analysis of Melt Flowing Behavior into Micro-scale Grooves during Cavity Filling Process in Injection Molding

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Replication of micro or nano-structures in polymer is being widely applied in the fields of IT and biotechnology. Studies on the replication process are therefore important and visualization is the best way to reveal the replication process. In our experiment, the behavior of melt flowing over a stamper with V grooves was observed through a prism glass installed in the mold, using an ultra-high-speed video camera connected with a long distance microscope. The replication process was observed successively at various injection rates, groove sizes, mold temperatures etc., and then, through image processing, the effects of the above factors on the replication process were analyzed. In this study we defined the filling ratio as the ratio of the surface area that comes into contact with the resin melt, to the whole area in the groove surface of the stamper, in order to analyze quantitatively the filling behavior of the melt into grooves. When molding using a stamper with V-grooves with a pitch of 100μm, and at an injection rate of 50cm³/s, the filling of melt into the grooves was mainly completed during the first several milliseconds after the melt flowed over the grooves. However, when using a stamper with smaller V grooves, with a pitch of 50μm, the filling of the resin melt into the grooves was slowed down, and the filling ratio decreased. As the injection rate increased, the filling of the melt into the grooves accelerated and the filling ratio increased. Furthermore, the effects of mold temperature and cavity thickness on the replication process were investigated and reported in this paper. The results of above visualization analysis offer a unique opportunity to understand and improve the replication process by injection molding.