WHAT CAN BE LEARNT FROM FLOW VISUALIZATION WITH RESPECT TO THE EXTRUSION OF POLYMER MELTS

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Processing equipments like extruders or injection molding machines and even capillary rheometers are “black boxes” with respect to the flow processes of polymer melts taking place during their usage. In order to understand the processing operations better and to be able to assess the influence of molecular parameters in more detail, a quantitative knowledge of the flow profiles during processing is desirable.

For that purpose, two methods have been in use at the Institute of Polymer Materials: Laser-Doppler Velocimetry (LDV) and Digital Particle Image Velocimetry (DPIV). The first one is preferably applied to measure flow fields within a duct, the latter to get information on the flow outside a die as in the case of film extrusion, for example. Two special devices with glass windows for the access of light were constructed. The one makes it possible to investigate flow patterns occurring inside and outside of a slit capillary on a laboratory scale, the heart of the other is a slit die for film extrusion of 300 mm in width. Together with the corresponding drawing unit and the extruder, this machine works on a technical scale.

This presentation is mainly concerned with flow properties relevant for processing. The first phenomenon discussed, is the entry flow of various polymer melts into a slit. Particular interest is devoted to the vortices observed for long-chain branched polyethylenes and polypropylenes and their dependencies on extrusion conditions. Within the capillary the occurrence of wall slip is experimentally addressed and its development under the influence of particular additives presented. Such kind of investigations throws some light on the origin of the different modes of melt fracture. It is demonstrated that the so-called shark skin is a surface defect which originates from the flow conditions at the die exit and that the gross melt fracture can be traced back to effects in the entrance region of the slit.

Still closer to real processing operations are the velocity measurements during film extrusion which have been performed on polypropylene. The exit velocities of the melt can elegantly be measured along the slit width by LDV, and conclusions can be drawn with respect to the uniformity of the flow which is a precondition for the extrusion of homogeneous films. Such knowledge, for example, can contribute to an optimization of the geometry of the “coat-hanger” manifold. Besides that, the influence of the drawing velocity on the flow profiles within the die can be investigated, which is still unknown.

With DPIV the velocity distributions occurring across the films during extrusion were determined for different processing parameters. They give insight into the drawing behaviour, particularly, with respect to the uniformity of deformation and its limitations.