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FLUIDITY OF THERMOPLASTICS ELASTOMERS

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Abstract: *Polymer injection molding is the most used technology of polymer processing nowadays. It enables the manufacture of final products, which do not require any further operations. Working of shaping cavities is the major problem involving not only the cavity of the mold itself, giving the shape and dimensions of the future product, but also the flow pathway (runners) leading the polymer melt to the separate cavities. The runner may be very complex and in most cases takes up to 40% volume of the product itself (shape cavity). This work gives the results of studying the influence of the quality of flow pathway surface and influences of other technological parameters on the polymer melt flow.*

Key words: *injection mold, surface roughness, fluidity, polymer, thermoplastic elastomer*

1. INTRODUCTION

Polymer injection molding is the most used technology of polymer processing nowadays. It enables the manufacture of final products, which do not require any further operations. The tools used for their production – the injection molds – are very complicated machines that are made using several technologies. Working of shaping cavities is the major problem involving not only the cavity of the mold itself, giving the shape and dimensions of the future product, but also the runners leading the polymer melt to the separate cavities. The runners may be very complex and in most cases takes up to 40% volume of the product itself (shape cavity). In practice, high quality of runner surface is still very often required. Hence surface polishing for perfect conditions for melt flow is demanded. The stated finishing operations are very time and money consuming leading to high costs of the tool production. This work gives the results of studying the influence of the quality of flow pathway surface and influences of other technological parameters on the polymer melt flow.

Results of the experiments carried out with selected types of thermoplastics proved a minimal influence of surface roughness of the flow channels on the polymer melt flow. This considers excluding (if the conditions allow it) the very complex and expensive finishing operations from the technological process as the influence of the surface roughness on the flow characteristics does not seem to play as important role as was previously thought.

2. INJECTION MOLDING PROCESS

Injection molding is a way of shaping polymeric materials, during which the molded material is filled at high rate (injected) into a closed cavity of a tempered mold. It produces high quality and precise products (shots) from a wide range of plastics. Injection molding has some other advantages. For instance, precise mold design might eliminate other working. Cold runner molds in case of thermoplastics can be crushed and reused, decreasing the polymer waste to minimum. The injection molding process is quite fast and can be well automated. In order to get a shot with good physical properties and good surface, the filling of the mold must be controlled so that the melt would not flow into the form in one flow front but gradually. A plastic nucleus is formed by this way of laminar flow, which enables the compression of the melt in the mold and consecutive creeping. A constant flowing rate given by the axial movement of the screw is chosen for most of the flows. During filling the mold cavity the plastic material does not slide along the mold surface but it is rolled over. This type of laminar flow is usually described as a "fountain flow" (Fig. 1.).

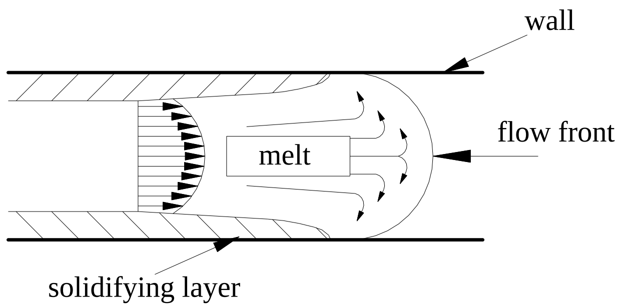


Fig. 1. Fountain flow of polymer melt

3. INJECTION MOLD FOR SAMPLES

The injection mold was designed for the easiest possible manipulation both with the mold itself and during injection while changing the testing plates, size of the mold gate etc.

The cavity of injection mold is in a shape of a spiral with the length of 2000 mm. The cavity is created when the injection mold is closed, i.e. when shaping plate seals the testing plate. The dimensions of cavity are indicated on Fig. 2.

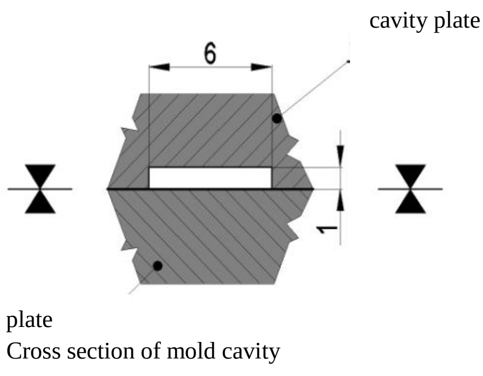
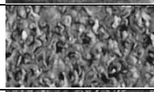
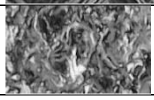


Fig. 2. Cross section of mold cavity

3.1 Testing plates

The injection mold can operate with 5 exchangeable testing plates with different surface roughness. The surface of the plates was machined by four different technologies, which are most commonly used to work down the cavities of molds and runners. These technologies are polishing, grinding, milling and electro-spark erosion. The testing plates are used for changing the surface of the mold cavity.

Technology	Photo	Surface roughness
Polishing		Ra = 0,102μm
Grinding		Ra = 0,172μm
Electro – spark machining (fine design)		Ra = 4,055μm
Milling		Ra = 4,499μm
Electro – spark machining (rough design)		Ra = 9,566μm

Tab. 1. Surface of testing plates

4. TESTED MATERIALS

Representatives of thermoplastic elastomers with varying flow properties were chosen for the experiment with the other decisive criteria being representation of almost all kinds of materials that are commonly used in injection molding. These are: TPE HYTREL 7246, TPE HYTREL 3078, TPE E27, TPU 372, TPU 8060SGN, TPU 1485A.

Injection molding machine ARBURG Allrounder 420C with oil tempering unit Regloplas 150 were used to prepare samples (Figure 3).

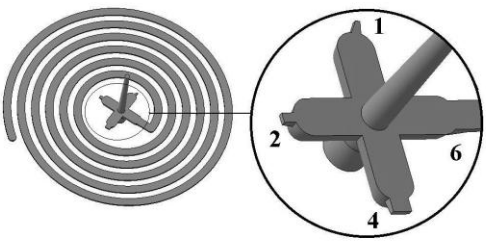


Fig. 3. Testing sample

5. RESULTS

The aim of the measurements was to find out the influence of separate technological parameters, especially the quality of the injection mold cavity surface, on the flow length of the injected materials.

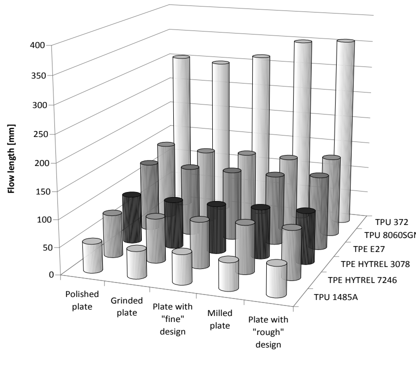


Fig. 4. Dependence of the flow length on the injected material (injection rate 60 $mm.s^{-1}$, injection pressure 60 MPa)

The observed influences on filling the injection mold cavity (the flow length respectively) in the thermoplastics were injection pressure, injection rate, size of the gate and the surface roughness of the testing plates.

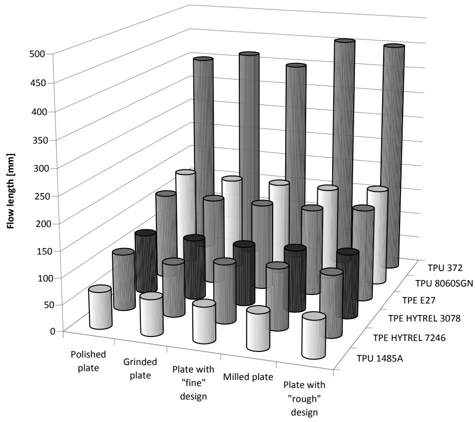


Fig. 5. Dependence of the flow length on the injected material (injection rate 60 $mm.s^{-1}$, injection pressure 80 MPa)

6. CONCLUSION

This research looked into the influence of technological parameters on filling the injection mold cavity and the flow length respectively. The parameters observed during the experiments were injection pressure, injection rate, size of the gate, surface roughness of the testing plates and injected material. All stated parameters, especially injection pressure and injection rate, showed influence on the flow length of all three groups of materials; the influence of surface roughness on the flow length of thermoplastic elastomers was not so significant. The differences in flow lengths at the plates were very small, rather higher in case of rougher surfaces. The measurement shows that surface roughness of the injection mold cavity or runners have no substantial influence on the length of flow. This can be directly put into practice. It also suggests that working and machining (e.g. grinding and polishing) of some parts of the mold, especially the runners, are not necessary. Application of the measurement results may have significant influence on the production of shaping parts of the injection molds especially in changing the so far used processes and substituting them by less costly production processes which might increase the competitiveness of the tool producers and shorten the time between product plan and its implementation.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

Chvatalova, L.; Navratilova, J.; Cermak, R.; Raab, M. & Obadal, M. (2009). *Joint Effects of Molecular Structure and Processing History on Specific Nucleation of Isotactic Polypropylene*, Macromolecules, 42, 7413-7417, ISSN 0024-9297

Manas, D., Stanek, M., Manas, M., Pata, V. & Javorik, J. (2009). *Influence of Mechanical Properties on Wear of Heavily Stressed Rubber Parts.* KGK – Kautschuk Gummi Kunststoffe, Hüthing GmbH, 62. Jahrgang, Mai 2009, p.240-245, ISSN 0948-3276

Stanek, M.; Manas, M.; Drga, T. & Manas, D. (2006). *Testing Injection Molds for Polymer Fluidity Evaluation*, 17th DAAAM, Vienna, Austria,p.397-398, ISBN 3-901509-57-7

Stanek, M.; Manas, M.; Manas, D. & Sanda, S. (2009). *Influence of Surface Roughness on Fluidity of Thermoplastics Materials*, Chemické listy. Volume 103, p.91-95, ISSN 0009-2770