10TH International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2006, Barcelona-Lloret de Mar, Spain, 11-15 September, 2006

INFLUNCE OF TECHNOLOGICAL PARAMETERS ON FLUIDITY OF POLYMER MELT

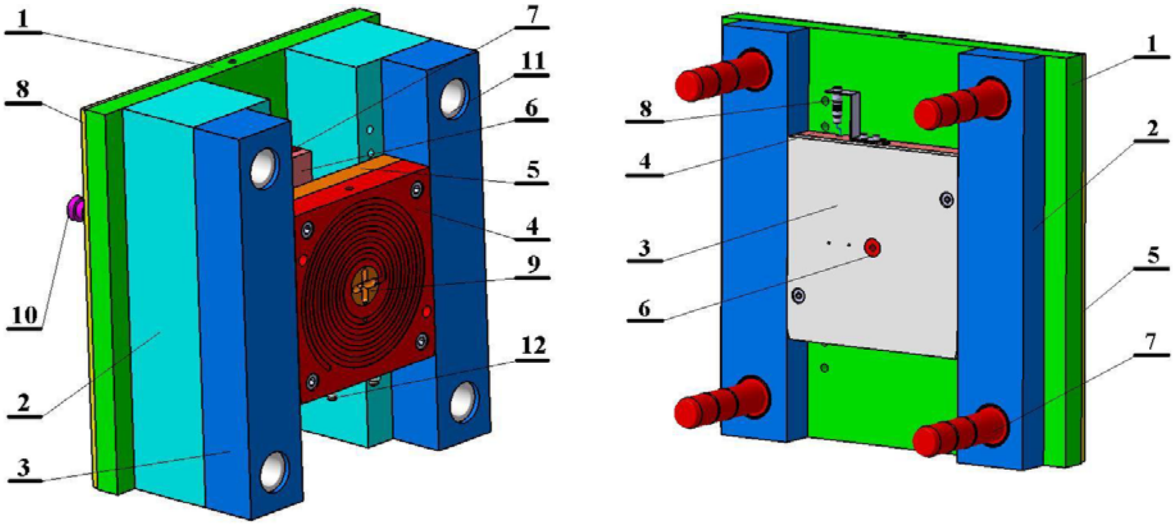
Michal Stanek – Tomas Drga – Miroslav Manas – David Manas
Tomas Bata University, Faculty of Technology, Department of Production Engineering,
TGM 275, 762 72 Zlin,
Czech Republic

ABSTRACT
The fluidity of polymers is affected by many parameters inc. mold design. Evaluation of set of data obtained by experiments in which the testing conditions were widely changed shows that the quality of cavity surface and technological parameters (injection rate, injection pressure and gate size) has substantial influence on the length of flow.
Keywords: injection molding, surface roughness, plastics, melt, runners

1. INTRODUCTION
Injection molding is one of the most widely spread technologies in plastic processing. Delivery of polymer melt into mold cavity is the main stage of injection molding. The melt freezes in the mold cavity and the product gains its final form and dimensions. The injection molding process and polymer melt solidification take place under non-isothermal conditions; the process and the solidification are affected by a complex of rheological properties of the polymer.

2. EXPERIMENT
The main aim of our experiment is to describe influence of surface roughness of mold cavity (runners) on fluidity of polymer melt. To be able to study this behaviour special injection mold has been designed and machined. Then have been chosen plastics with different flow properties which are commonly use in industry.

2.1. Injection mold
Injection mold is made up of two main parts. These parts are shown on Figure 1. and Figure 2. The mold is equipped with pressure and temperature sensors in order to be able to measure the actual value of pressure and temperature in the mold cavity during the injection molding process. Special sprue puller insert enables the exchange of differently sized gates. Size of the gate could be 1, 2, 4 or 6 mm. The injected sample is spiral shaped. The width of spiral is 6 mm, its length is 2000 mm and depth is 1 mm. Length of testing samples has been measured by a measuring jig. Afterwards the experimental data have been statistically processed and evaluated.



a) **b)**

Figure 1. Injection mold

a) Left side of injection mold (ejection side)

1 – clamping plate, 2, 3 – spacer plate, 4 – cavity plate, 5 – plate, 6,7 – ejector plates, 8 – insulating plate, 9 – sprue puller insert,10 – ejector rod, 11 – guide bush,12 – hose nipple

b) Right side of injection mold (sprue side)

1 – clamping plate, 2 – spacer plate, 3 – testing plate, 4 – plate, 5 – insulating plate, 6 – sprue bushing, 7 – guide pillar, 8 – connector of pressure sensor,

2.2. Testing plate

The bottom of the mold cavity is formed by exchangeable testing plates. The surface of the plates (bottom of spiral) is machined using various types of working technologies: milling, grinding, polishing and electro-spark cutting. The quantitative expression of surface quality of the plates is given in the Table 1.

Table 1 Tooled surfaces of testing plates

Tooling technology	R_a [μm] (contact method)	R_a [μm] (non-contact method)
Polishing	0,1020	0,4208
Grinding	0,1720	0,4530
Electro – spark machining („fine“)	4,0550	4,3638
Electro – spark machining („rough“)	9,5660	12,7434
Milling	4,4990	4,9996

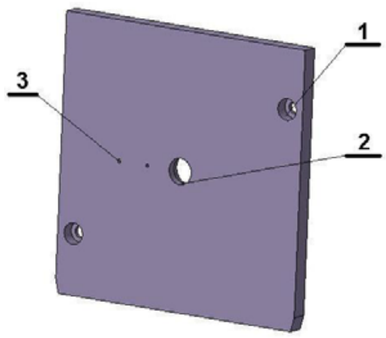


Figure 2. Testing plate
1 – hole for sprue bushing, 2 – hole for screws, 3 – hole for temperature and pressure sensor

2.3. Injected plastics

- polypropylen (PP) Mosten GB 003, MFI = 3,3
- polyethylen (LDPE) Bralen VA 20-60, MFI = 20
- termoplastic polyurethan (TPU) Ellastolan C 78 A, MFI = 6,1
- akrylonitril-butadien-styren (ABS) Polylac PA 757, MFI = 2,4
- polypropylen filled by 20% of chalk Taboren PH 89 T20, MFI = 14,4
- polypropylen filled by 10% of chalk Keltan TP 7603, MFI = 16,9

3. RESULTS

The major results are presented in the Figure 3-5. Better cavity (spiral) filling by materials with better flow properties was expected. Also the results obtained during injection moulding at various injection rates or under different pressures of polymer melts were expected. Unusual (not expected) behaviour of polymer flow using various surface qualities of spiral cavity walls was observed. Better quality of wall surface worsened the flow conditions (the length of injected sample was shorter).

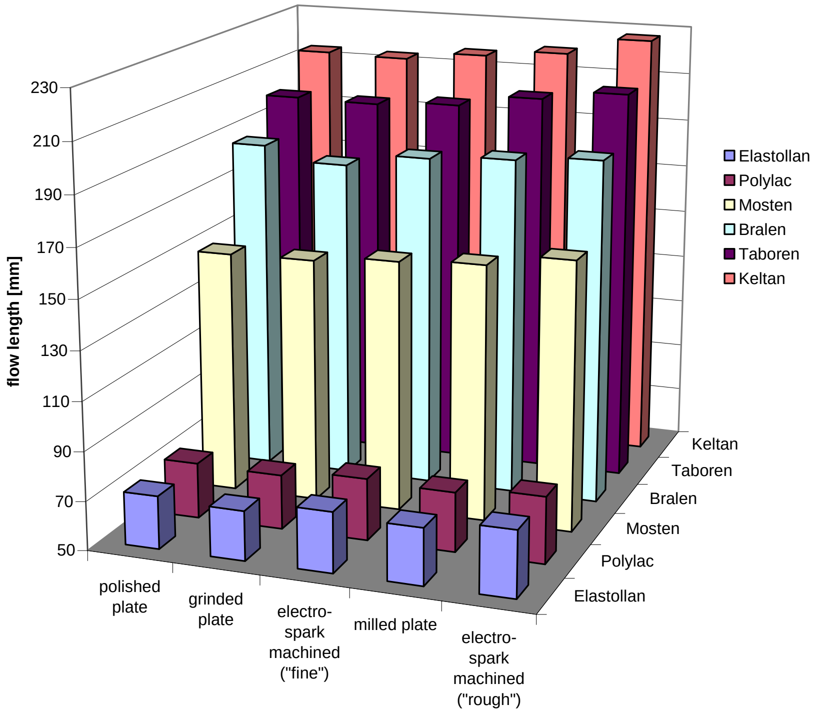


Figure 3. Dependence of flow length on surface quality and type of polymer (injection pressure 6 MPa)

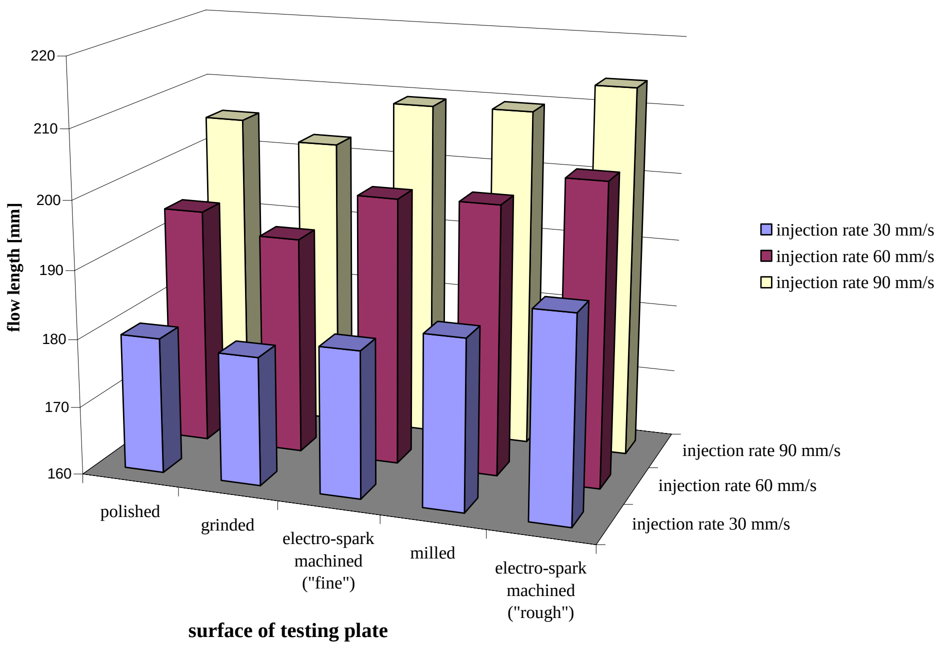


Figure 4. Dependence of flow length on surface quality and injection rate (Taboren, gate 6 mm, injection pressure 6 MPa[1])

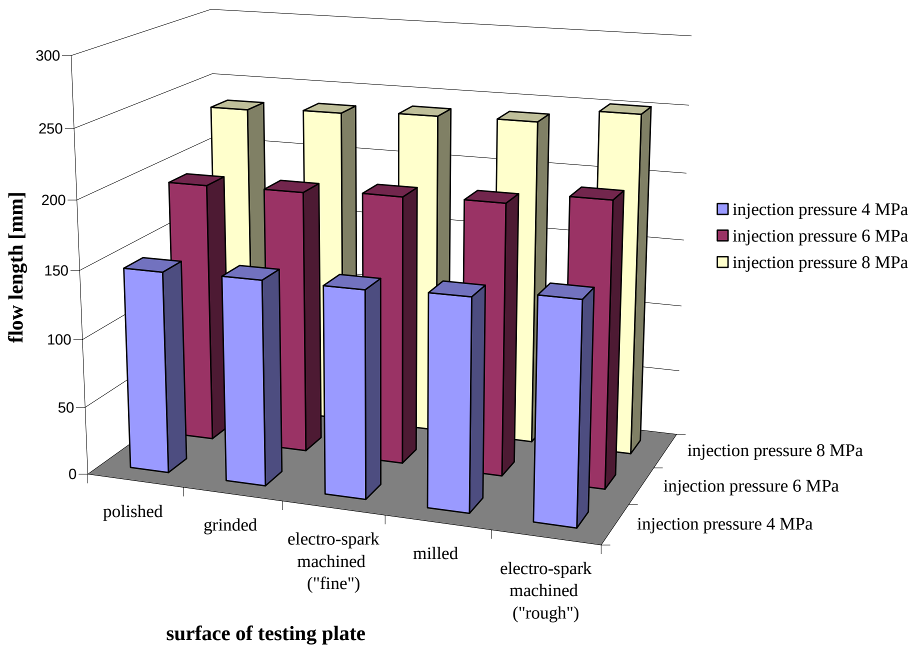


Figure 5. Dependence of flow length on surface quality and injection pressure (Keltan, gate 6 mm, injection rate 30 mm.s^{-1})

4. CONCLUSION

Measurement shows that surface quality has substantial influence on the length of flow. Samples which were injected into the spiral (cavity) with the worst surface quality have the longest length of flow.

For verification of these results further experiments have to be carried out. During these, different materials will be used and exposed to a variety of testing conditions.

5. ACKNOWLEDGEMENT

This article is financially supported by the Czech Ministry of Education, Youth and Sports in the R&D project under the title 'Modelling and Control of Processing Procedures of Natural and Synthetic Polymers', No. MSM 7088352102.

6. REFERENCES

[1] STANEK M.: Modelovani procesu tvareni polymeru, vcetne technologickeho reseni nastroju. Disertacni prace. VUT FSI Brno, 2005. ISBN 80-214-3025-7

[2] AGASSANT J.-F., AVENAS P., SERGENT J.-Ph., CAREAU P. J.: Polymer processing. Munich: Hanser Publishers, 1991. ISBN 3-446-14584-2

[3] BEAUMONT J. P.: Runner and gating design handbook. 1st ed. Munich: Hanser Publishers, 2004. ISBN 3-446-22672-9

[4] LINDNER E., UNGER O.: Injection molds. 3rd ed. Munich: Hanser Publishers, 2002. ISBN 3-446-21448-8

[5] MANAS M., VLCEK J.: Aplikovana reologie. Zlin, UTB 2001, ISBN 80-7318-039-1

[6] REES H.: Mold engineering. 2nd ed. Munich: Hanser Publishers, 2002. ISBN 3-446-21659-6

[7] MENGES G., MICHAELI W., MOHREN P.: How to make injection molds. 3rd ed. Munich: Hanser Publishers, 2001. ISBN 3-446-21256-6