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The polymer flow in a mold cavity during the injection molding process. Comparison of an experiment and computer simulations

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The results of research concerning monitoring of the thermoplastics flow during the injection molding process. The results of the computer simulations were compared to the experiment. Mold with a glass wall was constructed in order to enable recording of the thermoplastic flow in the cavity. Recording of the thermoplastics flow in the cavity may provide many important information about the behavior of polymers during the injection molding process. Moldflow ver. 2.0 was used to carry out the computer analysis of the filling, packing and cooling phases of injection molding.

1. INTRODUCTION

The recording of the polymer flow in the mold cavity using a video recorder was possible thanks to the usage of a mold, constructed for this purpose, of which one wall was equipped with a sight-glass. The construction of the mold is shown in fig.1. Due to occurring of high temperature gradient at the edge: glass wall – melted polymer, polycarbonate separators were used.

The mold enables injecting of cuboids parts, measuring:

- width 20 mm,
- length 80 mm,
- height 4 mm.

The polymer was carried through the gate of a 1.2 mm diameter placed in the middle of the smallest wall of the part (fig.2). The construction of the mold enabled the use of changeable inserts adding new elements to the mold cavity. For the needs of this thesis an insert adding a cuboids obstacle 5 mm from the gate (fig.2) was used. This allowed an observation of interesting phenomena taking place during flowing round an obstacle by injecting polymer.

Moldflow ver. 2.0 was used to carry out the simulation. High density polyethylene produced by Borealis, of the HE 2494 trade name, was used in tests. The injection was carried out using the Krauss-Maffei KM-65/C1/160 injection molding machine.

The FEM model used for numerical calculations was consisted of 3658 triangular elements and 1938 nodes. The model was built using the midsurface method.

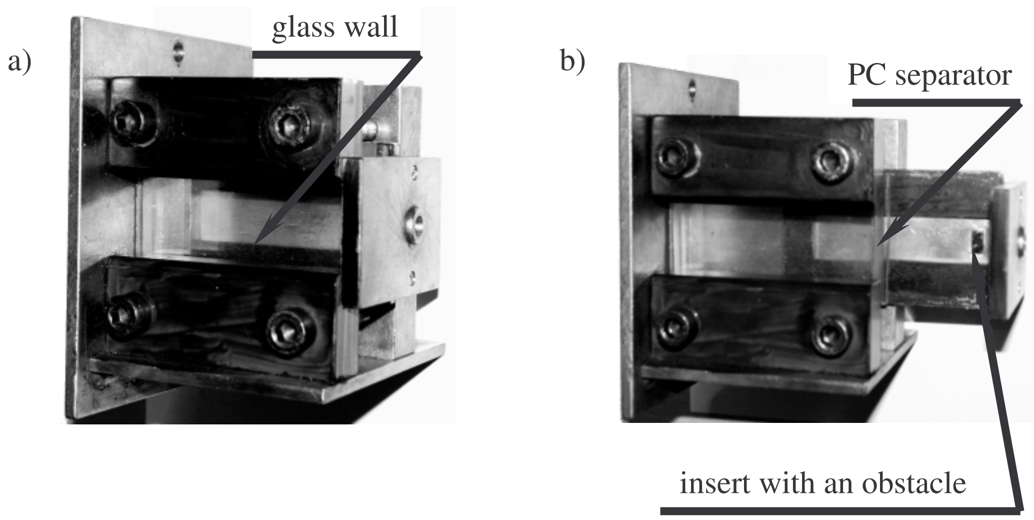

Figure 1. Construction of the mold with a glass wall: a) closed mold, b) mold ajar

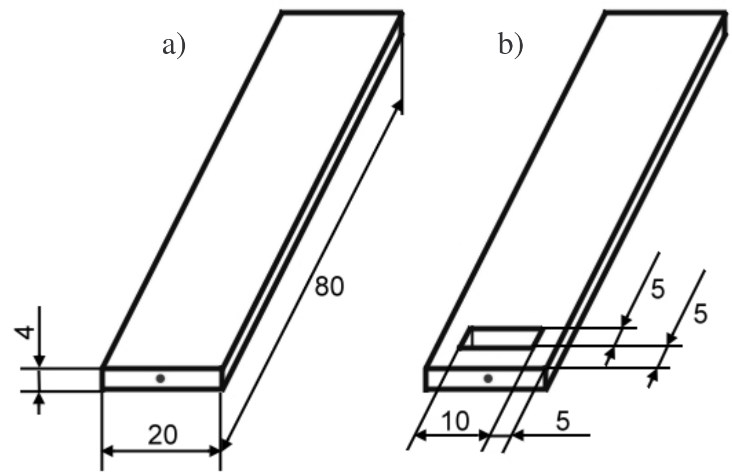

Figure 2. Geometrical shape of the mold cavity: a) without an obstacle, b) with an obstacle

2. RESULTS AND DISCUSION

Experiments for two types of pads were carried out: with and without an obstacle. In case of using the pad without the obstacle, a stream flow was noticed (highly unwanted during processes of polymer processing). Forming of the polymer stream and the way of filling of the mold cavity were recorded. As the next step, a trial of computer simulation of this type of flow has been made. Numerical calculations have not given satisfactory results (as it was expected). The finite element method and control volume method do not guarantee the modelling of the flow of this sort. The results were obtained from the process conducted in the following conditions:

- the injection temperature 240 ºC,
- the injection rate 28.3 mm/s,

– the maximum injection pressure 55 MPa,
– the cooling time 10 s.

The injection was conducted at zero packing pressure. In fig. 3 the results of experiments for the pad with an obstacle placed opposite the inlet point are presented. The phenomenon of hitting of the polymer stream against the obstacle and the flow similar to the laminar are until the mold cavity has filled in were observed.

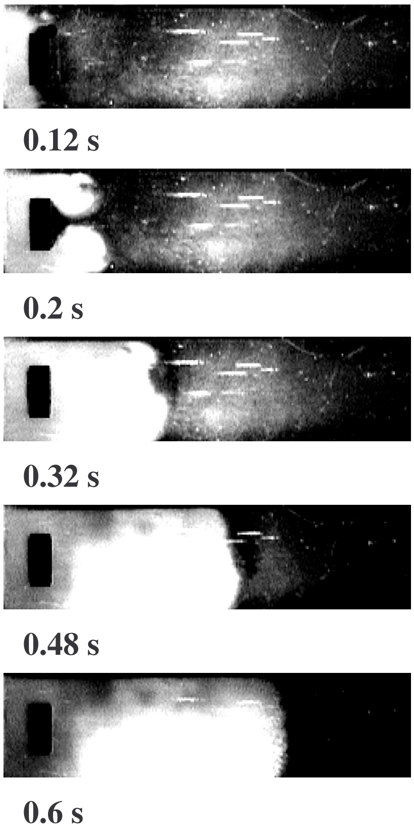

Figure 3. Selected results of the recording of the polymer flow in the mold cavity (snapshots; the pad with an obstacle)

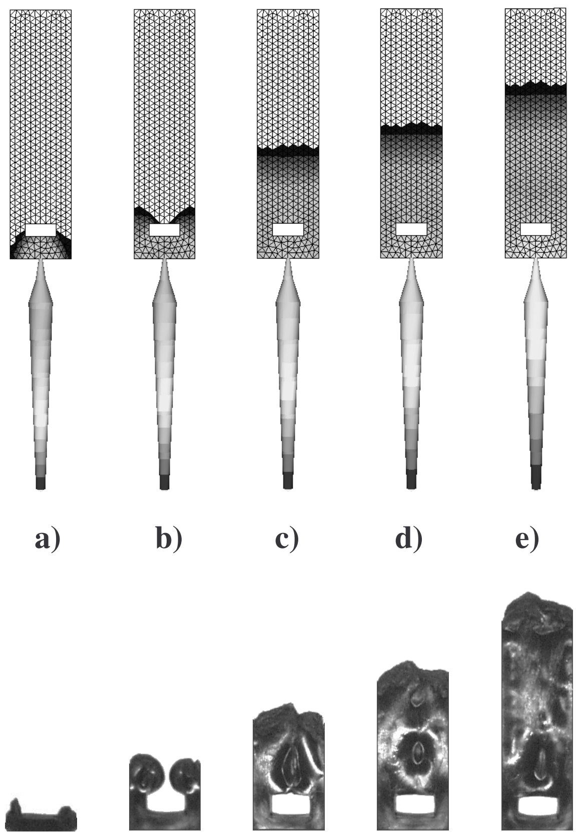

Figure 4. The comparison of selected simulation and experiment results for the pad with an obstacle; the filling time: a) 0.5 s, b) 0.6 s, c) 0.7 s, d) 0.8 s, e) 1 s

The comparison of the results of the experiment and results of numerical calculations enables stating that the modeling methods used satisfactorily represent phenomena occurring during the examined flow. Time values given in the fig. 3 describe the time measured from the moment of appearing of the polymer in the mold cavity.

In fig. 4 the results of experiments for the pad with an obstacle placed opposite the inlet point are presented. The phenomenon of hitting of the polymer stream against the obstacle and the flow similar to the laminar are until the mold cavity has filled in were observed.

The comparison of the results of the experiment with results of numerical calculations enables stating that the modeling methods used satisfactorily represent phenomena occurring during the examined flow.

3. CONCLUSIONS

Presented results allow to draw the following conclusions:

- To understand the phenomena occurring during the injection process it is important, according to the authors, to have the possibility of observe the filling of the mold cavity. Recording the occurring of the particular phenomena enables to understand them better. The usage of a prototype mold for the research carried out within this work showed the results that encourages to continue the experiments.
- The comparison of the simulation results and the video recording of the polymer flow in the mold cavity has shown the lack of universality of the numerical calculations used. Those methods cannot be used for the modeling of some kinds of flow (e.g. stream or fountain flows). In case of the regular flow the FEM, FDM or CV methods ensure exactness of numerical calculations.
- The result of research encouraged the authors to continue the experiments of monitoring of the plastics flow during the injection molding process. Changes in the construction of the mold (particularly of the mold plugs) will enable video recording of further interesting phenomena.

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