

## COMPARISON OF MOLDEX3D AND MOLDFLOW INJECTION MOULDING SIMULATIONS

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### ABSTRACT

*Injection moulding is one of the most significant polymer processing procedures and is highly positioned on the scale of the production of goods. One of the reasons of its importance is the possibility of economical production of great number of complex mouldings with high-quality surface. In order to eliminate unnecessary mould trials, minimize product development cycle, reduce overall costs and improve product quality, polymeric engineers use new CAE technology (Computer Aided Engineering). This technology is a simulation tool, which combines proven theories, material properties and process conditions to generate realistic simulations and produce valuable recommendations. Based on these recommendations, an optional combination of product design, material and process conditions can be identified. In this paper, comparison between two different softwares for injection moulding simulation, Moldex3D and Moldflow, were conducted. Comparison was made in the following fields: ease of usage, setting up the model, filling phase, packing phase, cooling phase, warpage phase and report generation.*

**Keywords:** *Moldex3D, Moldflow, injection moulding simulation*

### 1. INTRODUCTION

Tool and mould making is nowadays in developed countries very important economic branch, which deals with development, engineering, manufacturing and testing of moulds. Introduction of new scientific and research results enables the mould makers fulfilling of increasingly higher demand for products and shortening of needed time to market. [1]

With usage of injection moulding simulation it is possible to predict most of problems which could occur during the process of injection moulding, so that they could be solved in virtual – computer environment. With usage of this software it is possible to analyse influence of mouldings geometry, characteristics of polymeric material, mould material and injection moulding parameter settings. Most of new injection moulding simulations consists of four different numerical calculations (analysis): fill analysis, pack analysis, cool analysis and warpage analysis. [2]

Fast development of computers and the required software's has brought about an increasing application of numerical methods in injection moulding simulations. One of the most frequently used methods is the *Finite Elements Method (FEM)*. This method is most used when analytical solving of exact problem equations is complex or impossible. It should be noted that the finite elements method is only approximate, therefore, in order to obtain acceptable results it is necessary when solving certain tasks to have also database with accurate data necessary for the calculations. This means that the results obtained by this method have to be considered critically. [3]

## 2. INJECTION MOULDING SIMULATION

The majority of computer programs for injection moulding simulations include rheological and thermal mould calculation, and the calculation of the moulded part deformation after demoulding (shrinkage and warpage). The numerical rheological mould calculation includes calculations of pressure gradient in the runner system and mould cavity while filling it with thermoplastic melt. Based on the calculated pressure gradient optimal dimensions of the runner system are determined. The rheological calculation also gives insight into the occurrences happening in the mould cavity during the filling, i.e. the basic parameters of the injection moulding process are determined: pressure and temperatures distribution in the mould cavity, values of shear rates and share stresses in the thermoplastic melt and structure orientation. [4]

Thermal calculation of the mould for injection moulding of thermoplastic includes calculations of duration of the injection moulding cycle (duration of hardening and auxiliary times) and important parameters during injection moulding (temperature of thermoplastic melt, temperature of cavity wall, temperature and rate of the cooling/heating medium, ...). [5]

A great number of calculations in mechanical mould calculation consist of dimensioning of given mould elements. This refers primarily to the cavity walls. The pressure in the cavity presents active load on the cavity wall, based on which the stresses and deformations of mould plates are calculated. Computer programs which can apply allow simulations of stresses and deformations of mould cavity walls. [5]

The procedure of injection moulding simulation differs in applying different computer programs. However, basically it consists of several main steps (Figure 1). [6]

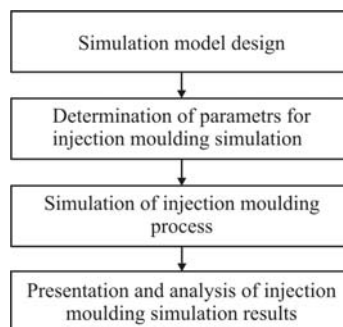


Figure 1. Steps in injection moulding simulation [6]

## 3. EXPERIMENT

For the comparison of two different softwares for injection moulding simulations, product with specific wall thickness of 1 mm was used. Two used computer programs were *Mold Adviser* and *Moldex3D*. To achieve more comprehensive analysis of the simulation results, two versions of *Mold Adviser* were used. An analytical calculation of moulding cooling time was made as well. Table 1 shows input data for analytical and numerical calculations while figure 2 shows simulation models.

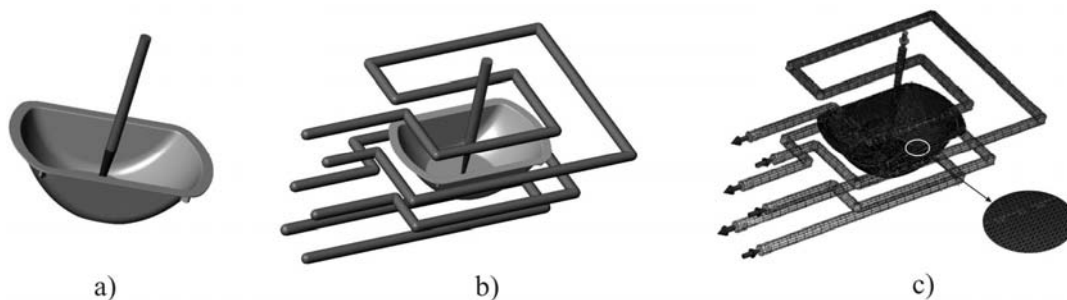


Figure 2. Simulation models: a - *Mold Adviser* 6.0, b - *Mold Adviser* 7.0, c - *Moldex3D*

Table 1. Input data

Input parameter	Mold Adviser 6.0	Mold Adviser 7.0	Moldex3D
Simulation model	stl file	stl file	finite elements mesh (shell – 2,5D)
Thermoplastic PP BJ360MO (Borealis)			
Melt temperature $T_T = 533$ K (260 °C)			
Mould cavity wall temperature $T_K = 343$ K (70 °C)			
Heat deflection temperature $T_{PO} = 373$ K (100 °C)			
Coolant	-	water (temperature 14 °C)	water (temperature 14 °C)
Characteristic dimension of moulded part $s_o = 1$ mm			
Injection moulding machine <i>Boy 30</i>			
Effective thermal diffusion $a_{ef} = 6.2 \cdot 10^{-8}$ m <sup>2</sup> s <sup>-1</sup>			
Coefficient of the moulded part interior $K_{U2} = 8/\pi^2$			
Coefficient of the shape of the moulded part $K_o = 1$			

#### 4. RESULTS

The general expression (equation 1) for the cooling time of moulded part [7] was used for calculation of moulding cooling time. Data for this calculation is presented in table 1.

$$\bar{t}_h = \frac{s_o^2}{K_o \cdot a_{ef} \cdot \pi^2} \cdot \ln \left[ K_{U2} \cdot \frac{T_T - T_K}{T_{PO} - T_K} \right] = 2.68 \text{ s} \quad \dots (1)$$

After having performed the simulations of injection moulding procedure by means of all three computer programs and after having done real injection moulding procedure under the simulation defined conditions, the results presented in table 2 were obtained. Figure 3 shows the comparison of the analysis of the mould cavity filling phase with the real filling of the mould cavity.

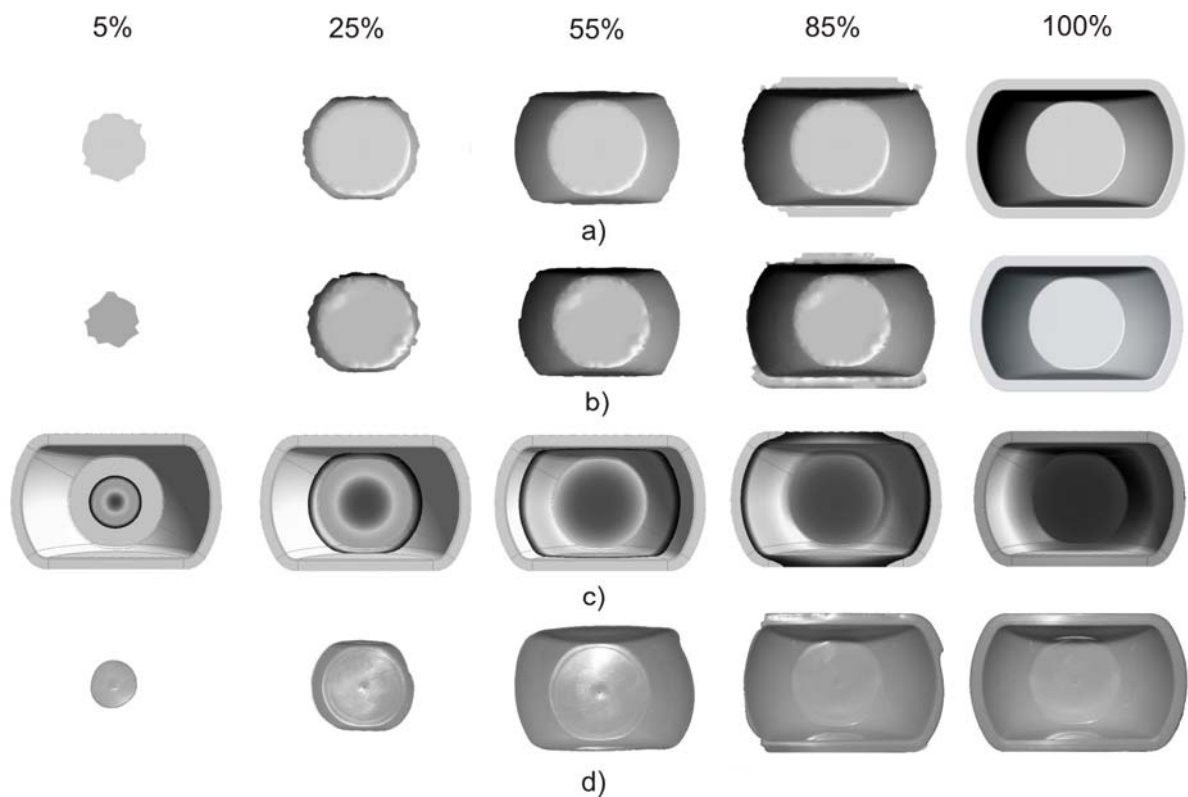


Figure 3. Injection phase: a - Mold Adviser 6.0, b - Mold Adviser 7.0, c - Moldex3D, d - real

Table 2. Injection moulding simulation results

Simulation parameters/results	<i>Mold Adviser 6.0</i>	<i>Mold Adviser 7.0</i>	<i>Moldex3D</i>	Experiment
Type of analysis	filling, packing, cooling, sink mark	filling, packing, cooling, sink mark, warpage	filling, packing, cooling, warpage	
CPU time	3 min 5 s	7 min 50 s	25 min 45 s	-
Injection time	0.09 s	0.11 s	0.15 s	0.3 s
Injection Pressure	52.29 MPa	59.61 MPa	57.87 MPa	58 MPa
Moulding cooling time	-	-	2.85 s	2.9 s (2.65 s – calculated)
Confidence of fill	high	high	high	-
Shot volume	2.66 cm <sup>3</sup>	2.82 cm <sup>3</sup>	3.25 cm <sup>3</sup>	3.1 cm <sup>3</sup>
Weld lines	yes	yes	yes	-
Air traps	yes	yes	yes	-
Ease of usage	easy	medium	hard	-
Report generation	good	good	best	-

## 5. CONCLUSION

Two programs for simulation of injection moulding of thermoplastics are compared in the paper - *Mold Adviser* and *Moldex3D*. Based on received data, it can be concluded that there are many differences between compared simulations, but there are also some similarities. Already in the beginning there is a big difference in simulation model. *Mold Adviser* uses *stl* model type for simulation input, whereas for *Moldex3D* it is necessary to generate finite elements mesh of model, mould, runner system and cooling channels. Generating of mesh is the most demanding and the longest part of simulation process. This is the reason why *Moldex3D* is evaluated as user unfriendly (table 2). There are some significant differences in simulation processing times. It is necessary to note that simulation processing time does not include model preparation time. It is also interesting to point out that real injection time is much greater than injection time obtained by simulations. One of the reasons could be the fact that simulation does not account of the state of injection moulding machine. Injection pressures do not differ considerable, as well as mould cavity filling images (figure 3). Moulding cooling time, as one of the most important injection moulding parameters that directly affects injection moulding cycle time, moulding properties (mechanical, optical etc.) and the price of the moulding, was obtained only by *Moldex3D*. Quantity of achieved data and final reports are satisfactory in all simulation programs, nevertheless it is necessary to stress that *Moldex3D* provides the largest quantity of data. It can be concluded that both programs can be used for simulation of injection moulding of thermoplastics, but obtained data must be used with caution, because none of the programs can simulate all conditions of real injection moulding process.

## 6. REFERENCES

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