Investigation of the formability of polymeric elements in different software environments for the automotive industry

Péter Zoltán Kovács¹ and Bence Tóka²

¹Associate professor, University of Miskolc, Institute of Material Science and Technology, 351 Miskolc, Miskolc-Egyetemváros, Hungary
²BSc student, University of Miskolc, 3515 Miskolc, Miskolc-Egyetemváros, Hungary

E-mail: metkpz@uni-miskolc.hu

Abstract. Market-leading injection molding simulation software enables product designers, designers, injection molding tool manufacturers to predict the outcome of their work, making injection molding technology and end product quality much more reliable. This article describes how Moldex3D, with its advanced networking and computational mechanism helps simulate injection molding processes across multiple application areas. In addition, it optimizes product design and manufacturability, thus shortening the time to reach the market and maximizing the return on investment (ROI) of the product.

1. Introduction

In the 21st century, thanks to the exponential increase in computing power, many design and simulation programs help engineers avoid global design losses due to poor design / manufacturing.

The most significant simulation program (CAE application) for the plastics industry is Moldex3D. Within the program can be performed simulations on a given workpiece according to various plastic machining technologies and evaluate the result. Technologies include: injection molding (conventional, reactive, combination (bi - 2 channel, 2 component or co - 1 channel, 2 component), gas injection, water injection), foaming, injection molding, precision casting, PIM, MIM.

The Moldex3D program can be divided into four large sections during the study: product geometry, product design, mold design, material selection and injection machine injection molding technology.

With Moldex3D, due to advanced computational methods, can be determined the temperature and angle, and the tear stress, of the collision lines in order to avoid strength problems. Helps to optimally position the sprues, and how the polymer will behave in future applications. Inspection of air bubbles and welding / collision lines may help with aesthetic changes. In addition, the proper adjustment of the tool temperature for warp testing greatly contributes to optimum warping, and examining percentage shrinkage results will assist in the subsequent optimization process.

2. Optimization studies in Moldex3D to avoid / reduce errors due to different material selection, machine setup and structural design.

The properties of the ABS (Terluran GP-22) chosen as the base material of the spacer (Figure 1.) made by us as an automotive supplier are represented in Figure 2.
Various comparative tests were performed on the component (selecting ABS + PC material instead of ABS, gate and other channel locations), focusing on air bubbles and weld lines. Because the component is relatively small at a maximum distance of 49 mm from the barrier, it is difficult to show a significant difference, but small changes tend to show some tendency.

2.1. Etalon

Initially, the simulation ran based on the configuration of a particular machine (Table 1.) (optimal sprue and channel placement, and ABS (Terluran GP-22) material that was manufactured in-house) at a constant pressure of 600 bar. Keep this setting for now called etalon.

| Table 1. Standard machine settings |
|-----------------------------------|
| Injection time (sec) | 5.5 |
| Melt Temperature (°C) | 250 |
| Mold Temperature (°C) | 50 |
| Maximum injection pressure (MPa) | 240 |
| Injection volume (cm³) | 47.9704 |
| Maximum packing pressure (MPa) | 240 |
| Cooling time (sec) | 13 |
| Mold-Open Time (sec) | 5 |
| Eject Temperature (°C) | 110 |
| Air Temperature (°C) | 25 |
| Cycle time (sec) | 23.5 |
| Mesh file | Tavtarto+0.6% zsugor-ABS |
| Material file | ABS_TerluranGP-22_1.mtr |
Can be seen during filling the standard setting with 12 possible air bubble locations (Figures 3 and 5.), which are all on the surface (possible ventilation points for the tool), this is a better case because if there is a greater chance leads to burn-in and cannot be solved with ventilation, other construction (eg.: geometry conversion, sprue, channel placement and size) is required. In addition, 10 clash lines are formed, each of which, globally, is concentrated in 2 locations (Figures 4 and 5.). Finally, the program indicates that 2% of the piece is subjected to high tear stress (Figure 5.).

2.2. Different sprue and channel arrangement

On the next run, the sprue and channel will be bypassed from the program-recommended location at one end of the component, but the machine settings will be the same as those mentioned in the benchmark. It can be observed with the other sprue placement that although the number of air bubbles decreases (Figures 6. and 8.), the number of collision lines increases (Figures 7. and 8.). It is primarily due to the suboptimal location of the barrier, of course, due to the small volume of the cavity, growth is not significant but is present. So proper placement of the barrier in the mold cavity is very important to avoid future problems.
2.3. **Short shot**

If I change the injection molding time in the setup (Table 2.), leaving the barrier in the standard and ignoring the Moldex3D recommendations can easily discern any problems. While using the same material, changing the injection time (lowering below the lower limit) results in a short shot (The melt drips into the mold cavity before filling it completely).

| Table 2. Bad machine settings |
|-------------------------------|
| **Filling time (sec)** | 0.3 |
| **Melt Temperature (°C)** | 250 |
| **Mold Temperature (°C)** | 50 |
| **Maximum injection pressure (MPa)** | 60 |
| **Injection volume (cm³)*** | 35.5575 |
| **Packing time (sec)** | 4 |
| **Maximum packing pressure (MPa)** | 60 |
| **Cooling time (sec)** | 13 |
| **Mold-Open Time (sec)** | 5 |
| **Eject Temperature (°C)** | 110 |
| **Air Temperature (°C)** | 25 |
| **Cycle time (sec)** | 22.3 |
| **Mesh file** | Tavtarto+0.6% zsugor-ABS |
| **Material file** | ABS_TerluranGP-22_1.mtr |
Looking at the spread of the melt front over time (Figure 9.), the program will produce a very representative figure to illustrate the fact of the short shot, and it is clear that the inlet pressure reached the set maximum very quickly (Figure 10.) time was too short, resulting in a short shot. There are several ways to eliminate this problem (leaving the injection time unchanged): changing the barrier diameter, increasing the injection pressure and choosing another material.

Figure 9. Flame frontal propagation in the case of short-shot

Figure 10. Pressure versus time inlet

2.4. Choice of other material
In the third case, I changed the ABS material to ABS + PC from an arbitrary supplier (Table 3.). If you use the standard machine settings for this material, you will find problems with the material's temperature conditions and warping.
### Table 3. Material properties of selected ABS + PC

| Item name   | Item data |
|-------------|-----------|
| Material type | Thermoplastic |
| Generic name | PC |
| Supplier     | SABIC (LNP) |
| Trade name   | Thermocomp DX06313l |
| MFI          | MFI(300.5)=30 g/10min |
| Fiber percent| 30.00 (%) |
| Melt temperature range | 315 – 340 (°C) |
| Mold temperature range | 80 – 115 (°C) |
| Ejection temperature | 123 (°C) |
| Freeze temperature | 150 (°C) |

The recommended temperature for melting the raw material is between 315 and 340 °C. At these machine settings, however, at elevated temperatures, air bubbles are more likely to burn (Figure 11.).

![Analysis Result Summary](image)

**Figure 11.** Possible Problems with ABS + PC Material at Machine Settings

The elevated temperature results in a much greater volume shrinkage (Figure 13.) during filling than in the case of plain ABS material (Figure 12.), thereby increasing the formation of suction and cavities. This is why it is recommended for this material, if you want to keep the preset geometric parameters unchanged, to modify the cooling system (to reduce later warping) and to adjust the postpressure accordingly.

![Max Volume Shrinkage (%)](image)

**Figure 12.** Volume shrinkage distribution and tabular values for ABS material
Figure 13. Volume shrinkage distribution of ABS + PC material in the mold cavity and tabular values

3. Summary of received results

It can be seen from the obtained simulation results that the standard barrier setting, barrier arrangement, machine setup has actually been optimized and, with different settings, the possible errors and their probability. Personally, I have experienced how much time it takes for a machine to set up a machine during my internship, and in light of this, it can be said and proven that Moldex3D can do a great deal to achieve optimal settings in terms of cost and time.

Acknowledgements

This research was supported by the European Union and the Hungarian State, co-financed by the European Regional Development Fund in the framework of the GINOP-2.3.4-15-2016-00004 project, aimed to promote the cooperation between the higher education and the industry. The authors would also like to thank PSM Hungary KFT. for their assistance in providing Moldex3D with the help of Bay Zoltán Nonprofit Ltd. for Applied Research.

References

[1] József Péterfalvi, Péter Primusz, Péter Szabó, Computer-based modelling systems (in Hungarian), online document, 2011, https://docplayer.hu/8006522-Szamitogepes-modellezo-rendszerek.html

[2] Tibor Czvikovszky, Péter Nagy, János Gaál, The Basics of Polymertechnology (in Hungarian), online document, 2007, https://regi.tankonyvtar.hu/hu/tartalom/tkt/polimertechnika-alapjai/index.html

[3] József Gábor Kovács, Design and Simulation of Injection-molded products (in Hungarian), Budapest University of Technology and Economics, Faculty of Mechanical Engineering, PhD dissertation, online document, 2007, https://repozitorium.omikk.bme.hu/bitstream/handle/10890/556/ertekzes.pdf?sequence=1&isAllowed=y

[4] Dr. Balázs Mikó, Design and Production of Injection-molded products (in Hungarian), Óbuda University, Donát Bánki Faculty of Mechanical and Safety Engineering, online document, 2006, http://old.bkg.uni-obuda.hu/pgyt/targyak/seged/bagms15mnk/szterveyart.pdf

[5] László Molnár, Basics of CAD (in Hungarian), online document, 2012, https://regi.tankonyvtar.hu/hu/tartalom/tamop412A/2010-0017_43_cad_alapok/adatok.html

[6] Moldex 3D application: https://www.moldex3d.com/en/products/software/moldex3d/