Transilvania University of Brasov
FACULTY OF MECHANICAL ENGINEERING

COMAT 2020 & eMECH 2020

Brasov, ROMANIA, 29-31 October 2020

DESIGN OF A PLASTIC INJECTION MOLD

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Abstract: *This paper consists of a research project that aimed to create a plastic object and an injection mold by applying modern techniques and knowledge specific to mechanical engineering. Designing the plastic part and the injection mold was made by using the computer aided design method and also the mechanical strength of the mold was verified by using finite element analysis method.*
Keywords: *mold, design, FEA, plastic, injection.*

1. INTRODUCTION

The domain of plastic injection molding is in a continuously expansion in popularity as a modern manufacturing technology. Automotive industry, aeronautical industry, telecommunication and also railway industry adopted this technology to produce parts for their large-scale projects.
The most important thing is that the design of the injection mold is correct so that during its operation there are no problems that can lead to incorrect operation or even endanger the one who operates it.

2. OBJECTIVES

The objective of this project was to design a plastic injection mold that can be highly productive and also to produce high quality parts. The design of the mold was based on a plastic part that was also designed in this project by using specialized software and specific engineering calculations.
For this project I used Autodesk Inventor CAD software because it contains all the tools that I have needed to design the mold.
The first step of the project was to design the plastic part that will be injected into de mold. So, the part is called Flange (figure 1) and it has the role to seal the automobile reservoir and also to allow the combustible to flow to the car engine and back.

Figure 1: 3D model of the plastic part (isometric view)

A very important condition when designing a plastic part for injection molding is that the part exterior walls should have a draft angle for and easy evacuation from the mold, because the plastic material can contract and the risk of the part to get stuck is very high. For that, it has been performed an analysis of the part with “Draft Analysis” tool from Autodesk Inventor to make sure that the condition is met.

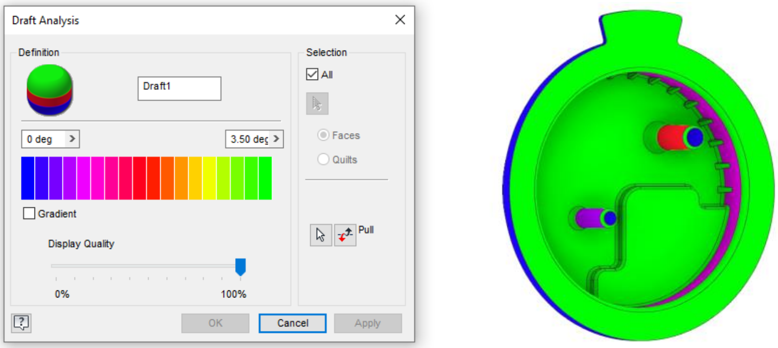

Figure 2: Draft analysis of the part

The part is provided with stiffening ribs fixed by connecting spokes. Being arranged on both sides of the part, they increase the mechanical strength and rigidity of the product, while also improving the flow of the plastic into the mold cavity.
Due to the operating conditions (thermal regime, mechanical vibrations) of this product, it was established that the part should be made of Polyacetal plastic (POM). This type of material is often used in the automotive industry due to its special characteristics:

- high rigidity and mechanical strength,
- good workability,
- dimensional stability,
- thermal stability (in ambient conditions between -40 ... + 140˚C),
- dielectric characteristics (good electrical insulation).

In the below figure it is presented the mold and his main components. It is a mold with two cavities with a cold runner injection system. This type of injection system is often used at multi cavity molds due to the reason that it facilitates the correct and concomitant filling of the cavities.

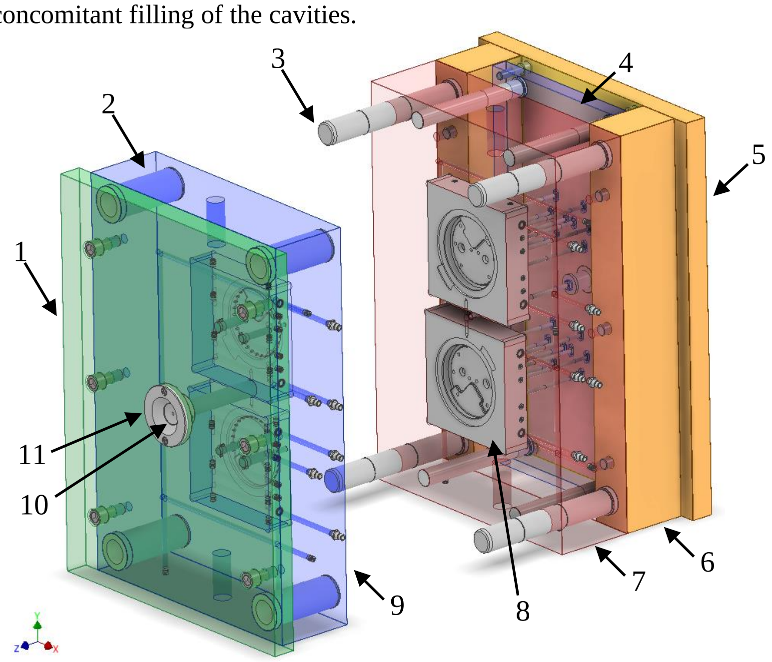

Figure 3: 3D model of the mold.
1-support plate; 2-guiding bushing; 3-guiding bar; 4-ejection system; 5-support plate; 6-spacer bar; 7-cavity plate; 8-mold cavity; 9-cavity plate; 10-sprue bushing; 11-locating ring.

Because the plastic material is injected into the mold at pressures that reaches over 100MPa, the simulation of the injection process helps to understand in detail the behavior during operation of the mold and the material from which it is made. The simulation is performed by the finite element method which is the most used method for the calculation of mechanical structures.
In this project, the purpose of this analysis is to determine as concretely as possible the field of deformations of the forming plate produced by the injection pressure of the plastic material. At the same time, the geometric

model of the mold will be optimized so that the deformations are pleasant to be as small as possible for sustainable operation and for a superior quality of the plastic product.

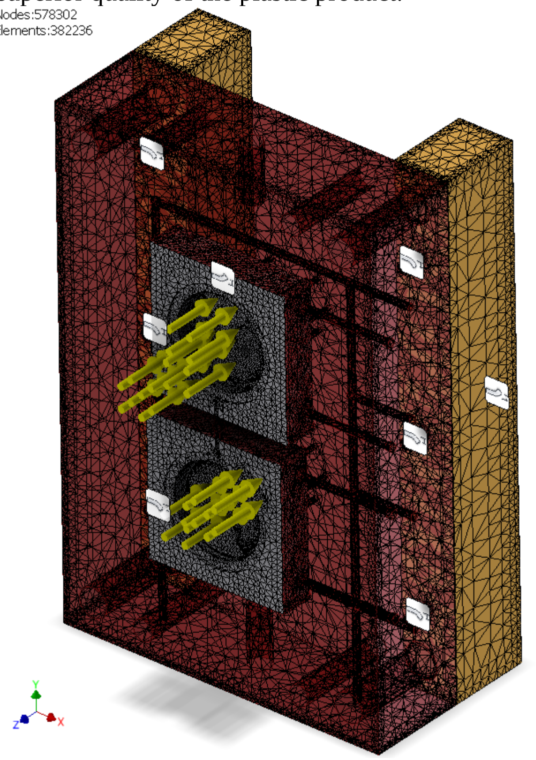

Figure 4: Representation of the pressure on the meshed model

In the image above it represented the pressure of the injected plastic material that is applied on the face on the cavity mold. The model is meshed in 578302 nodes and 382236 elements.

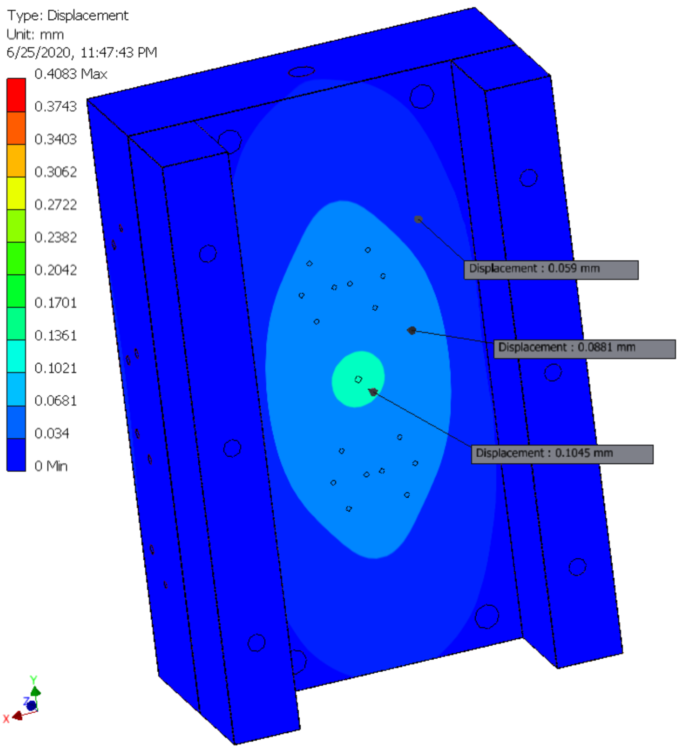

Figure 5: Displacement fields of the forming plate

The deformations produced are considered to be too large and this can cause defects of the injected parts or even the blockage of the ejection pins in their specific bores.
In conclusion, a constructive variant is needed in which the plate deformations are much lower.

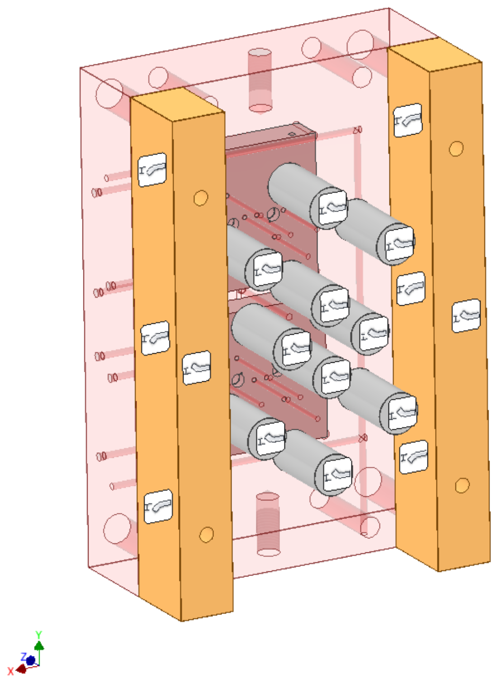

Figure 6: Optimized mold with 10 support pillars.

To reduce the deformation of the mold, the mold was optimized by adding 10 support pillars (see figure 6) that are placed according to the magnitude of deformations resulted in the first simulation. After that, another simulation was performed in order to see the effect (see figure 7).

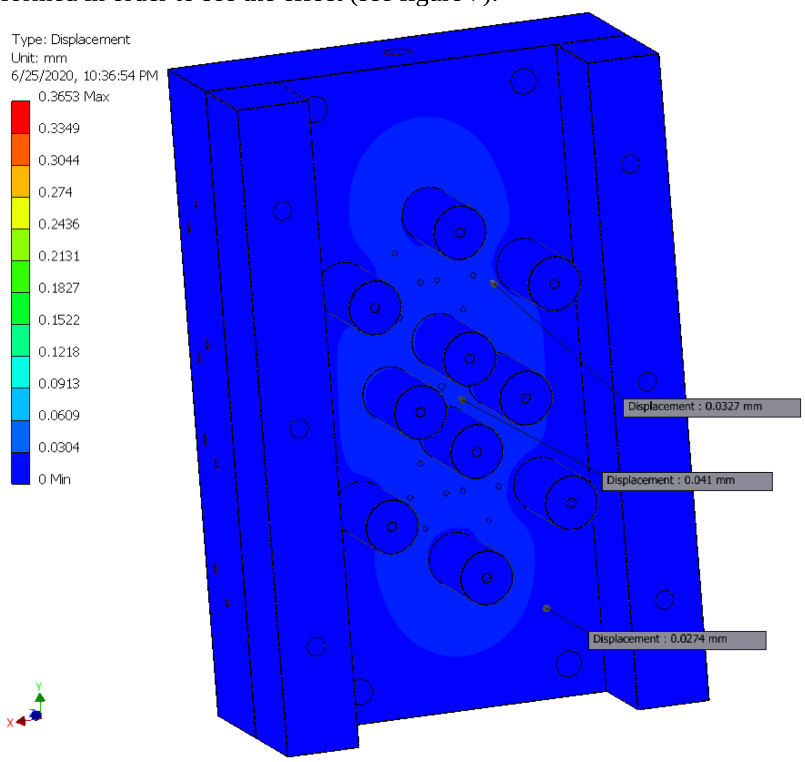

Figure 7: Displacement of the mold optimized with support pillars.

As we can see in figure 7, the displacement of the optimized mold has decreased by more than 50%.
In conclusion, following these two analyzes, it is established that the constructive variant of the mold will consist of support pillars made of carbon steel with a diameter of fifty millimeters.
In the technological process of plastics processing, the temperature of the mold is one of the most important technological parameters that directly influence the quality of the injected plastic parts.
For a cooling system to be efficient, it must take into account several important criteria such as:

- uniform cooling of surfaces;
- the flow of the cooling medium is of a turbulent nature;
- the temperature of the cooling medium should be as low as possible;
- ensuring tight cooling circuits

The cooling system of the mold is established constructively with rectilinear channels with circular section for the cavity plates and for the cavity inserts.

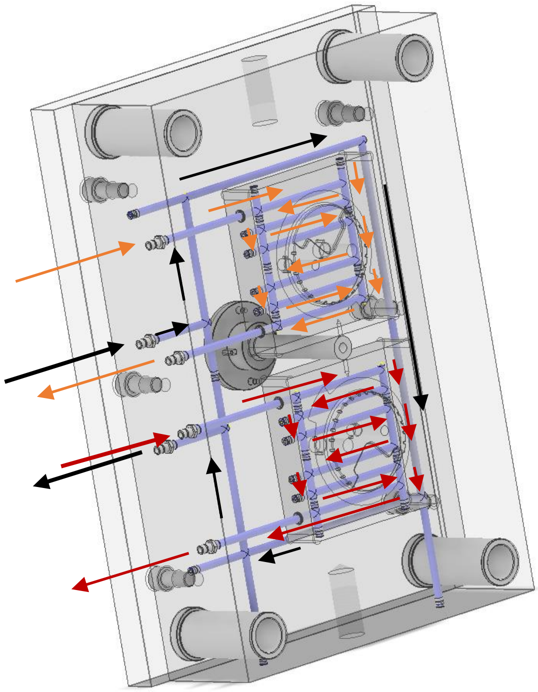

Figure 8: Mold cooling system

Regarding the plastic injection process, the simulations save considerable resources of money and time. Professional simulation solutions provide support in determining the feasibility of specific projects in the initial phases of a project. At the same time, specialized design programs allow the configuration of molds and the establishment of optimal process parameters before the production of the first parts.

The injection process simulation was performed using the Autodesk Inventor Professional 2020 program. Figure 9 shows the plastic filling time of the two cavities. As can be seen, the two cavities are filled simultaneously.

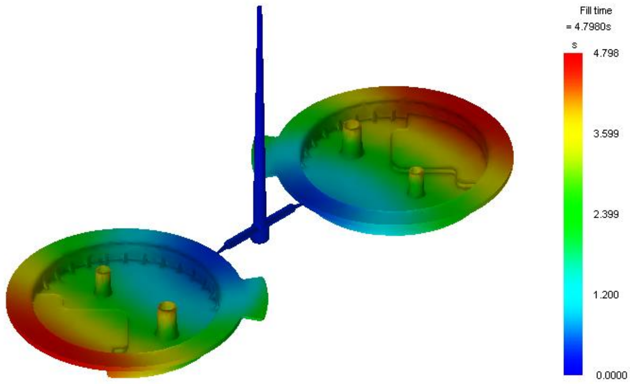

Figure 9: Filling time of the two cavities.

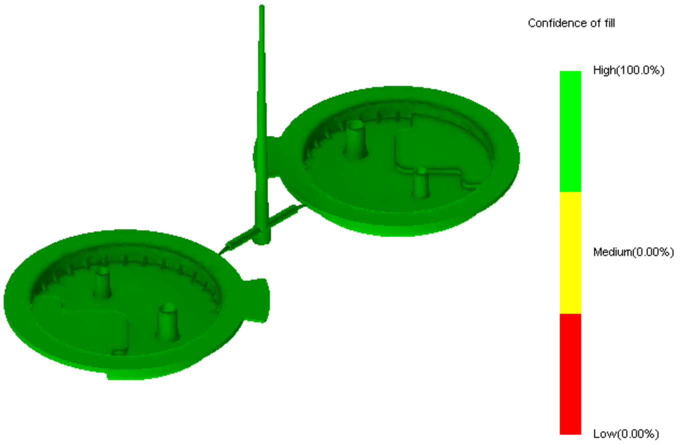

Figure 10: Confidence of fill of the mold cavities.

Also, in figure 10 it is represented the simulation of the confidence of fill of the mold cavities. The mold cavities will have a fill confidence of 100% and means that the plastic parts won't have quality issues like air traps.

3. CONCLUSION

The results obtained during the project show us that the designed mold is sustainable as well as that it has a high productivity.
The personal contributions in this work consist in the effective design of a mold based on an original plastic part also designed in this project through specialized programs such as using specific engineering calculations.

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