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MODERN APPROACHES IN DEVELOPMENT OF PLASTIC PRODUCTS

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ABSTRACT

In order to shorten manufacturing time for new products and their moulds, the use and the development of modern techniques are critical. One of such technologies is the rapid prototyping method, which enables to designers and customers to see the physical presentation of a new product. Application of the CAE methods is accentuated in the development phase of the product, which redounds to cost reducing on tools and moulds development. The paper deals with several steps in prototype development, the application of computer simulation by means of CAE system Moldflow MPI in mould development for mold plastic part and utilization of CAM system for NC programming of the mould manufacturing.
Key words: *Rapid Prototyping, CAE technology, injection molding simulation, NC programming*

1. INTRODUCTION

A present–day rapid growth in diverse industries put the demanding requirements on rapid innovations of products. In order to reduction of manufacturing time for new products and their moulds, the use and the development of modern techniques are critical. One of such technologies is the Rapid Prototyping method, which enables to both, designer and customer to see the physical presentation of a new product.

The design of molded plastic parts as well as design of moulds for plastic injection processes is comparatively complicated process. It is needs takes into the account costs, production time, part design, ergonomic and aesthetic requirements. The part development process includes conceptual design – CAD model, engineering analysis, process simulation, manufacturing of prototype and testing [1,2]. The utilization of CAE methods allows through simulation to speed up the mould design process and the injection molding process optimization. Research in plastic injection molding area has brought a many scientific papers with the aim to improving optimization algorithms of mold design [3,4].

Many other authors utilize CAE tools for optimization of variable parameters in plastic injection processes, as are minimal pressure [6], shrinkage prediction [7], determination and evaluation of weld/melt lines [8] and elimination of distortion and uniform of hot-melt flow in mold cavity [9].
The integration of product development processes like Rapid Prototyping, CAE and CAM methods has been presented in the paper. The procedure in prototype manufacturing by FDM method and subsequent plastic injection simulation by means of Moldflow MPI software was presented. In this analysis was analyzed injection molding parameters as are the fill time, injection pressure, distortion, shape precision as well as the influence of gate location.

2. EXPERIMENTAL PROCEDURE

2.1 Rapid prototyping

The Dimension 3D printers utilize for build model the FDM technology also known as Fused Deposition Modeling is layered manufacturing process. Dimension SST machine offers functional prototypes with ABS. The required geometry is produced in thin layers by a small CNC-controlled extruder A thin bead of molten plastic is extruded through the computer controlled nozzle, which is deposited on a layer-by-layer basis to construct a prototype directly from 3D CAD data. The technology is commonly applied to form, fit and the function analysis and the concept visualization. In addition, parts can be used for form fit and light testing purpose.
In order to reduction of manufacturing time and increasing of design reliability is needs to utilize the Rapid Prototyping methods in product development phase. After this it is possible to check if the product is adequately aesthetic, or if the part meets to specifications for requirement function. The Rapid Prototyping contributes to early mold development for given part.

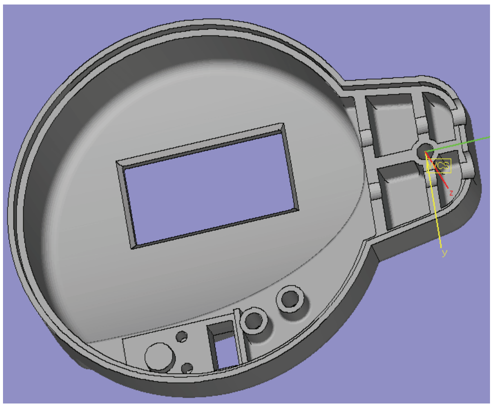


Fig. 1 - 3D model of the product

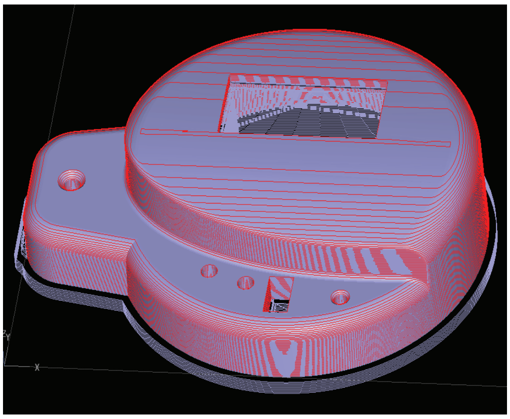


Fig. 2 - Model with supports

A 3D computer model of the product presents the basis for the prototype manufacturing is shown in Fig.1. The prototype was oriented in machine's working area in consideration of functional, stiffness, and other product requirements. For the quality of manufacturing of the prototype, so-called supports that are attached to the model have to be determined, these supports being presented in Fig.2.

After that the manufactured parameters must be prepared. When the printing of prototype is finished Fig.3, the supports must be removed, and the prototype must be cleaned, hardened and completed. For rapid removing the supports from the prototype, it is suitable to apply device making use of sinuous flow of special solution.

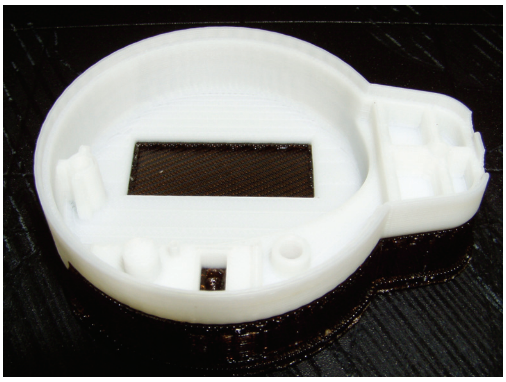


Fig. 3 - Prototype after printing with support structure

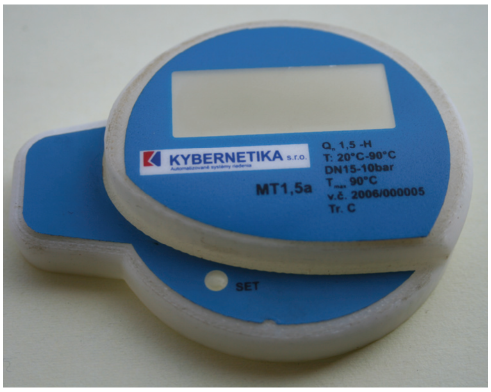


Fig. 4 - Prototype with removed support ready for testing

Depending on next exploitation of prototype, the prototype can be used directly for testing and presentation (Fig.4) or after surface finishing used as master model for manufacturing of a silicon mould for the first production (up to 100 parts), for easier design of the real moulding, as an aid in visualization and as an aid in sales activities.

2.2 Injection molding simulation

The simulation was performed in three variants of gate location. The gate selection was performed on the basis of part geometry, surface quality of part and analysis performed for optimal gate location (MPI) (see Fig. 5). The simulation was done with equal terms in all three cases, listed in Table 1.

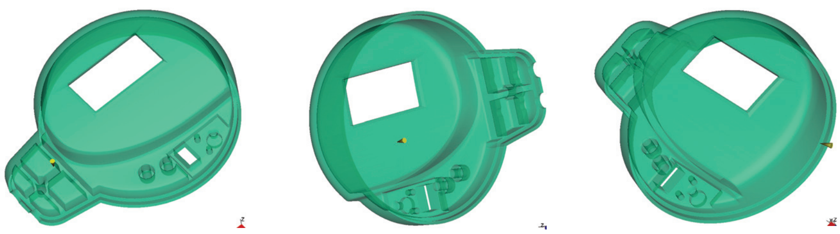
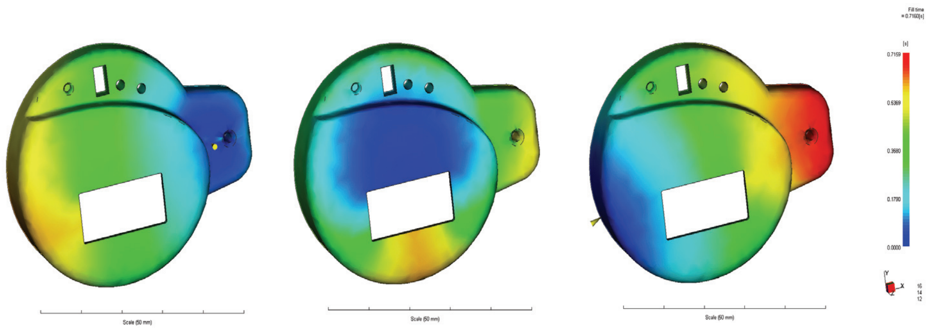


Fig. 5 - Gate location for variant A, B and C (from left to right)

Table 1. Settings of simulation process

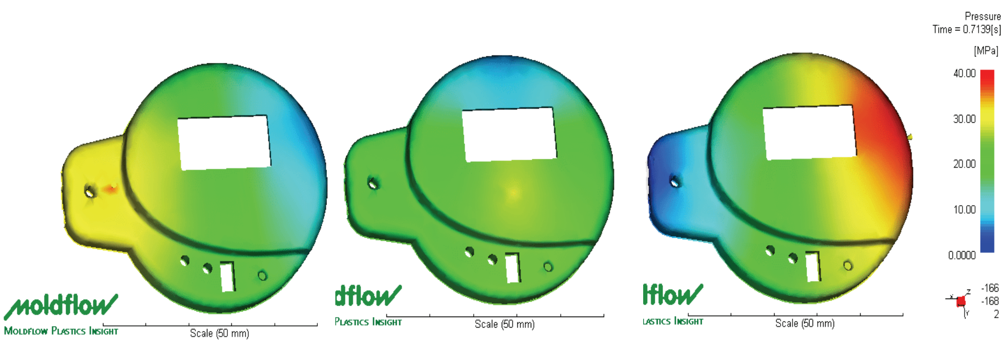
Material	Enduran 7065 PBT
Melt temperature	280°C
Mold temperature	60°C
Cooling time	20 s
Fill control	automatic
No. of nodes	17579
No. of tetraeder elements	97916

Manufacturability was checked from several different points of view, among which the optimal one had to found: the lowest fill time, the lowest injection pressure and minimal shrinkage and warpage of part. The results of simulation for concrete examined parameters and all variants are mentioned below.



variant A – 0,6141 s   variant B – 0,6135 s   variant C – 0,7170 s

Fig. 6 - Results of analysis – fill time

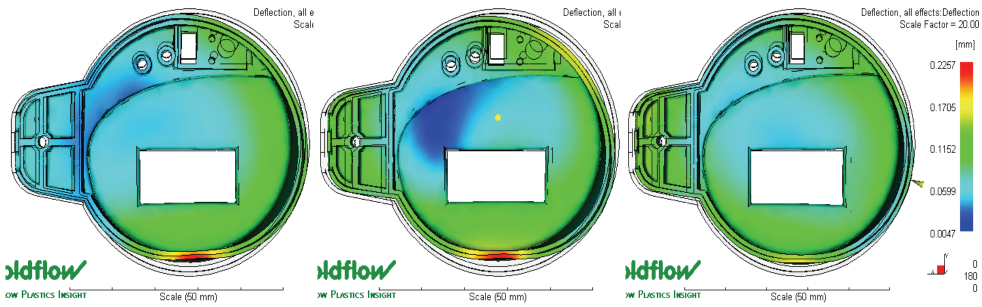


variant A   *variant B*   *variant C*

Fig. 7 - Injection pressure at end of fill

From results (Fig. 6) it is possible to see, the fill time is shortest for variant A, however, the difference among all variants is within the range 0,1 s. Considering this small difference, the fill time will have low importance in selection of final variant. Injection pressure was analyzed for selection of injection molding machine, especially, at which tendency is to minimize it. Fig. 7

shows minimal injection pressure for variant B and maximum injection pressure for variant C. From Fig. 8, it is possible to see shrinkage and warpage of part as well as geometrical precision of molded parts. For better illustration, the results were enlarged 20 times. The precision of molded pieces is very important due to fact, that part is component of thermometer who measures the fluid flow exactly. An emphasis will be focused just on this criterion.



variant A *variant B* *variant C*

Fig. 8 - Shrinkage and warpage of part

CAE analysis of injection molding offers many other outputs, to observe and evaluate influence of all conditions that enters injection molding process. The user performing this analysis has to choose which result is important in his case and can affect next steps in mould production.

2.3 Computer Aided Manufacturing of the mould

In the mould making industry there are even higher demands for the reduction of manufacturing time. In order to achieve the most optimal manufacturing as regards reduction of manufacturing time and surface quality, some different milling strategies were carried out. A detailed description of milling operations will be done only for the core side of the mould – Fig.9 and Fig. 10. Manufacturing for the core side of the mould was simulated in system Catia V5.

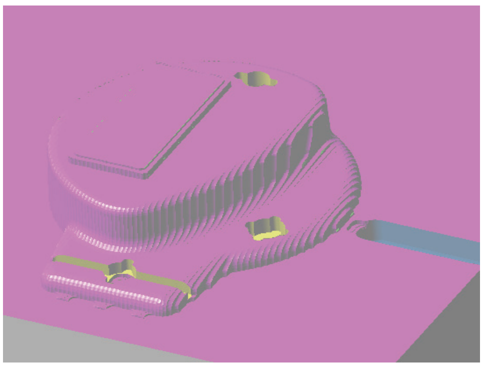


Fig. 9 - Visualization of the surface quality after rough milling

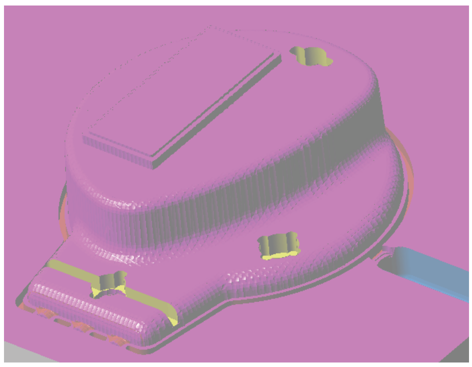


Fig. 10 - Visualization of the surface quality after finish milling

The machining was suggested and realized as follows:

- rough milling of the mould by sweeping strategy (also runner system) – Fig.9,
- finish milling by pocketing strategy,
- drilling of tempering system and
- finish milling by sweep roughing strategy - Fig. 10 (applied on runner system too).

When all required operations for machining of the mould was suggested, the simulation of whole CNC machining process was performed. The verification of the CNC program was performing to detect errors, potential collisions, or areas of inefficiency. The CAM system enables to correct errors before the program is ever loaded on the machine, thereby eliminating manual prove-outs.

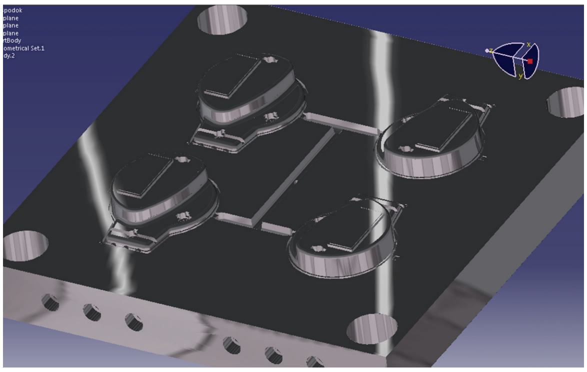


Fig. 11 - The detail of cavity side of the mould (bottom part)

For the mould forming system was applied material Alumec 89 with hardness 199 HV30. All milling operations were made on the Emco Mill 155 machine with the Heidenhain 426/430 TNC control system.

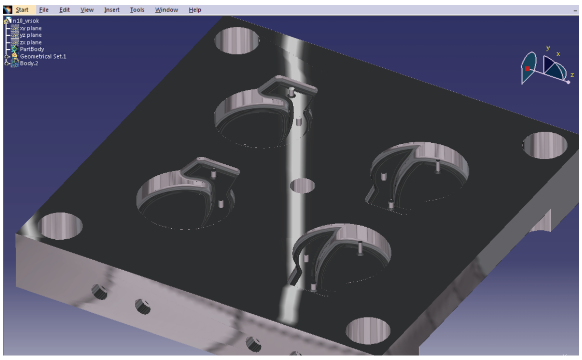


Fig. 12 - The detail of cavity side of the mould (top part)

The forming system of the mould was assembled by standard parts from catalogue HASCO - Fig. 13. This allows design engineers to design only cavity, runners, cooling and ejection system and all other parts of the mould can be selected from catalogue of standard parts.

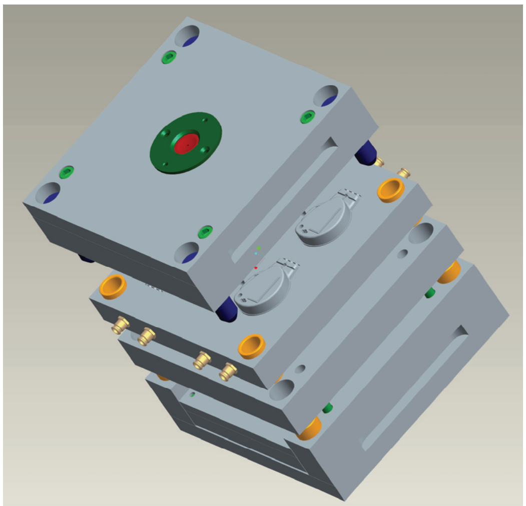


Fig. 13 - Complete assembly of the injection mould

3. CONCLUSIONS

In this paper, all key points in modem product like Rapid Prototyping, CAD/CAM/CAE tools and mould development are presented. This kind of knowledge enables the possibility to develop a completely new product in a period of 6 months, from the idea to the start of the production. This paper does not deal with the preparation of production in the plant.

CAE tools enables, except the design of moulds and optimization process conditions, respectively, determination some injection molding process limits like minimal thickness of thinnest area of the product to achieve required quality of molded part. In simulation of injection molding process, it is possible to assess some critical parameters some variables.

At the moment the ability to manufacture the prototype of the product in the period of 3-4 days, injection molding simulation in 4-5 days and the manufacturing of the mould in 2-2,5 months is given. If these processes are conducted simultaneously, the decrease of the development time of the mould down to less than 3 months is possible.

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MODERNI PRISTUP U RAZVOJU OBRADAKA OD PLASTIKE

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REZIME

U cilju skraćenja ukupnog vremena projektovanja i izrade novog proizvoda neophodna je primena savremenih metoda i tehnika. Jedna od takvih metoda je brza izrada prototipova (Rapid Prototyping) koja osigurava brzu izradu fizičkog modela budućeg proizvoda. Primena CAE metode je veoma značajna u fazi razvoja proizvoda jer se na taj način smanjuju troškovi alata. Ovaj rad opisuje istraživanja koja se bave razvojem prototipa, neophodnim koracima, primenom računara u potrebnim simulacijama i ostalim relevantnim faktorima u fazi razvoja proizvoda. Korišćen je CAE sistem Moldflow MPI za razvoj na polju alata za plastične delove, a primenjen je i CAM sistem za NC programiranje za izradu kalupa.

Ključne reči: *Brza izrada prototipova, CAE, simulacije, NC programiranje.*