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THE USE OF CAD CAM APPLICATIONS IN THE DESIGN AND MANUFACTURE OF BLOW MOLDS

Flaviu Corb [1], Traian Buidoș[2], Ralph Veres[3], Caius Stănășel[4], Iulian Stănășel[5]
[1]Doctoral School of Industrial Engineering – University of Oradea, corbflaviu@gmail.com
[2] University of Oradea – tbuidos@uoradea.ro
[3]Doctoral School of Industrial Engineering – University of Oradea, ralph.veres@catedralgroup.ro
[4]Master Program of Industrial Engineering – Univesity of Oradea, caius.stanasel@gmail.com
[5]University of Oradea – stanasel@uoradea.ro

ABSTRACT:Molds are an important piece of equipment in the production process due to the advantages they provide. Through development of computing systems, the performances of design and manufacturing applications have increased, allowing the design and production of products with increasingly complex shapes. Plastics products are used in the most diverse fields, from household products to parts for various industries. As a result of increasing customer demand, companies have to improve their design and manufacturing processes to ensure product quality and performance, and to increase the efficiency of production processes. Software applications have played an important role in the design simulation and manufacturing process of molds. Due to the complexity of the processes, product quality assurance cannot be predicted without design simulation and optimization applications and monitoring of production process parameters. In this paper the design and manufacture of blow mold for a plastic container is presented. The main design and manufacturing steps are presented using CAD-CAM applications.
KEYWORDS: blow mold, electrode, 3D model, machining

1. INTRODUCTION

Plastic bottles are used to package liquids or powders, or to make toys, in the field of sport, etc. These types of objects can be made economically by "blow molding", which makes it possible to obtain bottles of different sizes and complexity, for example packings from a few milliliters for the pharmaceutical industry to tanks of thousands of liters.

Due to the high performance and characteristics of the materials used, these types of products have also established themselves in the automotive industry, being used for coolant tanks, water tanks, fuel tanks, etc.

As a result of the increasing interest of the industry in this process, different researchers are addressing different aspects of making the design more efficient, optimizing working parameters, increasing productivity, etc.

Thus, in the paper [1] the modelling of heat transfer at the material-mold interface in press and blow forming processes is presented by making a numerical model that takes into account the process parameters: material temperature and viscosity, mold temperature and contact pressure. The model was validated by performing simulations that were compared with real case studies.

The authors [2] perform simulations for the design of the cooling channel for the "fast blow mold". The paper proposes redesigning cooling channels using computer-aided applications, simulation for channel optimization. The results obtained are compared with the initial situation, compared to which a shorter cooling time and a uniform temperature for the part are obtained.

Numerical heat flow simulations are also used by researchers [3] for "design of flash pocket inserts in an extrusion blow mold". Using ANSYS Polyflow software and the model of a real mold, the shape of the inserts and the cycle time of the extrusion blow molding were optimized.

Various rheological studies were used to investigate the processability of polyethylene terephthalate (PET). In [4] the influence of "the thermally stimulated current technique on the molecular relaxation of unstretched and biaxially stretched PET at 90 and 95°C is studied.

The authors [5] propose a set of differential equations describing the deformation model of the cylindrical membrane under free asymmetric swelling for complex geometries. A comparison between theoretical and experimental results validates the proposed model.

Study [6] presents an optimization method for the blow molding process of PET bottles using a connection of the Nelder-Mead optimization method and finite element modeling of the process using ABAQUS. Simulations were validated by tests and measurements on real parts, the proposed model correctly estimated both the blowing kinematics and thickness distributions of the glass.

Also, for containers made of PET in [7], two simulation methods were performed a direct pressure input (measured in the blowing machine) and a constant mass flow input (based on a pressure-volume-time relationship) using the finite element method applied with ABAQUS. Experiments confirmed that the simulation with a constant mass flow as input correctly estimates the volume variation versus time.

An important problem in the blow molding process is the creation of the parison, the size and shape of which depends on the geometry of the flask to be made, the working parameters, and the elastic properties of the polymer, and several trials are necessary to determine the appropriate shape and dimensions. Based on these observations, researchers [8] and [9] proposed a technique that uses a laser beam to determine the thickness of the parison walls, which allows shortening the time to obtain it.

In [10] different chemical architectures for PET from different suppliers are studied and the dependence between the polymer structure and its ability to be processed by blow molding is highlighted.

Modeling of the stretch blow molding process is investigated in the article [11] in which the researchers make measurements of the working parameters and highlight the interdependence between them. A thermodynamic model that can estimate the working pressure is implemented.

In the field of molds, there are concerns of researchers [12] to streamline the design process with the help of dedicated CAD modules, which use the geometry of the 3D model to be made when pre-selecting the shape of the cavity.

Another study [13] refers to the surface strengthening of matrices using spark deposition technology.

Also, to harden the die surfaces, the study [14] proposes the deposition of a chromium carbide layer. The experimental results give a good insight into the use of the method.

A concurrent engineering approach was used in [15] to reduce the total weight of a plastic part made by blow molding, the processing cycle time and working hours might be considerably reduced.

2. BLOW MOLDING PROCESS

Due to the efficiency of the process extrusion blow molding is the most common type of blow molding and is used to manufacture complex parts in large quantities. In blow molding, the extruder produces the semi-finished product in the form of a tube which is inserted between the two open half molds forming the outline of the product that has to be produced.

The two half-matrices are closed and also close the end of the tube. Compressed air is blown into the heated polymer tube in an advanced state of plasticity, which is inflated into the shape of the mold walls. After cooling, the half molds open and the product is removed from the mold.

Figures 1...4 show the main steps of the process.

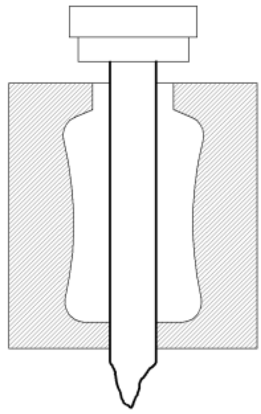

Figure 1. Extruded parison.

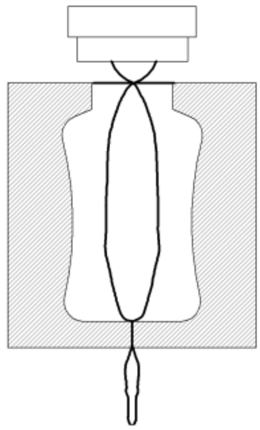

Figure 2. Closed blow mold.

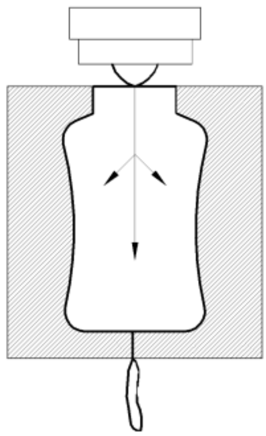

Figure 3. Parison swelling.

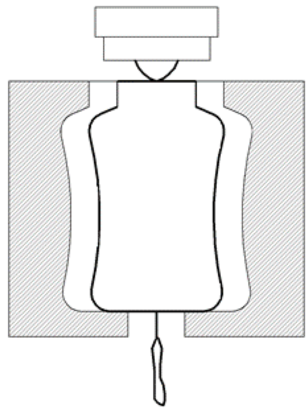

Figure 4. Open mold.

The shape of the piece must allow easy removal from the mold, with the walls sloping a minimum of one degree on each side.

As soon as it comes into contact with the mold wall, the material begins to cool and harden. In order to fill the cavity, the material has to stretch, a phenomenon that is more intense in the corner areas. To minimize stretching the rounding radius should be larger.

When choosing the material for the part, the shrinkage of the material when cooling the part must be taken into account. In design, the shrinkage is considered to be uniform, but as a rule, the longitudinal shrinkage is somewhat greater than the transverse shrinkage, which causes flat areas to deform due to internal stresses.

3. MOLD DESIGN

The 3D model of the part to be made is shown in figure 5.

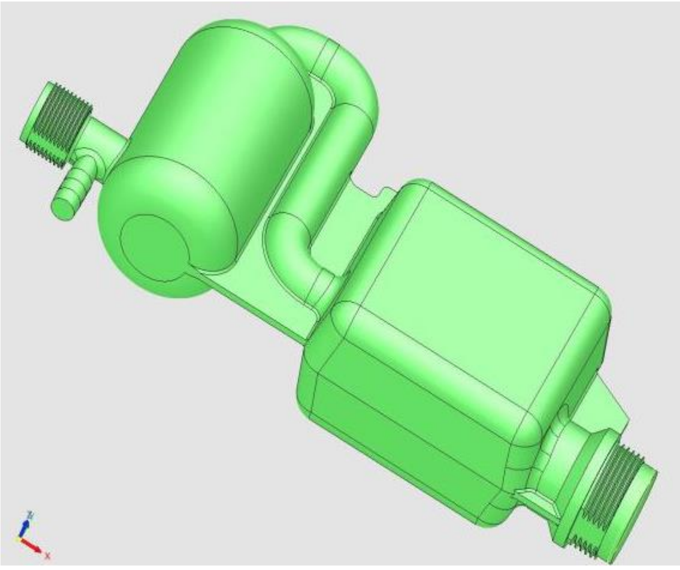

Figure 5. The product to be made.

To make the mold makes necessary to take into account the characteristics of the material to be used

The cavity of the mold takes into account the thickness of the walls of the part and the shrinkage coefficient of the material. In this way, the part model is scaled by the shrinkage coefficient and imported into the CAD file in which the mold is built.
After positioning, to ensure the separation plane of the two half molds, using Boolean operations, the cavities of the two half molds are extracted and obtained, having in their composition spacer bars, guide bushes and pressure plates, clamping plates, handling rings, locking flanges for transport, cooling system, and replaceable pads in the area containing the threads (figure 6 and figure 7). The assembled mold is shown in figure 8.

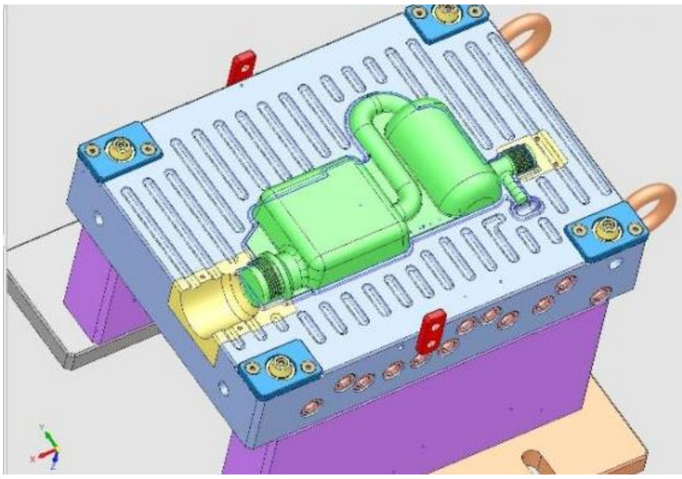

Figure 6. The 3D model for half-mold 1.

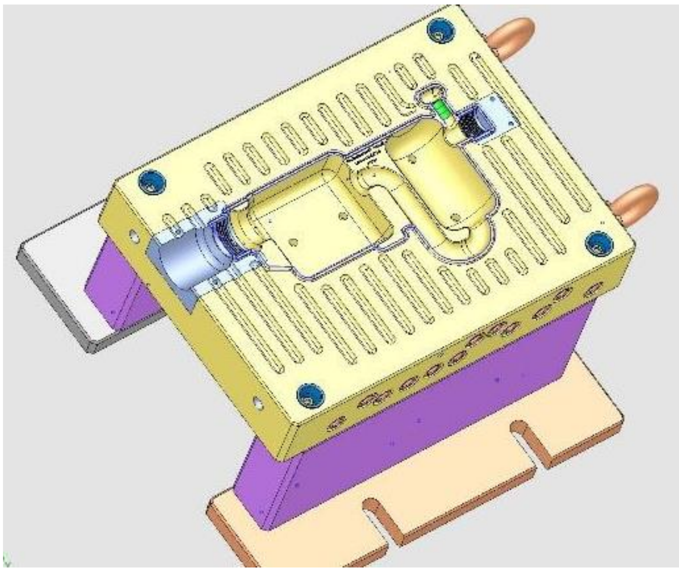

Figure 7. The 3D model for half-mold 2.

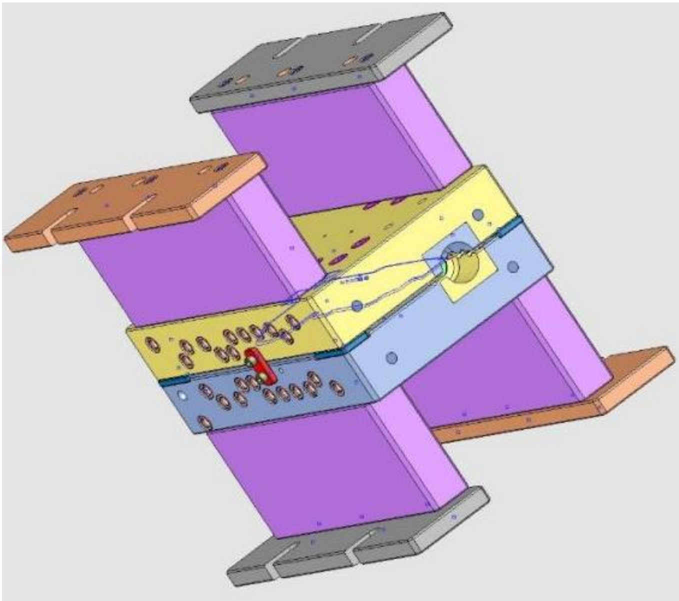

Figure 8. The 3D assembly of the blow mold.

Figure 9.

4. MANUFACTURING OF BLOW MOLD

The mold cavities are obtained first by rough milling followed by finishing milling.

Given the complexity of the shape, after the 3D model has been made, virtual manufacturing is carried out using a CAM application that allows the creation of paths for the chipping tools, and after post-processing, the CNC program is obtained for the machine tool equipment on which the machining is done.

When machining the threaded area, the copper electrode was designed (figure 9) and made [16], [17]. Figure 10 shows the program run for the electrode finishing operation to make the thread.

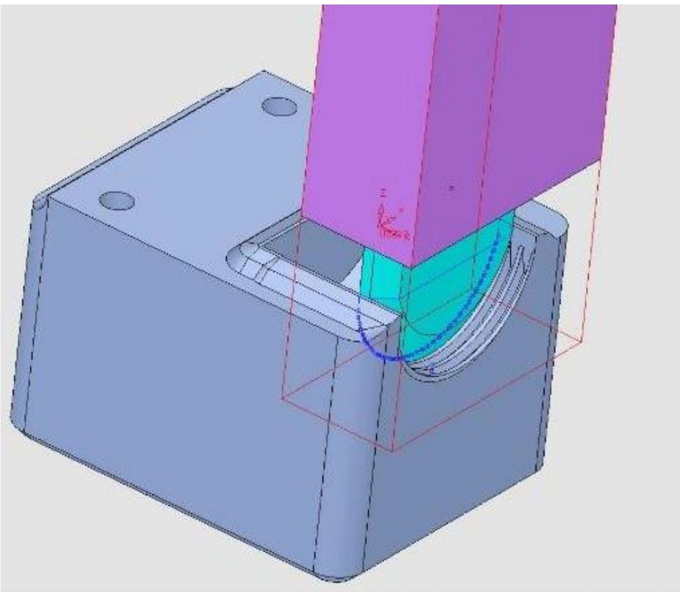

Figure 10. The 3D model of the thread electrode [16].

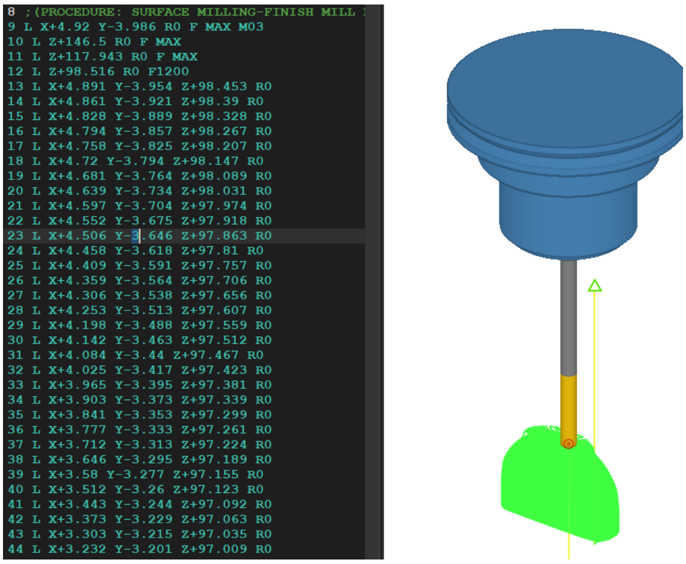

Figure 11. Simulation of CNC program for electrode finishing.

Figure 11 shows the processing of the threaded area of the die by electrical erosion.

The cavity check is done in two steps, the first on the milling machine (figure 12).

Figure 12. Electrical erosion machining of the threaded area.

The final check on the coordinate measuring machine (figure 13). A measurement report is made, mentioning the differences resulting from the comparison of the real model with the 3D model. The mold is validated if it is made within the specified tolerances.

Figure 13. Checking on the milling machine.

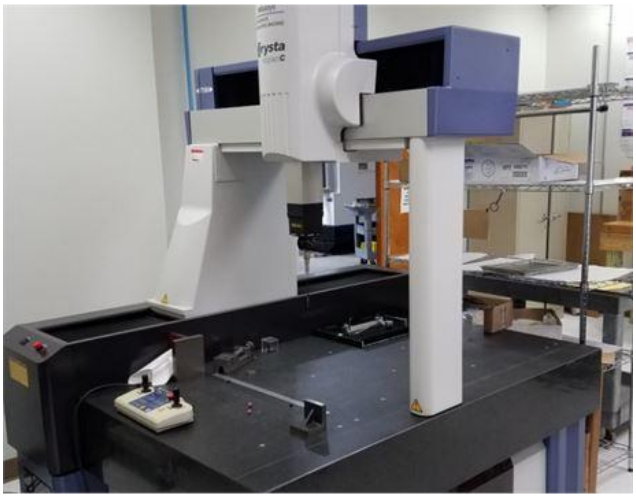

Figure 14. Checking on the coordinate measuring machine.

The half-mold obtained after milling is shown in Figure 14.

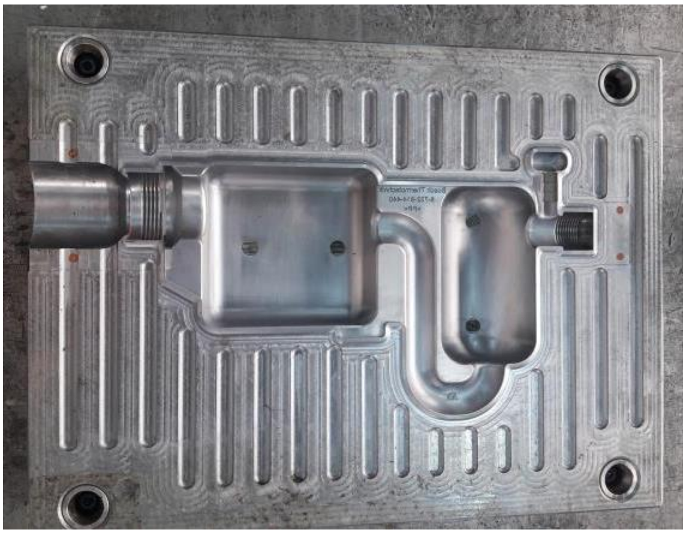

Figure 15. The half-mold.

5. CONCLUSIONS

The paper presents the 3D modeling and fabrication of the blow mold for a complex part.

For the production of the blow mold, CNC milling of the mold cores and electrical erosion machining with solid electrode for the threaded area were used.

Electrical erosion machining was less expensive than milling technology, which required the use of small diameter (0.6-0.8mm) milling tools with low rigidity, the price of these tools being higher than making copper electrodes and electrical erosion machining of pellets.

Obtaining container-type products by blowing has some advantages:

Reduce costs for large series production;

Parts can have complex configurations;

Good ratio between strength and mass of the parts.

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