STUDIES ON THE TECHNOLOGY FOR THE EXECUTION OF A PLASTIC INJECTION MOLD

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Abstract. *The mold is the mechanical subassembly that has the role of giving a certain shape to a plastic material with well-determined dimensions. The design and correct execution of injection molds conditions the achievement of high yields of injection processing. Molds for injection of thermoplastic materials are basically composed of two main parts: half mold from the injection nozzle side and half mold from the throwing side. The mold is fixed on the clamping plates of an injection machine. The majority of molds work by injecting the plastic material through a hole with the axis perpendicular to the plane to be separated. In the case of special injections (two-color or three-color injection), the injection is made both perpendicular to the plane to be separated and in the plane to be separated. In the construction of molds, thanks to the infusion of new technologies, optimization is constantly used. An example of this is NC milling after 5 axes. In addition to the reduced processing time of a mold, this also results in higher precision. Compared to NC milling after 3 axes, the processing after 5 axes of irregularly shaped surfaces is done with a smaller number of milling passes, with a better quality of the surfaces. The NC programs for 5 axes claim, thanks to the complex device, a large volume of calculation, at the corresponding processing speed. This can only be solved for the masses with the help of large computers. Complicated and long milling programs can be run with the help of these computers even during the night.*

Keywords*: special injections, plastic material, injection mold*

INTRODUCTION

Operation of a die

Depending on the geometric shape of the piece, the nature and characteristics of the plastic material, of the type of injection machine, there is a wide variety of constructive injection molds. [J.I. KARDOS , 1985, M. RATZSCH, 1988]. The injection mold is mounted on the clamping plates of an injection machine by means of clamping plates that are fixed with clamps or fixing screws. [ION SERES, 2002, ION SERES, 1999, ION SERES, 1996]. The centering of the mold is done with the help of centering rings that are attached to the clamping plates of the mold with the help of screws. [GHEORGHE IORDACHE, și colab., 1996].

The melted plastic material from the nozzle of the injection machine reaches the nozzle of the injection mold and through the injection network to the nests of the mold. The injected part is formed in the nest formed by a panson. After the hardening of the plastic material in the mold, as a result of the cooling of the mold plates, through the cooling circuit, the mold opens in the plane of separation. [PAUNICA, M. Și colab., 1988, RUSU, M., și colab., 1995].The injected part remains strengthened as a result of the contraction of the material on the panson. In order to remove the part from the mobile part, it is actuated by a rod on the injection machine and the throwing system that is activated causes the movement of the throwing plate used to throw the part from the mobile part. [FELDMAN, D., și colab., 1977].

Due to the great variety of the shape of the injected parts, the wide production series, the constructive systems developed for injection, casting, etc., the classification of molds is done according to several criteria. [HORUN, S., 1978, PAHARENKO, și colab., 1986].

According to the number of nests, molds are classified into: [http://www.imst.upb.ro› Sesiune Lucrari_2015, http://www.didactic.icpm.tuiasi.ro›]

- molds with a single nest;
- molds with two nests;
- molds with several nests (3,4, 5, etc.);

According to the injection system, the molds are classified:

- with direct injection through the cullet;
- with point injection;
- with injection with distribution channels;
- with film or film injection;
- with umbrella type injection;
- with annular injection;
- with tunnel channel injection;
- with injection with isolated channels;

According to the methods of actuation of the throwing system, the molds are classified: [KIM, V.S., și colab., 1988].

- with mechanical throw;
- with pneumatic throw;
- with hydraulic throw;

According to the number of planes to be separated, the molds are classified as follows;

- with a single plan to separate;
- with two separation planes;
- with several separation planes;

According to the constructive way of making the mold depending on the shape of the piece:

- simple;
- with boats;
- with unscrewing;

MATERIAL AND METHODS

The studies for the realization of this work were carried out at the company Evopart Solutions. The machining company deals with design and industrial automation, execution of automation assemblies and subassemblies: -Design; -Execution; -CNC machining

The most frequent projects we do are: robot arms, conveyors, sorting/cutting stations, customized components, etc.

Evopart Solutions is a Romanian company, based in Mosnita Noua (Timisoara)

Evopart Solutions offers computer-aided CAD/CAM design services.

Our main activity is represented by milling/turning operations on CNC machines.

The company currently has 6 CNC machines: 3xHAAS VF-2, 1xHAAS ST20Y, a DMC50 and a MAZAK lathe.

Automation systems

Design and manufacture of mechanical devices and equipment

- Equipment for mechanical testing and simulation
- Equipment for optical testing and parts verification
- Clamping devices used in technical processes
- Different assembly devices
- Bending, shaping and cutting tools for sheet metal parts

Design and execution of end-of-arm tools for injection and other processes

Assembly of subassemblies and components

Transport systems

Injection plastic parts

After establishing the semi-finished product and the material used, the establishment of the processing technology begins.

The first stage was to make a plane to straighten the semi-finished product and to place it on a straight surface.

For planing, a milling cutter with removable plates of diameter 63 mm with 8 teeth was used.

Cutting parameters:

Vc=197 m/min (S=1000 Rpm);

F=750 mm/min; (work advance)

Fz=0.125mm (advance per tooth)

Ap=0.75 mm;

Ae= 45mm;

The second operation is to bring the part to the dimensions of the technical drawing.

Milling modes for roughing, cylindrical-front milling cutter, diameter 16 mm Z=4

AP=15mm, (Z=-15mm)

Ae=0.15mm (X, Y=0.15mm)

Vc=100.5 m/min (S=2000 rpm)

F=800mm/min

For the roughing operation, the tolerance is 0.1 mm. I used a 16 mm cylindrical-front milling cutter with 4 teeth for roughing. The estimated time for the part outline was 2h 21 min.

The next operation is to finish the outline of the part and to bring it to its final dimensions.

I used a 20mm diameter cylinder-front milling cutter.

Ap=21mm

Ae=0.15

Vc=138m/min (S=2200 rpm)

Fz=0.83 mm

F=550 mm/min

For the finishing operation, the tolerance is 0.01 mm. For any roughing operation (removal of excess material) it is mandatory to leave an addition of axial or radial material or both to obtain good surfaces and with the best possible roughness depending of requirements. In this situation, the addition was 0.15 radial.

The estimated time for this finishing operation was estimated at 12 min 39 sec.

Then the material was roughened with a 32mm diameter removable plate cutter and 1.5mm radius.

Cutting parameters:

Vc=211 m/min (S=2100 rpm)

F=3500 mm/min

Ap=0.33mm

Ae=14 mm

An addition of 1 mm of material was left both axially and radially.

For this operation of roughing the material, the estimated time is 2h 44 min.

After the operation to remove the thick material, we will perform a "Remachine" operation, taking into account the cutter used previously to release even more material where the previous cutter did not take place, being a much larger cutter. The allowance is kept at 1 mm radially and axially. The milling cutter used was one with a diameter of 10 mm and a radius of 2.5 mm (bull nose).

Vc=204 m/min (S=6500 rpm);

F=1400 mm/min;
Ap=0.2 mm;
Ae=3 mm;
The estimated time is 1 h 23 min;

This operation is similar to the previous one. An even smaller cutter in diameter and with an even smaller radius will be used to remove even more of the desired material and leave the radius as small as possible. The addition is kept at 1 mm both radially and axially.

The cutting parameters are the following:
Vc=175 m/min (S=7000 rpm);
F=1200 mm/min
Ap=0.33mm;
Ae=6.5 mm;
The estimated time is 34 min;

After roughing out the extra material, a series of semi-finishing operations will follow.

This operation will be done on the Z level with an addition of 0.15 mm axial and radial of the profile. The cutter used is a 12 mm diameter cutter with a radius of 6 mm (Boll nose).
Vc=256 m/min (S=6800 rpm);
F=800 mm/min;
Ap=0.3 mm;
Ae=0.4 mm;
Estimated time is 2 hours.

Semi-finishing with a cutter of diameter 12, radius of 6 mm, a contour of the profile was made on the Z level. The addition is kept of 0.15 mm axially and radially. The parameters used:
Vc=256 m/min (S=6800rpm);
F=800 mm/min;
Ap=0.3 mm;
Ae=0.4 mm;

Semi-finishing and finishing of the areas where milling will be done horizontally and the processed areas are straight areas where the machine head is perpendicular to the work area. Radius tools are not required, so I used a 12 mm diameter cylindrical-front milling cutter, Z=4, for this operation. The allowance left on the walls is 0.15 mm for semi-finishing, after which finishing is done at 0.

Vc=188 m/min - for roughing (S=5000rpm); Vc=207m/min – for finishing (S=5500 rpm);
F=800mm/min; F=600 mm/min;
Ap=1.5 mm; Ap=4 mm;

Next comes the operation of semi-finishing and finishing the horizontal plane.

For semi-finishing, an addition of 0.1 mm was left on the horizontal plane, after which the finishing was carried out at 0. The cutting parameters are:

Vc=207 m/min (S=5500rpm) – for semi-finishing; Vc=226m/min (S=6000 Rpm)-Finishing;
F=1000 mm/min; F=800mm/min;
Ae=6mm; Ae=6 mm;

The next stage is the presentation of the part trajectory for the semi-finishing of two spherical cutters, respectively with a diameter of 8mm, a radius of 4 mm and a spherical cutter with a diameter of 6 mm, a radius of 3 mm. This operation will take into account the cutters used previously, an addition of 0.15 mm will be kept and the strategy will be on Z level to eliminate as much as possible the radii of the previous cutters.

Vc=180m/min (S=7200 rpm) Milling cutter 8mm; Vc=137 m/min (S=7300 rpm); 6mm milling cutter

F=1000 mm/min; F=800 mm/min;

Ap=0.3mm; Ap=0.16 mm;

Ae=0.3mm; Ae=0.2mm;

For finishing, an 8 mm diameter milling cutter with a radius of 4 mm was used, the finishing was done at an angle of 45 degrees. The parameters used for finishing were the following:

Vc=176 m/min (S=7000 Rpm);

F=800mm/min

Ap=0.18 mm;

Ae=0.18mm;

Estimated time is 6 h 18 min.

In the next stage, the final finishing was done on the cavity profile, the milling cutter used was a spherical milling cutter with a diameter of 6 mm and a radius of 3 mm. The finishing was done at an angle of 45 degrees with the following parameters:

Vc=137m/min (S=7300 rpm);

F=800 mm/min;

Ap=0.15mm;

Ae=0.15 mm;

The estimated time is 2h 50 min.

Vc=276m/min (S=4000 Rpm);

F=750 mm/min;

Ae=15mm.

RESULTS AND DISCUSSIONS

The productive programs calculate along with the milling trajectory, the collision and the angle of inclination of the milling cutter. For each point of the trajectory, the necessary tipping angle is calculated, so that the angle of the milling cutter adapts to the profile of the surfaces. This certifies the fact that no point on the surface of the milling cutter collides with the surface of the press. In addition, a surface finish is removed in the milling direction.

The component parts of the molds are removed from several processing operations by chipping: - drilling; -turning; -milling; - boring; -rectification.

Drilling, widening, reaming and laming.

In an injection mold, numerous holes are processed in the board package by drilling: spacer screws, centering pins, return pins, buffer pins, throwers, the tempering circuit, guide columns and bushings, etc.

The problems related to the processing of the holes become difficult due to the fact that the construction of the mold implies at the same time high precision and great depths for the holes. If the drilling depth is approximately five times greater than the diameter of the hole, technological difficulties arise that require special tools and appropriate technology. Conventional tools easily deviate from the correct direction of the holes, due to their reduced stability, and the lightness of the faces creates difficulties, causing the tool to brake, which leads to its breakage.

Due to the different functional and constructive characteristics, each of the drilling processes has a certain field of drilling diameters and drilling depth, to which the application of the process ensures the rational exploitation of the tools and the machine, achieving at the same time a certain quality of the executed hole.

It can be stated that in the range of diameters 2...60 mm, for drilling depths up to 25 times the drilling diameter, several drilling procedures are possible.

Depending on the processing precision required by the operation of the respective part, the corresponding operations are performed.

- the holes for the tensioner screws are made with a drill, depending on the drilling length;
- the ends of the string screws with a cylindrical head are made with countersinks;
- the housings for the cylindrical centering pins are made with drills for long holes, after which they undergo the reaming operation that achieves the precision required by the adjustment.
- the housings for the return pins are made with a drill for long length, then they undergo the reaming operation that achieves the precision of the adjustment in the guide area, etc.

Milling. It is the operation of mechanical processing by chipping with a very high weight in the field of making injection molds. A very large range of works can be performed on the milling machines: the processing of flat surfaces, the processing of channels, the processing of profiled surfaces. Milling operations are performed on normal milling machines and special milling machines.

When processing surfaces by milling, the following are used: cylindrical milling cutters, cylindrical-front milling cutters, disc milling cutters, angular milling cutters, profile milling cutters, etc.

The milling of horizontal surfaces can be done with cylindrical milling cutters on horizontal or universal milling machines and with front milling cutters on vertical milling machines or using the vertical head of the milling machines. The processing of discontinuous surfaces but located at the same level is recommended to be done with front cutters.

Milling with front cutters is done without big shocks, because all the cutter teeth work simultaneously, and the chipping efforts are partially balanced.

Milling of vertical surfaces can be done with both horizontal and vertical milling machines. In general, there is no essential difference between horizontal and vertical surfaces from the point of view of their milling, they can be easily transformed into another when necessary.

Inclined surfaces can be processed by several methods on horizontal or vertical milling machines.

Some of the parts that are part of the injection molds have profiled surfaces in the most different shapes. These profiled surfaces are obtained by milling on ordinary or special milling machines by several methods:

Processing with simple or combined profile cutters, processing by combining two advances;

Processing with the help of the rotary table;

Processing with the help of copying devices;

The method of processing with the help of profiled milling cutters allows the creation of surfaces through the very shape of the milling cutter. This process is more expensive than ordinary milling, because the execution and sharpening of the profiled milling cutter costs more than for normal milling cutters. In general, milling is performed in several operations, starting with drawing the required profile on the raw piece drawing using the template, then a profile composed of flat surfaces is drawn to follow the final profile, after which a roughing milling can be performed to remove the material addition. In this way, there remains a much reduced processing addition on the output, which will be removed by the finishing operation performed with the profile cutter, thus creating a surface whose profile, drawn in advance with the template, will correspond to that of the face.

CONCLUSIONS

For the realization of this work, the mold cavity was studied, on a milling machine with numerical control, the machine being a VF2 SS.

For NC programming, two software licenses were used, respectively Cimatron 13 and Fusion 360. The technology was divided into several steps to make the work easier and to obtain a better quality of the processed part. After the cavity was completed, it was sent to the client to check it with a 3D measuring device and for validation.

The plastics industry is in continuous development both internationally and nationally.

Processing by milling on complex surfaces represents the main technological operation of mold execution. The starting point is the 3D and 2D definition of the piece, the role of the CNC programmer, using a dedicated CAM software, to establish the technological process of execution and post-processing for the machine with a dedicated numerical command.

The main objective of this work is to present a technological innovation for the execution of a forming core for an automotive injection mold.

As an analysis of the costs of executing a mold, we can use the following formula:

Mold cost = Material cost + Design cost + Execution cost + Auxiliary cost (packaging, transport, tests)

Of the actual execution cost, approximately 60% is considered the processing of functional parts and cavities.

Taking these considerations into account, the impact of component processing is very high and the role of a CNC programmer is decisive in the choice of the technological career.

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