CAD/CAM METHOD FOR DESIGNING AND MANUFACTURING PRECISE ELECTRODES USED IN ELECTRICAL EROSION

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Abstract: This paper presents general notions about the use of CAD/CAM systems for design and realization of the electrodes used for working of the thermoplastic materials injection molds active parts. A case study is presented, concerning the fabrication of a PA66 polyamide part, with 2% contraction coefficient. Starting from the 3D model of the part to be made and taking into account the contraction coefficient of the material, the mold active part is generated. Once the dimensions of the mold active part are known, the 3D model of the execution drawing for the electrode used for EDM finishing of the mold active part is generated. These activities are carried out by means of an integrated CAD/CAM system. After simulating the tool trajectory, the effective working of the electrode with a numerical command FADAL-type machine is presented. This paper is based on the experience of the authors about design and realization of the plastic mass injection molds and the completion of several research contracts with specialized companies.
Key words: CAD/CAM, electrical discharge machining, injection mold, plastic materials

1. INTRODUCTION

The wide variety of the plastic injected parts led to the elaboration of specific constructive and technological solutions in the field of injection molds design and execution. According to the part geometrical shape, the plastic mass nature and characteristics, type of injection machine etc, there are many constructive versions of thermoplastic materials injection molds. The dimensions and accuracy of the tool-electrodes are very important in molds realization, because the execution accuracy of the mold active parts and implicitly the accuracy of the injected plastic parts depend on them. The design and correct execution ensures the final dimensions of the part to be injected, taking into account the super finishing and polishing additions for the mold active parts, and the linear contraction of the thermoplastic material to be injected (Ding, 2002).
The CAD/CAM systems cover the information processing in the following fields , (Shah & Mantyla, 1995):

- computer-aided design;
- computer-aided fabrication planning;
- fabrication automation.

The CAD/CAM systems evolved, so that nowadays we have integrated systems (Schulte & Padmanabhan et al, 1992) (fig.1). Such an integrated system is a multi-modular system based on numerical calculation systems (NC) which link the mold construction, the fabrication programming and the NC fabrication on modern mold working machines (Wen & Ronak, 1997). The data flow in such a system is shown in fig.2 (Seres, 1996) .

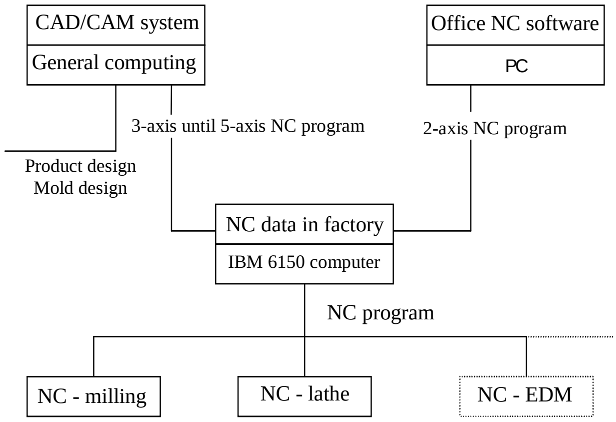

Fig.1. Integrated CAD/CAM systems for mold realization

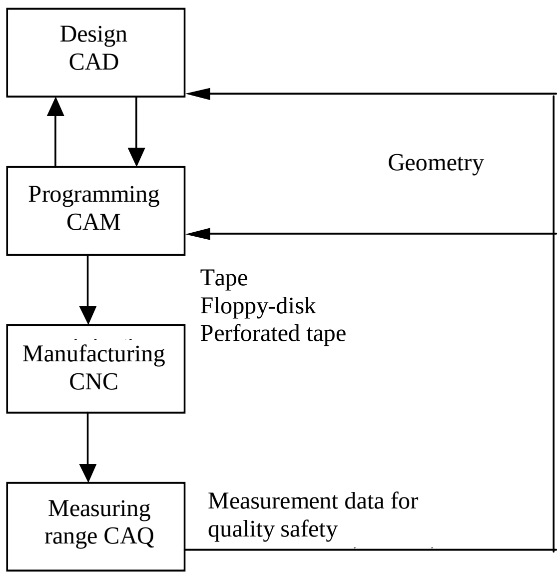

Fig.2. Data flow for mold fabrication

The CAM system includes all the activities connected to execution and supervision of the injection mold fabrication process, and it refers to (McMahon. & Jimmie, 1998):

- fabrication automation and control;
- tools and materials handling and moving;
- fabrication supervision.

Along the CAD/CAM systems, there are also stand-alone NC programming systems, which allow the attainment of new part geometry and the processing of the geometrical data from CAD systems (Manole et al, 2010). An example consists of 5-axes NC milling, based on the principle shown in fig.3 and fig. 4 (Seres, 1996).

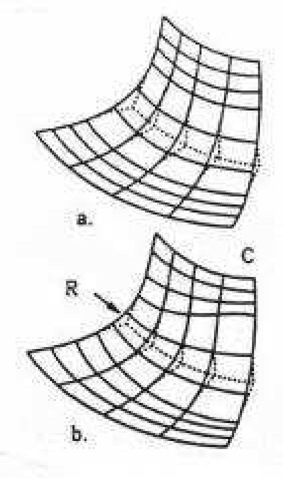

Fig.3. Law of free surfaces: a - constant; b - variable; R - radius

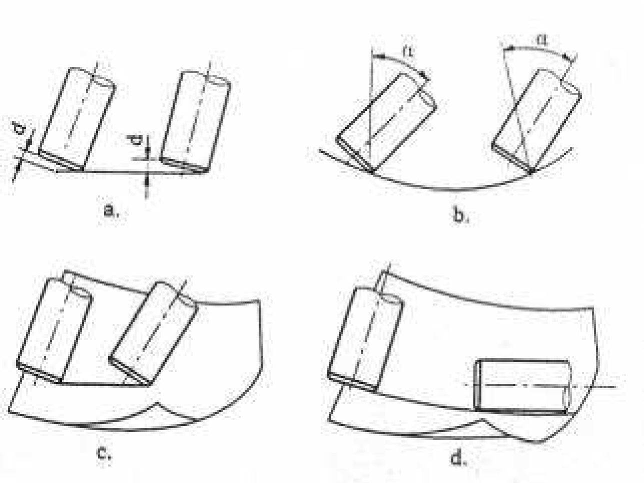

Fig.4. Milling geometry for 5-axes milling with frontal mill: a – constant *d* distance; b – constant α angle; c – maximum tool-part contact; d – NC rolling (flank processing)

The 5-axes NC milling has the following advantages:

- more accurate processing, compared to copy-milling by model;
- better surface quality (the finishing duration is reduced);
- reduced milling time, due to the decreasing of passing number and to the high efficiency of NC machines.

2. DESIGN OF THE ELECTRODE FOR PART “AUTO TUBING SUPPORT”

The part to be made is sown in Fig.5. According to the execution design of the mold’s active parts, the electrode is designed (Beno, 2003), (Mantyla, 1988) taking into account the electrode material and the part material, which will be polyamide PA66 with 2% contraction coefficient.

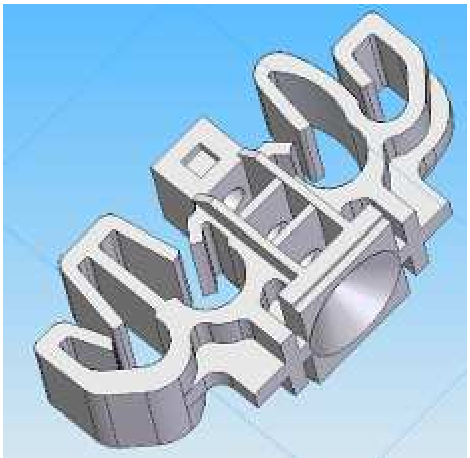

Fig.5. Auto tubing support.

Because of the complex configuration of the part and its thin walls, the electrode will be made of ELLOR+25 graphite, which has the following characteristics: 1.82 g/cm^3 density, 8% porosity, 58 MPa breaking resistance, 1400 μΩ·cm resistivity, 10 μm granulation; fig.6 shows the structure of the ELLOR+25 graphite [*** catalog].

Graphite is widely used as material for electrodes used in electrical discharge machining (EDM). Compared with copper electrodes, the graphite electrodes allow a significant reduction in production costs and providing the same quality of processed surface.

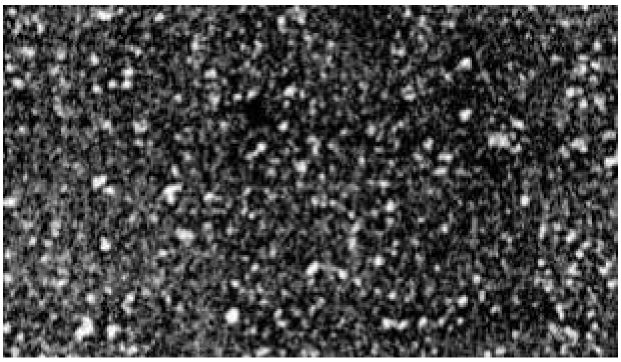

Fig.6. Structure of ELLOR+25 graphite

Fig.7 shows the principle of the electrode realization for the “auto tubing support” part by means of CAD/CAM systems.

The following goals must be achieved by means of CAD/CAM system:

- shorter time for the part development, from idea to construction;
- the mold is made with rationalized construction

system and no more by routine work;
- increased product quality, due to CAE systems which yield optimum injected parts and molds.

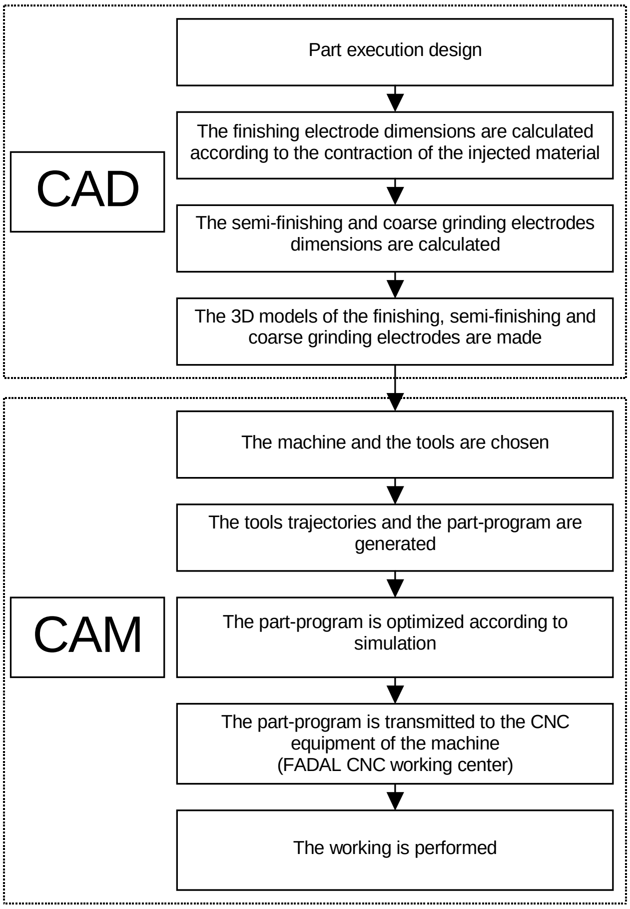

Fig.7. Principle of the electrodes realization

3. DESIGN OF THE MOLD CAVITY

The Mold Design from Solid Edge Mold Tooling assumes working through automated steps, which makes it quick and easy for molds design for plastic injection. The module has a library that contains standard components of leading manufacturers in the industry.
Solid Edge Mold Tooling also contains a module Solid Edge Electrode Design which is used for designing step by step both the simple and the composed electrodes for manufacturing the injection mold cavity.
This paper presents an integrated method for design and realization of electrodes used for electric discharge machining of the injection mold active parts, starting from the 3D model of the plastic part to be made and knowing the plastic material to be used.
In order to make the electrode, it is necessary to model the cavity of the semi-mold where the part will be injected. For this purpose, the 3D model of the plastic part is imported in the “Mold Tooling” module of the Solid Edge application. This module contains a set of specific commands for making of the injection molds (Solid Edge, 2007).
A work session begins with the specification of the part name, the place on the hard disk where the new mold will be saved, the mold orientation and the measuring units system (fig.8).

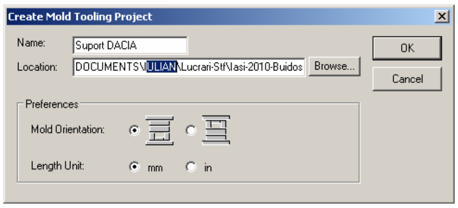

Fig.8. Interface for creation of a new „Mold Tooling” project

After inputting the required parameters in the previous dialog box, the user imports the part for which the mold is to be made. The part analysis yields a symmetry plane that can be considered as the mold separation plane. Also, it is to be seen that the semi-molds will be identical by using this separation plane. The cylindrical transversal hole will be made by inserting a core, which is not difficult to be made and will not be discussed here.
The attainment of the active part of the mold for the required part implies activities that specify to the software a series of parameters, as: the surface on which the part is oriented in the mold, the contraction coefficient of the part material (2% in this case), the mold separation plane, dimension of mold opening, dimensions of the plates which contain the core and the cavity in which the part will be injected etc, and the result will consist in the two semi-molds (fig.9).
As the realization of the mold is not the object of this paper, the two semi-molds can be saved as separate 3D models and next the electric discharge working electrodes will be designed.

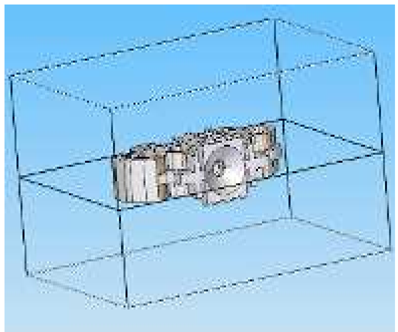
Fig.9. The semi-molds (without the cylindrical core) for the plastic part to be made

4. REALIZATION OF THE ELECTRODE

Electrical erosion process allows obtaining simple or complex shaped parts with high dimensional and surface accuracy. Removal of material is based on electric arc that is formed between parts and tools (electrode). Electrode tools can be massive tools - used in processing of complicated surfaces by copying the shape and dimensions of the electrode on the part or might be filiform (by wire) mainly used for the cutting of complex shapes on CNC machines.

The massive electrodes can be realized by copper or graphite.

Depending on the dimensional accuracy and surface quality required to be obtain on the part, electrical erosion processing with solid electrode can be achieved in several passages: roughing, half-finishing and finishing. For each step is required to design and perform the tool electrode.

When processing molds with several cavities it is economic that the manufacturing to be performed at the same attachment to the processing machine, in this case being necessary more identical electrodes in a device. In order to increase accuracy it is recommended that the device used for attaching the electrodes to be the same at their processing. This leads to a higher precision processing by EDM of an order of 0.01 mm.

The design of the electrode for electric discharge machining of the injection semi-mold active part uses the “Electrode design” module, which is also included in Solid Edge application. This module is integrated in the “Mold design”, which is used to design the injection mold.

The electrode design starts with the specification of the cavity (semi-mold) for which it will be used, so it is necessary to select all surfaces that compose the cavity where the electrode is to be designed.

Next, the user specifies the electrode material (fig. 10) and inputs the working additions for EDM roughing, semi-finishing and finishing of the cavity where the part is to be injected (fig.11).

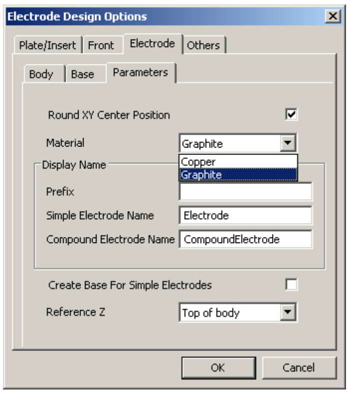

Fig.10. Specification of the electrode material

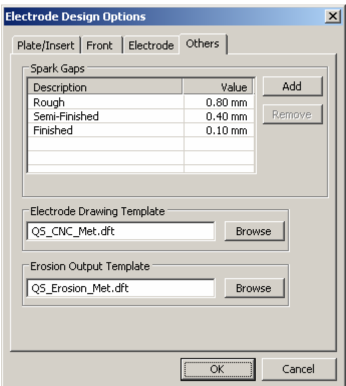

Fig.11. Specification of the electrode parameters

After calculations, the software shows the 3D model of the electrode, in this case the electrode for mold cavity EDM finishing (fig.12).

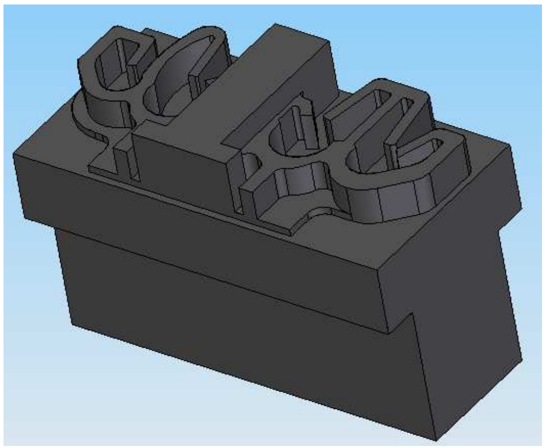

Fig.12. The 3D model of the electrode for finishing

The electrodes are worked on a FADAL-type CNC machine, by means of a modular device which allows the clamping (Tero (1995), and working of four electrodes simultaneously. Fig.13 shows the electrodes positioned for processing .

Fig.13. Modular device with four clamping elements, mounted on the table of machine FADAL VMC2216

After the positioning of the electrodes, the NX Machining application is opened (fig.14), integrated in Solid Edge, where the CNC program for processing of the four electrodes clamped in the modular device will be made (Tickoo 2009).

Fig.14. Opening of the NX Machining application, used for processing of electrodes

In order to make the program for working on CNC machines, several steps are to be followed (Parthiban, 2002):

- origin setting;
- semi-fabricate selection;
- selection of the part (electrode) geometry (fig.15);

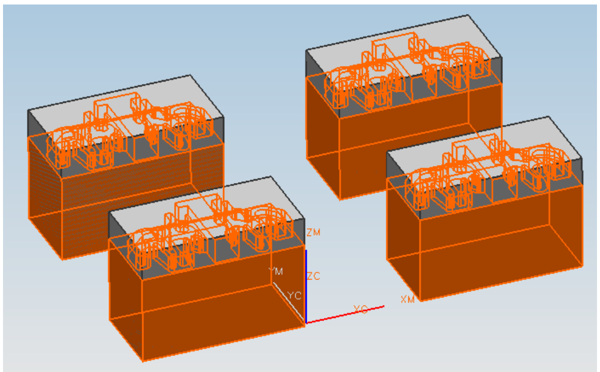

Fig.15. Selection of part (electrode) geometry

- specification of tools roughing and finishing (fig.16);

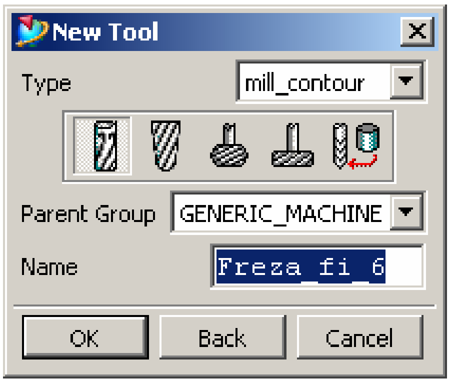

Fig.16. Specification of milling tool

- specification of milling type (fig.17);

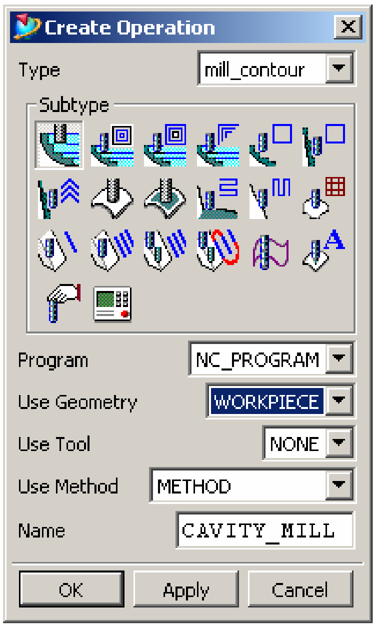

Fig.17. Selection of milling type

The paths of the tools for roughing and finishing are resulted from calculations.

Before post-processing the roughing and finishing CNC programs, it is very useful to check the tools trajectories by simulation of the working (fig.18).

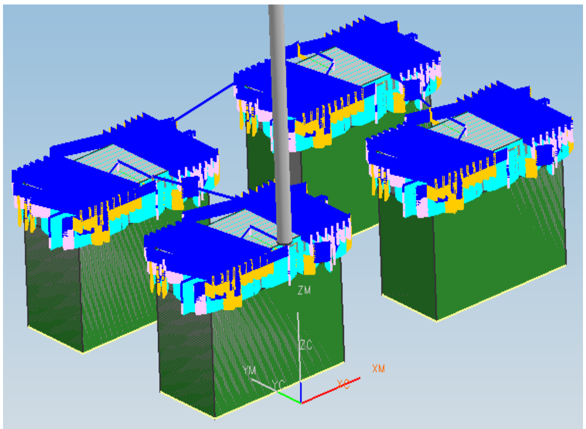

Fig.18. Trajectory of the milling tool

The NX Machining application includes a very developed simulation module, which can provide information about possible collisions or wrong working, can save the computed models for later measurements etc. Also, the coarse grinding and finishing programs are made and run.

In order to achieve precise electrodes, a special device was designed. The device that is shown in fig. 19 can be used to process the electrodes in the same fixture as well as the processing mold cavity, without requiring separation of electrodes. Another advantage of this device is that it can be used to work at the same fixture for roughing and finishing electrodes.

Fig.19. Modular device with four clamping elements, mounted on the table of machine FADAL VMC2216

After the simulation of the working, the post-processing is carried out by means of NX Machining application, which features a series of post-processors for the most common CNC machines. The roughing electrodes, by means of a Ø6 end mill, are shown in fig.20, and next the finishing is carried out by means of a Ø2 end mill.

In fig.21 are presented the electrodes obtained after the finishing operations

Fig.20. Roughly trimmed electrodes

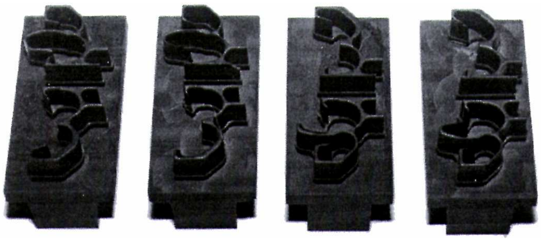

Fig.21. Ready made electrodes

5. CONCLUSIONS

Nowadays, in mould and electrode making, the routine work is abandoned in favour of rational design system. Thus, the CAD-CAM systems have evolved, coming to integrated systems based on numerical computing systems, which connect the mould construction, fabrication programming and the effective realization of the parts on modern numerical commanded machines.

The electrode wear increases the costs of the molds, when using the EDM. This is why it is very important to fulfill certain criteria for the choice of the electrode material.

The presented paper represents a new solution for rapid production of new products, shorter manufacturing cycle time, reduce costs by allowing reuse of components, technologies, knowledge and scrap reduction, increase quality by providing an integrated set of analysis tools.

The presented method includes a wide range of applications based on the same platform, thereby providing an integrated solution and associative, so information spreads rapidly throughout the design and production process. This information allows a synchronized collaboration of all concerned, thus eliminating unnecessary consumption of resources due to transfer information between departments, systems and stages of the production process.

The main advantage of this way of work consist in: reduce the time needed to search for information or waiting for test results to eliminate resources spent to carry out projects that will not finish, or unwanted documents and prototypes. That leads to an increase of individual and departmental productivity, thus improving efficiency of the overall process.

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