ELECTRIC DISCHARGE MACHINING FOR CAVITY CORE OF A PLASTIC INJECTION MOULD

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Abstract: In this paper, an electrical discharge machining (EDM) method for a core cavity is presented. To be able to manufacture the cavity core using EDM, a large number of electrodes is required. These electrodes were designed to cut the part using two methods for EDM: the *SPIRAL METHOD* and *the EQUIDISTANT METHOD.*

Keywords: electrical discharge machining (EDM), electrode, core cavity

1. PRINCIPLE OF EDM

1.1. What is EDM? [2]

Electrical discharge machining (or EDM) is a machining method primarily used for hard metals or those that would be impossible to machine with traditional techniques. EDM only works with materials that are electrically conductive. EDM can cut small or odd-shaped angles, intricate contours or cavities in prehardened steel without the need for heat treatment to soften and re-harden them as well as exotic metals such as titanium, kovar, carbide etc.

EDM is a nontraditional method of removing material by a series of rapidly recurring electric arcing discharges between an electrode (the cutting tool) and the workpiece, in the presence of an energetic electric field.

The EDM cutting tool is guided along the desired path very close to the work but it does not touch the piece. Consecutive sparks produce a series of micro-craters on the work piece and remove material along the cutting path by melting and vaporization. The particles are washed away by the continuously flushing dielectric fluid. It is also important to note that a similar micro-crater is formed on the surface of the electrode, the debris from which must also be flushed away. These micro-craters result in the gradual erosion of the electrode, many times necessitating several different electrodes of wire EDM machining, constant replacement of the wire by feeding from a spool. [1]

In figure 1, the phases of EDM process can be observed. By introducing the two pieces (the workpiece and the working tool, namely the electrode) into a dielectric fluid, there will occur an electric arching between them which, because of the dielectric fluid and by local vaporization of the material, creates a gas bubble. This gas bubble increases the local temperature to an interval between 8000°C and 12000°C, which accelerates the removal of the melted shape material phenomenon from the surfaces of the two parts.

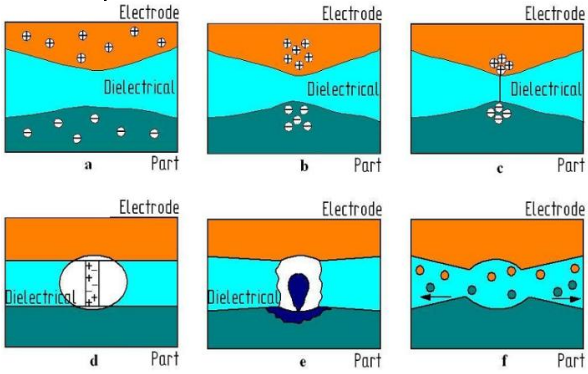


Fig.1. Principle of EDM

Assuming that the two parts are at initial distance D and at different electrical potential V and that they are closing each other (as in figure 1) we are going to have (Table 1):

Table 1.

Figure a	Figure b	Figure c	Figure d	Figure e	Figure f
D> GAP, V > 0	D = GAP, V > 0	D = GAP, V > 0, I > 0	D = GAP, V = 0, I = 0	D > GAP, V = 0, I = 0	D > GAP, V = 0, I = 0

Figure 2 shows schematically the basic working principle of EDM process.

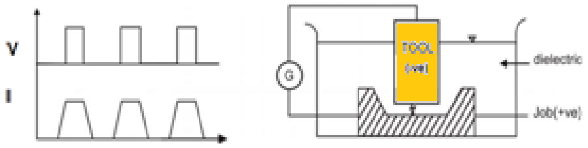


Fig.2. Schematic representation of the basic working principle of EDM process (according to [4])

1.2. ADVANTAGES AND DISADVANTAGES [5]

Some of the advantages of EDM include machining of:

- ✓ complex shapes that would otherwise be difficult to produce with conventional cutting tools or extremely hard material to very close tolerances;
- ✓ very small work pieces where conventional cutting tools may damage the part from excess cutting tool pressure;
- ✓ there is no direct contact between tool and work piece, therefore delicate sections and weak materials can be machined without any distortion;
- ✓ A good surface finish can be obtained and very fine holes can be easily drilled.

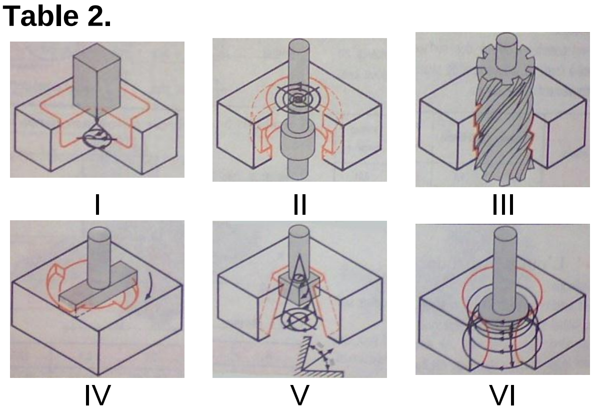
Some of the disadvantages of EDM:

- ➢ The slow rate of material removal;
- ➢ The additional time and cost used for creating electrodes for ram/sinker EDM;
- ➢ Reproducing sharp corners on the workpiece is difficult due to electrode wear; - Specific power consumption is very high; - Excessive tool wear occurs during machining;
- ➢ Electrically non-conductive materials can be machined only with specific set-up of the process.

1.3. ROBOFORM CAM CYCLES

In table 2, the manufacturing cycle using Roboform program is presented [6].

Table 2.



In table 2, figure I presents orbital manufacturing in which the manufacturing axes are x, y, or z. In figure II orbital plane manufacturing is presented in which the manufacturing axes are x, y or z. In figure III a helical manufacturing is presented. Figure IV presents the vectorial manufacturing. Conical manufacturing in which angles from 0 to 90° can be programmed is presented in figure V. The manufacturing axes are x, y, or z. In figure VI, the convex spherical manufacturing with x, y or z axes is presented.

2. CAVITY CORE THAT HAS TO BE MANUFACTURED BY EDM

The cavity core is a result of a complex part that has to be used further in automotive industry. The complexity of the core imposes using the EDM method due to active edge that cannot be manufactured otherwise. The design of the core cavity was made using the ProEngineer software, with license at the company on which the part was designed, and this part is presented in the figure 3, below.

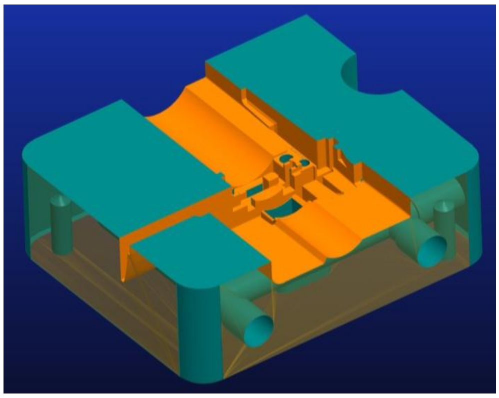


Fig.3. The core cavity.

In the most of the part area, the electrodes were designed using the spiral method, which assures a faster wear of the material and also a better time for manufacturing the metal.

The schematic principle of spiral method is presented in the figure 4.

It can be observed that, by using this method, on the "z axis" there will be no gap, but on the lateral side there will be a working gap (roughness, semi finis or finis). That means that the electrode is doing a circular movement, resulting in less manufacturing time and lower cost in comparison with the equidistant method.

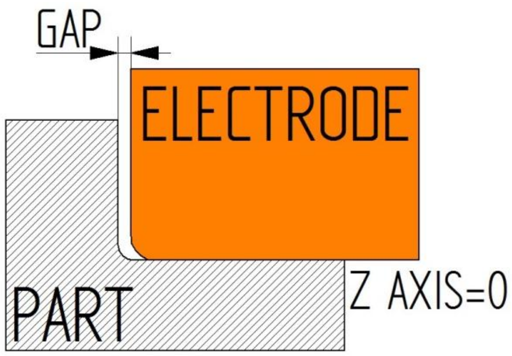


Fig.4. The principle of spiral method

But the spiral method cannot be used everywhere in the part area. Because there are some surfaces that are very difficult to design, in the respective area, the equidistant method is imposed. This method assures that the surfaces are well copied and the electrode will adequately manufacture the part. The schematic principle of equidistant method is presented in the figure below (figure 5)

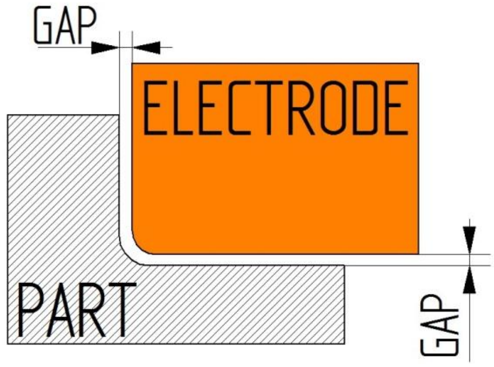


Fig.5. Equidistant method

The equidistant method has increased manufacturing time in comparison with the spiral method and usually the electrodes are quite complex, that means that they require more attention in designing and especially in manufacturing. This method is not widely accepted, but because special and complex surfaces cannot be done otherwise, it is accepted.

3. CHOOSING THE TECHNOLOGY FOR EDM AND DESIGNING THE ELECTRODES

In the cavity core presented above there were designed 28 electrodes for manufacturing the part. One of them was designed for roughness and for finis also in the area where a lot of material has to be removed. Excepting 3 electrodes that were designed using equidistant method because they had complex shape, the rest of the electrodes were designed to work using spiral technology.

The core of the cavity has to be empty of material, state which can be achieved by removing the metal according with the designed part. In the examples below (figure 6) all the electrodes and the part they remove from the cavity core are presented.

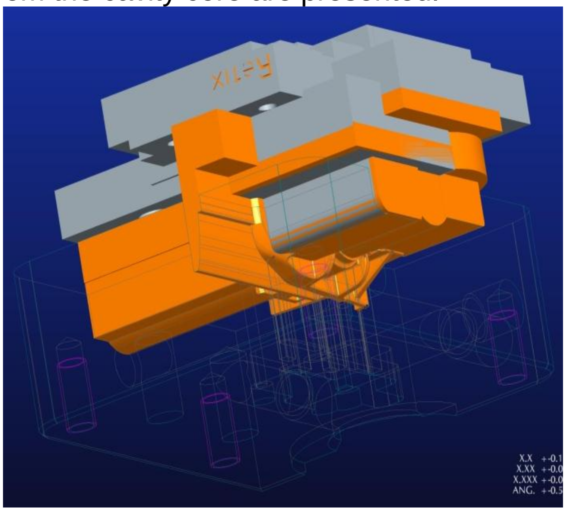
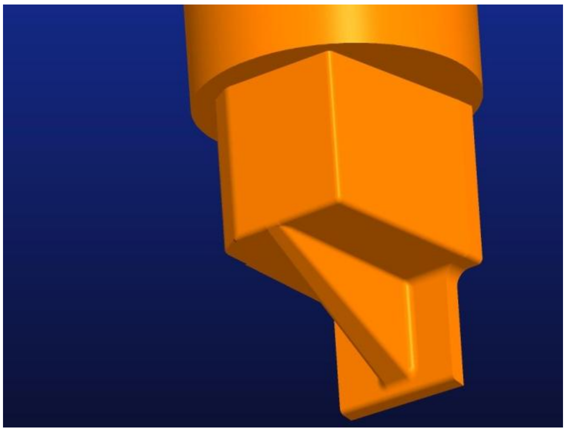
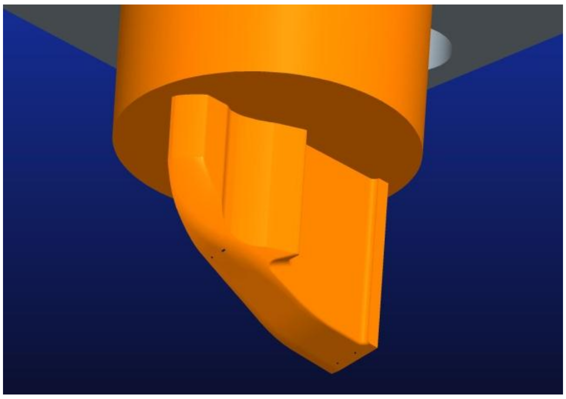


Fig.6. Electrodes for cavity core



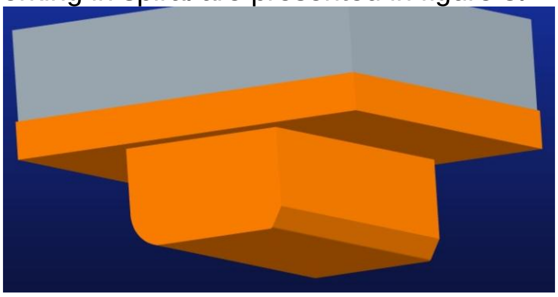
a.



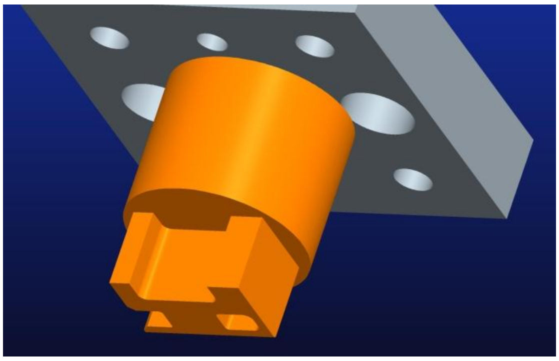
b.

Fig.7. Electrodes for equidistant manufacturing

It can be observed that the surfaces with complex shapes have electrodes with those surfaces copied (figure 7). The electrodes that are doing the spiral movement are covering the rest of the part, the order in which every electrode is working is given by a technological plan that depends on how much material was removed and how much is still there. Certain examples of electrodes working in spiral are presented in figure 8.



a.



b.

Fig.8. Electrodes for spiral manufacturing

4. CONCLUSIONS

EDM is considered the best method for manufacturing difficult parts and surfaces when CNC manufacturing is not possible. But choosing the right technology for the electrode working on a part is the most important problem. Considering that we can design the electrode with the working gap included in it, we can program the working table of the electric discharge machine to make the spiral movement which decreases the manufacturing time and reduces the cost. This paper demonstrated that the electrodes designed in spiral method are the fastest but they are not easy to design when they have to manufacture complex surfaces.

REFERENCE

[1] Flavius ARDELEAN, *Injection process optimization for a plate part using the Mold Flow software,* The 4th of the Interdisciplinarity in Engineering, International Conference, Inter-Eng 2009, “Petru Maior” University of Tg.Mures, 12-13 Nov. Tg. Mures, Romania

[2] Flavius A. ARDELEAN, Iulian STANASEL, Stefan MIHAILA, *Electric discharge machining for a sliding core of a plastic injection mould*, Revista de Tehnologii neconventionale 2009, University of Oradea, Romania.

[3] Flavius A. ARDELEAN, Sorin ILIE, Ştefan MIHĂILĂ AND Dan CHIRA, *Study of the mould cavity manufacturing using cam soft*,

[4] 4.*** http://nptel.iitm.ac.in

[5] 5.*** http://en.wikipedia.org/wiki/Electrical_discharg e _ machining

[6] 6. A. CHEVALIER, J. BOHAN, *Guide du technicien en productique, Hachette Technique, 1995*