

## **ELECTRIC DISCHARGE MACHINING FOR A SLIDING CORE OF A PLASTIC INJECTION MOULD**

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**Abstract:** In this paper, an electrical discharge machining method for a toothed part is presented. The toothed part has to be manufactured by this method because of the complex shape of the teeth and because of their small dimension. The teeth are displayed over a defined curve. The front side of the part where the teeth are, is under a  $1^\circ$  angle from the main surface. The part is a sliding core from a plastic injection mould.

**Keywords:** electrical discharge machining (EDM), electrode, dielectric, electrical discharge machine

### **1. PRINCIPLE OF EDM**

#### **1.1 What is EDM?**

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 pre-hardened 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 varying tolerances to be used, or, in the case

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 arcing 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  $8000^\circ\text{C}$  and  $12000^\circ\text{C}$ , which accelerates the removal of the melted shape material phenomenon from the surfaces of the two parts.

The moment when the potential difference between the workpiece and the cutting tool is interrupted, the abrupt decrease of the temperature induces the gas bubble implosion which causes certain dynamic forces with a major impact in projecting the melted material out of the formed cavity. The eroded material solidifies in dielectric fluid and it is eliminated by a dielectric flux from that area [2].

This microscopic phenomenon is rapidly produced and in a great numbers, resulting a macroscopic effect.

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

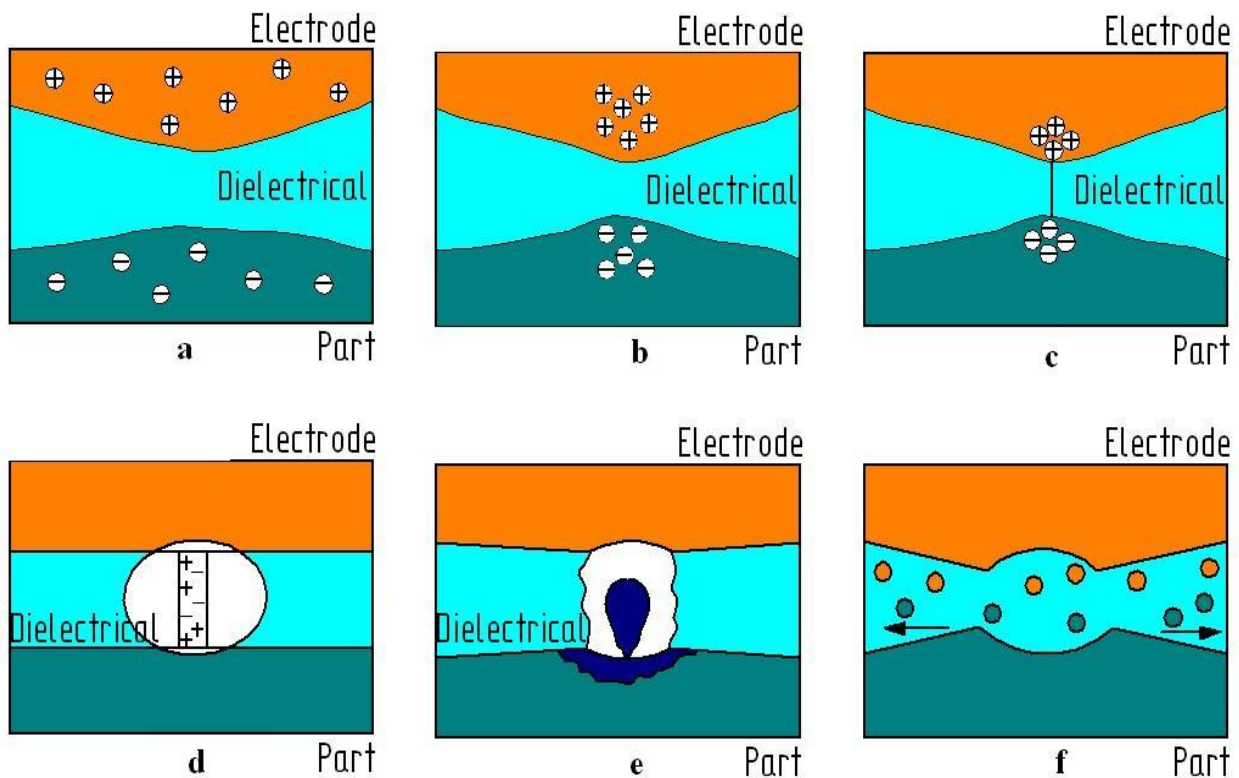


Fig.1. Principle of EDM

Table 1.

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

### 1.2 EDM on the electric discharge machines

There are two electric discharge machines for EDM: with wire (WIRE cutting) and with massive electrode (DIE SINKING).

The electric discharge machines with massive electrode reproduce in the metallic workpiece the geometric shape of the cutting tool, namely the electrode.

The mode of action depends on the chosen technology. Most used are equimode and spirale. The electrode geometrical shape is identical with the one of the part that will be

obtained. The electrodes are made basically from copper and graphite. Between the electrode and the piece there is never mechanical touch. During manufacturing, the workpiece is fixed on the machine table and the electrode is moving around the four axes: X, Y, Z and C (which is a round movement around its axis).

The common pieces, which are made using EDM technology, are plastic injection mould and its components (cores, sliding cores etc)

The scheme of the EDM with massive electrode on electric discharge machine procedure is shown in figure 2.

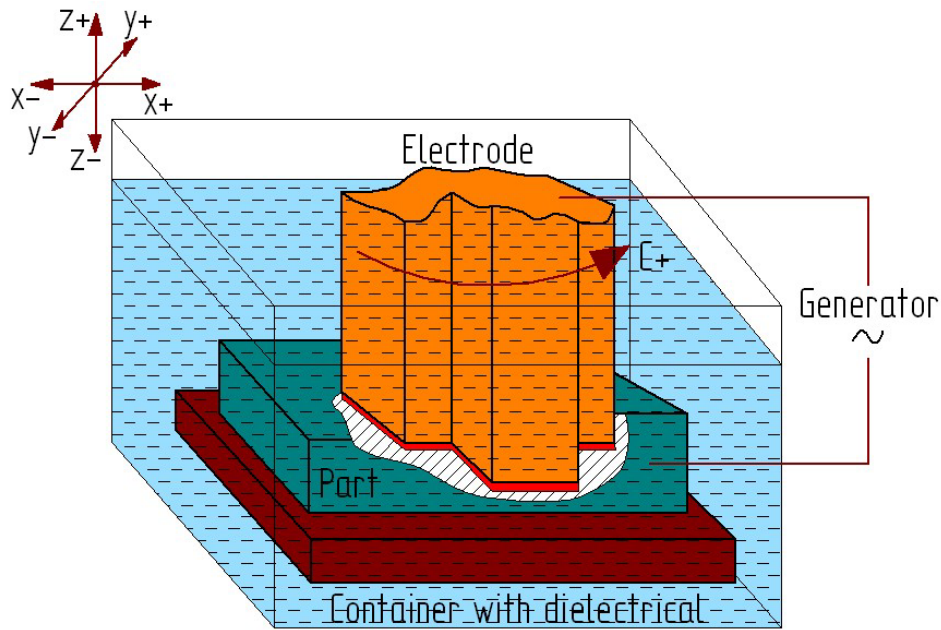


Fig.2. The scheme of EDM.

## 2. EDM OF “BAC” PART

The “bac” part is a sliding core from a plastic injection mould that had to be re-manufactured because of its great wear.

Most of the manufacturing operations were made on the CNC, except the front side

that has a toothed part and a 1° angle from the main surface, which had to be made using EDM.

The “bac” part, as it was projected, looks just like in figure 3.

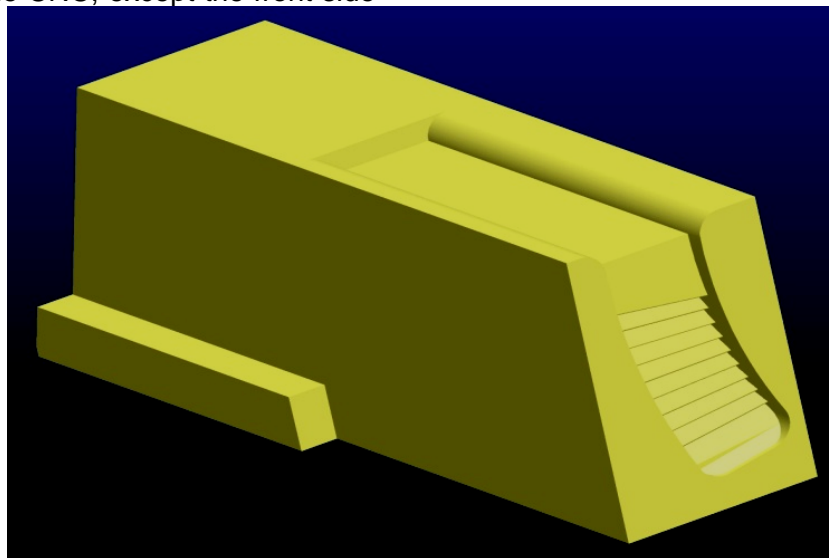


Fig.3. The “bac” part.

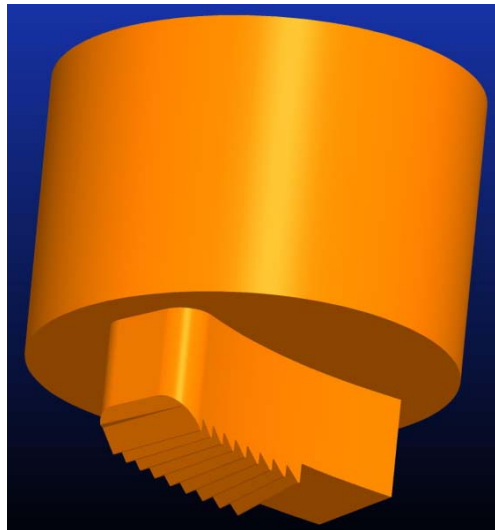
Analyzing the surface that requires EDM operations, we discovered that the EDM should be made in two steps:

**1st step** – a rough phase

**2nd step** – a finish phase

For the rough phase it was considered a 0.4 mm GAP for the cooper electrode which processes the “bac” part. For the finish operations it was considered a 0.2 mm GAP.

For those two operations it was considered two cooper electrodes with the GAP as it were projected, a picture of an electrode with 0.4 mm GAP being shown in figure 4. It is important to consider the final part dimension in designing the electrodes due to the fact that the finish electrode will give the final dimensions of the piece.



**Fig.4. 0.4 mm GAP electrode**

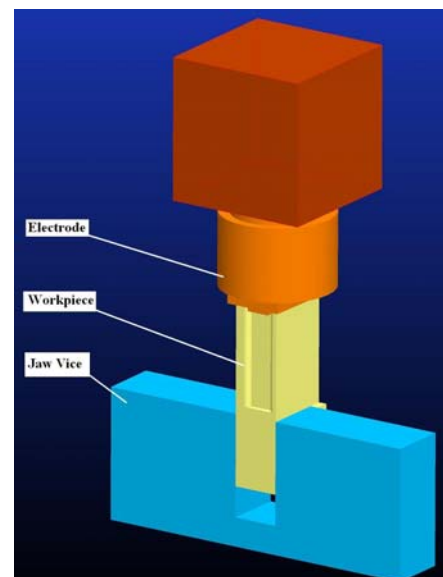


**Fig.5. Charmilles Roboform 20 EDM machine.**

The chosen technology for the EDM for the “bac” part was equimode, the machine for manufacturing being Charmilles Roboform 20, as in figure 5. EDM manufacturing of the workpiece was made with the part fixed on the jaw vice on the machine table, as in figure 6.

A detail which simulates the electrode that approaches the workpiece, is shown in figure 7. This detail reproduces the exact movement of the real electrode as we manufactured at the place where the part was made.

The final part can be observed in figure 8, a after all the operations were done and in figure 8, b the initial wear part. In initial part it can be seen the wear at the toothed side part which produce many disadvantages to the plastic injected part.



**Fig.6. Scheme of the “bac” part EDM.**

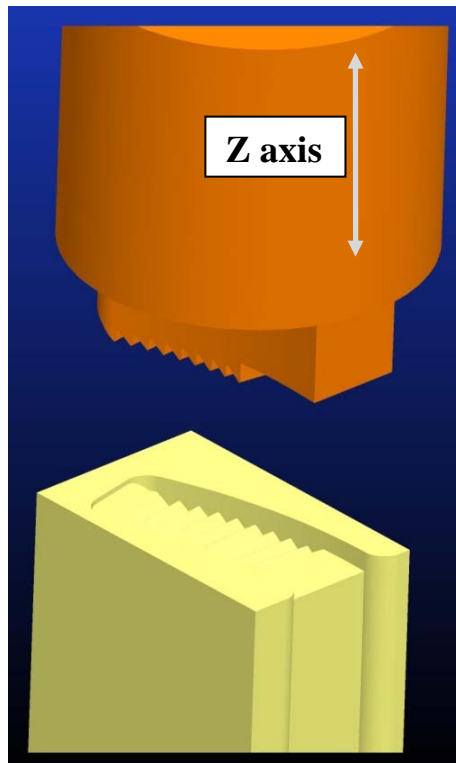


Fig.7. Detail of EDM for the ‘bac” part.

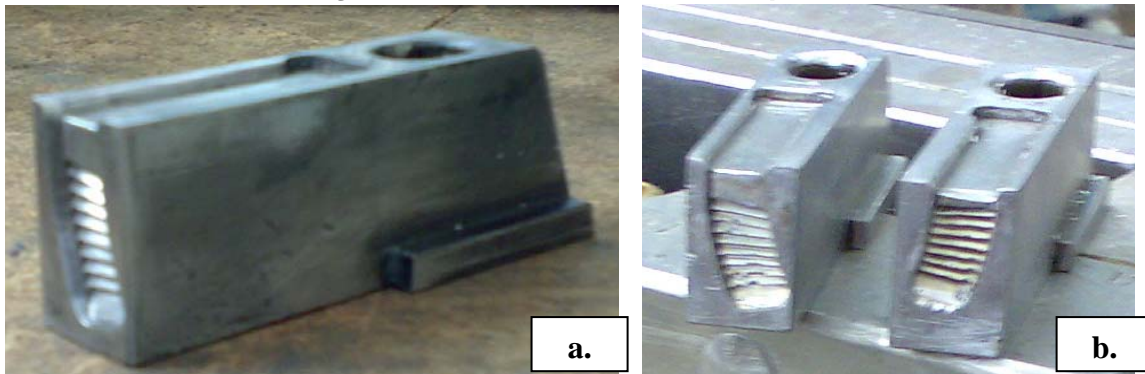


Fig.8. Part “bac”.

### 3. FINAL CONSIDERATIONS

Using the die sinking method (EDM with massive electrode) for complex cavities manufacturing in steel blocks was required due to its high capacity in realization dimensional accuracy and for obtaining more and more complex shape for plastic injection mould and its components.

The previous presented part requires an EDM because of its shape which cannot be processed with classical methods. The toothed part, with small teeth (aprox. 1 mm), arranged over a curve and with a slope surface to a 1° angle would be processed on EDM over the Charmilles Roboform 20 machine. The part is fixed on the machine table by the help of a jaw vice and the

electrode is doing the z axis movement. The working program for the EDM machine was write on the design office and it was send to the machine in the working hall, the program being transferred into the machine equipment directly from the PC.

### REFERENCE

- [1] \*\*\*<http://encyclopedia.thefreedictionary.com>
- [2] \*\*\*<http://www.charmilles.ro>
- [3] Flavius Ardelean, *Injection process optimization for a plate part using the Mold Flow software*, The 4<sup>th</sup> of the Interdisciplinarity in Engineering, International Conference, Inter-Eng 2009, “Petru Maior” University of Tg.Mures, 12-13 Nov. Tg. Mures, Romania