CAD-CAM SYSTEMS USED FOR DESIGNING AND MANUFACTURING OF AN ELECTRODE USED FOR THREADING BY MEANS OF ELECTRICAL ERROSION

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ABSTRACT: Electrical discharge machining, known as EDM, is one of the most known and used nonconventional manufacturing method. The material is removed by the erosive effect produced by the electric discharges that occur between the electrode and the workpiece. The performance of the process depends on many factors including the material and the complexity of the electrodes shape. The cost of the part is influenced by the material, the complexity of the electrode shape and the way it has been manufactured. The continuous progress of computer aided systems has allowed the development of high-performance applications in the mechanical field, in the field of computer-aided design and the field of assisted manufacturing technologies, making it possible to design and manufacture increasingly complex parts. . In the current competitive market, with an emphasis on reducing costs, this paper proposes a variant of processing a thread on a part of a mold using a simplified electrode
KEYWORDS: EDM, Discharge, Electrode, Copper, Dielectric

1. INTRODUCTION

Electrical discharge machining is based on the removal of the material in a dielectric medium by the action of electrical discharges that occur between the electrode and the workpiece. Under certain conditions, when the intensity of the electric field reaches a certain value, the local rigidity of the dielectric is penetrated resulting an electric discharge that determines the formation of erosion craters by melting, evaporation and local expulsion of the material, which has the effect of processing the part and wear of the electrode. This manufacturing method can be used only on materials that are conducting electricity.

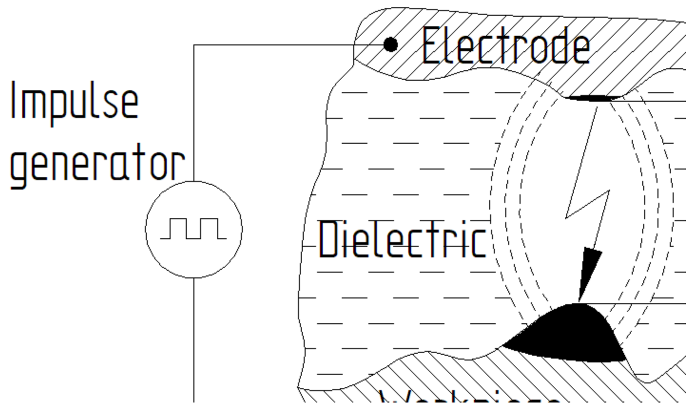

Figure 1. – EDM process

Due to the electric discharges in the dielectric liquid, irreversible chemical processes take place that produce the modification of the electrical rigidity and the space between the electrodes. This makes it necessary to force the dielectric liquid into the working gap.

The performances of the process are determined by several factors involved in the work process;

- parameters of electrical impulses;
- parameters ordered by the technological equipment;
- programmed characteristics of the working fluid circulation equipment and those of additional actuation of the electrode, which is the object of energy transfer;
- characteristics of the part material;
- characteristics of the electrode material
- characteristics of the work environment

The most widely used performance indicator of this manufacturing process is the manufacturing productivity, Qp [mm3 / min] [1]. In the case of bulk electrode erosion processing, Qp is defined as the volume of material removed from the object to be processed, Vp [mm3], being correlated to the total processing time Tp [min]:

$$Q_p = \frac{V_p}{T_p} \qquad (1)$$

Average conventional manufacturing speed v_{pc} [mm/min];

$$v_{pc} = \frac{L_{pc}}{T_p} \qquad (2)$$

Specific productivity for the used current unit Q_{pl} [mm^3/min·A]:

$$Q_{p1} = \frac{Q_p}{I_m} \qquad (3)$$

Regarding the surface quality there are two aspects taken into account: the microgeometry of the surface and the properties of the surface layer.

Roughness is usually followed by the arithmetic average deviation of the roughness profile, Ra [μm].

Installation characteristics between the workpiece and transfer piece are having a decisive influence on several performance indicators, but, in particular, they influence the dimensional accuracy of the object to be processed.

There are some cases when it is necessary to obtain a high dimensional accuracy. For this, a roughing electrode is used in the first phase for processing, then a semi-finishing electrode, and in the last phase a finishing electrode is used.

To eliminate these deviations, it is very important to use specialized devices for gripping, centering and processing both the electrodes and the workpiece. Modular clamping and machining devices are currently used, which can be adapted to both milling machines and numerically controlled lathes; they process the electrode directly into the clamping device, together with which it will be mounted on the EDM machine. [2].

Also, in the case of complex-shaped and thin-walled electrodes, graphite electrodes can be used, which can be processed in better conditions than copper ones. In [3] is presented a case study carried out for a part of the automotive industry on numerically controlled machines in which a device for fixing the graphite workpiece during electrode processing was used, which is then mounted on a EDM machine, using the same device in which it was fixed during processing, which allows to reduce the fixing time, but also the positioning errors.

In papers [4] and [5] we can find presented a computer-aided method for designing electrodes for electrical discharge manufacturing used in the manufacture of plastic injection moulds. The design of the electrode is based on the fact that the shape of the electrode is obtained automatically in the 3D modelling application by selecting the surfaces that limit the place to be processed on the part. The system takes into account the type of operation being performed and can design electrodes for roughing and finishing. The system also allows both the 3D model of the electrode and its support. This method has proven to be effective, reducing the design time of the electrode.

In [6] is presented a detailed study of the design and processing of electrodes for electrical discharge manufacturing. There are also reviewed some research that takes into account a reduced manufacturing time, costs and presents the evolution and furthers research.

Starting from the premise that the manufacturing cost of a part obtained by EDM depends very much on the cost of the electrode, the article [7] presents a study on the possibility of making electrodes from different materials and by different processing methods, taking into account the possibility of obtaining them by additive manufacturing.

In order to design an efficient electrode, researchers [8] approach a study on the influence of electrode size on productivity and roughness obtained by EDM. Experiments are performed with several types of electrodes, and after data processing the electrode that ensures optimal performance is highlighted.

In order to ensure optimal cleansing to remove the eroded material from the working gap and to allow proper cooling, article [9] provides data of an electrode made of a bundle of smaller electrodes grouped in a cell whose shape resembles the shape to be manufactured. A machine specially designed for this purpose is used to make the electrode bundle. The obtained electrode is used for the roughing processing of complex surfaces. In addition to the efficient washing and cooling of the gap, another advantage is related to the manufacturing costs of the electrode, which is much lower compared to the classic method of milling.

Article [10] presents an innovative study on the possibility of making electrodes by rapid prototyping using Fused Deposition Modelling (FDM) technology and metallic coating of the copper electrode. Comparative tests were performed on the performance of the electrode. The processing productivity, the surface roughness, the electrode wear were studied, resulting that the electrode designed and made by FDM technology behaved similarly to the conventional electrode. The study also highlights the factors that influence the behaviour of the electrode made by RP, the quality of the deposited copper layer being one of the factors with major influence. The method can be applied in situations where the shape of the electrode is complex, obtaining by RP being more convenient than that by milling.

In [11] is presented a method of obtaining electrodes for EDM also by the rapid prototyping method using gypsum powder and then coated with nickel and copper. The 3D model of the electrode is made in a CAD application and then transferred to a 3D printer adapted to work with gypsum powder. The method allows to obtain electrodes of complex shape in a short time and with low manufacturing costs. The processing results show that there are no significant differences between the electrode obtained by the proposed method and the classical electrode.

2. ELECTRODE DESIGNING

The 3D model of the bottle is shown in figure 2, and in figure 3 shows the 3D model of the half-mold designed to obtain the bottle. The thread has a size of 1 ”, the angle at the top is 55^0, and the pitch is 11 steps per inch.

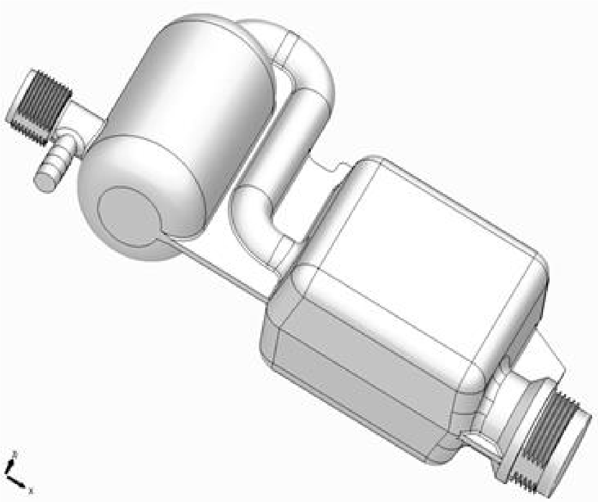

Figure 2. – The CAD designed workpiece – this workpiece represent an expansion tank for different washing machines

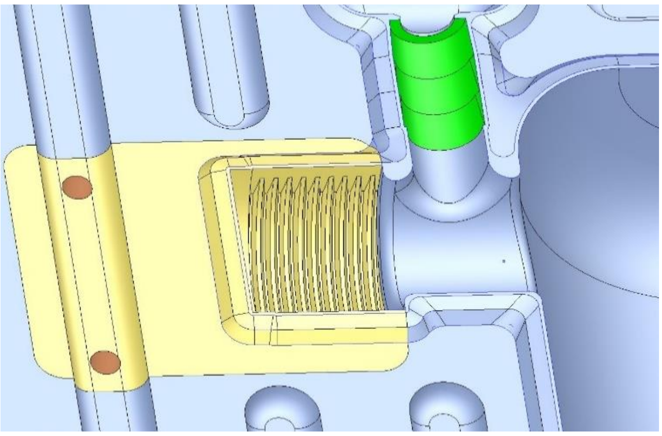

Figure 3. - Thread to be obtained via EDM

$$T_E = (0.3 \div 0.5) T_W$$

TE - electrode manufacturing tolerance

TW - the manufacturing tolerance of the surface to be processed written on the drawing

The manufacturing costs of electrical discharge machining also depends on the material from which the tool electrodes are made, the cost of which can reach up to 20%… 60% of the total cost [1]

From the material point of view, electrodes from any good electrically conductive or semiconductor material with good thermal conductivity can be used for EDM. For the designed electrode, in our case, copper was used as material with the properties presented in table 1, but there can also been made of graphite or any conductive materials.

As mentioned, in order to reduce the manufacturing cost of the electrode, the copper consumption and the processing time of the electrode, it was decided that the thread on the pellet to be made coil by coil using a lamellar copper electrode, on which half of the thread is done. The shape of the electrode is the negative of half the coil of the thread. The 3D model of the active surface of the electrode is presented in fig.4.

Table 1. Copper electric properties

Material	Cu
Density (g/cm^3)	8.94
Electrical resistivity (pΩ cm)	1.7
Thermal conductivity (W/mK)	388
Linear expansion coefficient (x 10^{-6}/K)	16.4
Melting range (°C)	1065-1083
Specific heat (J/kg K)	385

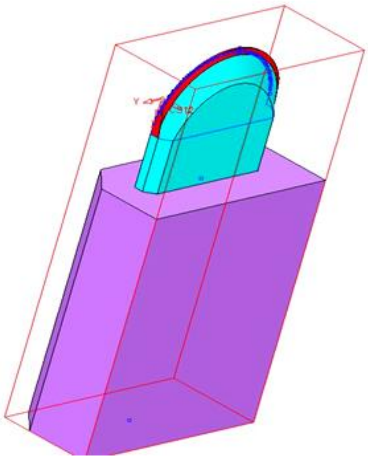

Figure 4. – Electrode active surface

To make the thread on the entire surface, after processing one half of the coil, the electrode will be moved along the axis of the threaded cavity with an axial step (Figure.5).

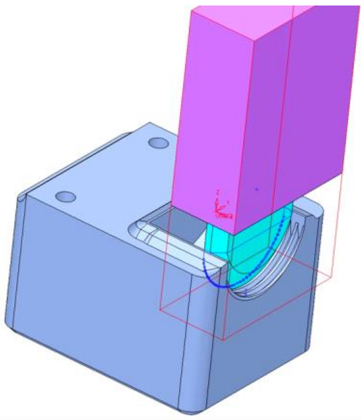

Figure 5. - Threaded cavity

3. ELECTRODE MACHINING

Due to the complex shape of the active area of the electrode, a CAM application was used for processing that allows the rapid generation of tool paths used in processing. The general processing steps are comprised in figure 6.

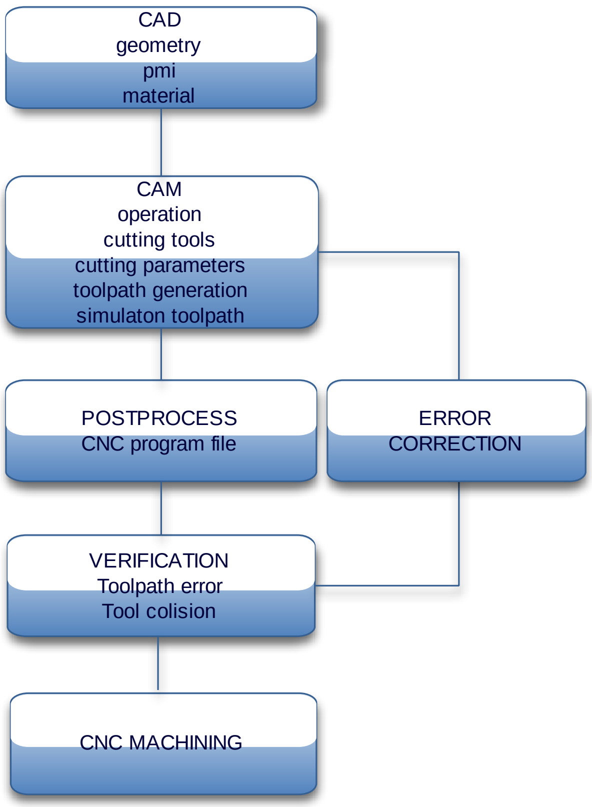

Figure 6. – General processing steps

In the CAM application used, the coordinate system used for processing, the geometry of the blank part and the part were defined, the cutting tools, the processing operations and the manufacturing parameters for each operation were defined. In figure 7 it is presented the tool path for finishing the electrode, and in figure 8 it is presented the simulation of the manufacturing process.

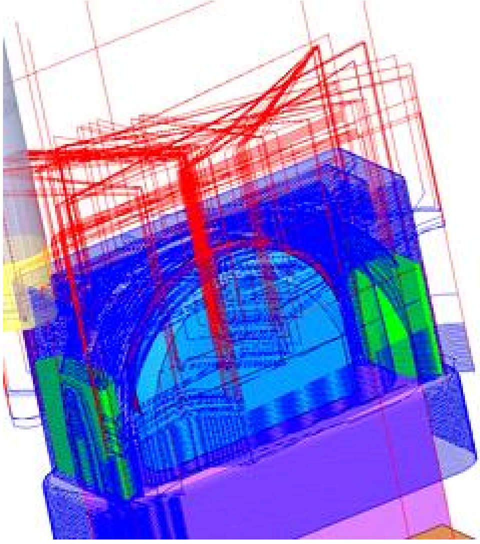

Figure 7. – Tool path

The CNC program obtained after post-processing (figure 9) is checked and implemented on the milling machine with numerical control. The electrode resulting from the manufacturing process is shown in Figure 9, and in Figure 10 is shown the threaded workpiece.

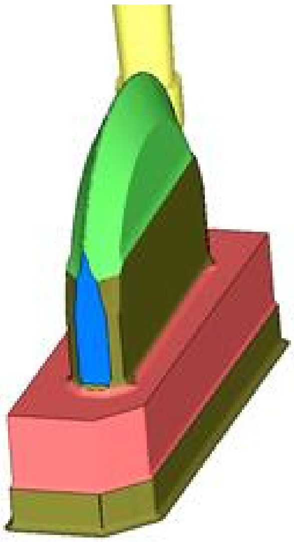

Figure 8. – Process simulation

Figure 9. – The processed electrode

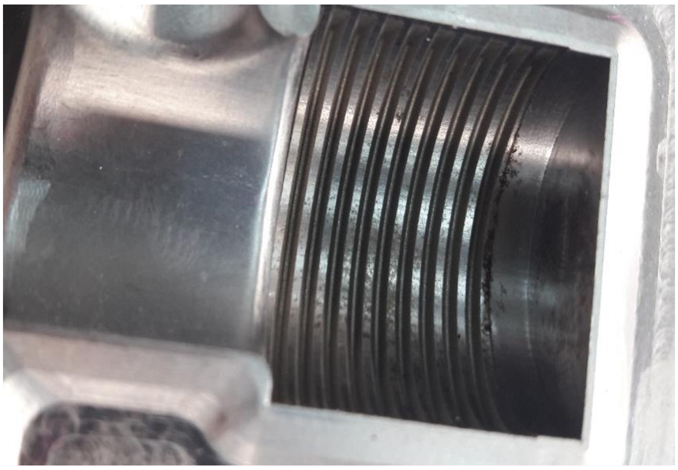

Figure 10. – Threaded workpiece

4. CONCLUSIONS

This paper is part of the current research and also we can see that there are concerns about increasing performance and reducing costs for EDM processes. There are different approaches for choosing the material, electrode shape design, manufacturing method. Starting from the virtual 3D model of the mould using a Boolean operations in a high-performance CAD application, the surface to be processed by erosion was extracted. The finishing electrode and the roughing electrode were then designed taking into account the relations regarding the execution tolerances presented in the paper. The complex surface of the electrode was machined using a CAM application that allowed obtaining the tool paths used for machining on numerically controlled machines. The simplified shape of the electrode allowed its realization with minimal costs, both in terms of material consumption and processing time.

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