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SURFACE QUALITY OF THE EDM PROCESSED MATERIALS

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Abstract – The article presents the importance of the EDM technology in the industry of machine building. It is mostly used in the machining of stamps and special processes in which the conventional technologies are inefficiently. It's known that only condition of machining with this method is that the material should be electro conductive. The main parameters that are followed during the process are the precision and the roughness of the surface. The collective tried to emphasise the importance variation of the roughness concerning some machining parameters. Some of the measurements were conducted at ETH Zurich using an electronic microscope.

Keywords: machining, EDM, roughness.

1. BASIC INFORMATION

In 1942 the Lazarenko couple discovered the EDM process. At the beginning it was used only in the military industry. EDM performed a long way till to its present high performances. EDM has appeared as a necessity to manufacture materials with better mechanic and thermal characteristics. The major advantage of EDM in comparison with other manufacturing processes is represented by the fact that the hardness of material is not important, the only condition being that the processed material must be electro conductive [1].

Today, the world is participating at an extraordinary growth of electronic and automatic, aeronautic and special industry, nuclear or micro technologies. All this domains have made the unconventional technologies to arrive in the top concerning the domain of manufacturing. This was possible by discovering new materials that are hard and sometimes impossible to be processed. Also the new dimensions in the electronic and automation opened the gates for the unconventional technologies to take position in the research departments.

Even if the unconventional technologies are for long time studied, some aspects are not yet perfectly known. For the industry that is using those technologies (for example EDM) is important to know every detail that could influent the quality of the work piece that is wanted to be manufactured.

2. GENERAL ASPECTS OF THE EDM PROCESS

One of the most known and studied unconventional process is EDM (Electrical Discharge Machining). The main principle of processing the material is to copy the form of the work tool into the work piece. Apparently it is a very simple process but it involves many phenomena during the process.

Electric discharge machining process is complex and stochastic in nature. The process involves a combination of several disciplines such as electrodynamics, electromagnetic, thermodynamic, and hydrodynamic making it difficult to present the process in a comprehensive model [2].

In EDM, conductive work piece materials are removed for the purpose of machining in a dielectric by electrical discharge. The material removal results from the erosive effect of subsequent, time wise separated, no stationary or quasistationary discharges between electrodes, i.e., between tool and work piece. Each discharge generates a microscopic removal on the two electrode surface. In principle, the process is based on thermal erosion. Hence, an efficient EDM process can only be realized by a purposefully uneven material removal on the two electrodes. Wire – EDM as kinematical variant of EDM allows hereby the machining or respectively, production of complex geometrical contours.

The properties of diatomic plasma were taken as a constant and the fluid dynamic equation was included in the model. Eubank [3] reported variable mass cylindrical plasma which expands with time. For an EDM process with a current of 2.34 A, the temperature and pressure of the plasma channel were approximated to be 11,210K and 54 bar after 6 µs. Another approximation of plasma channel for micro-EDM process was reported by Dhanik and Joshi where the temperature and pressure were found to be in the range of 8100±1750K and 6–8 bar, respectively [2,3,4].

One of the parameters that depend on these phenomena is the roughness of the surface obtained by processing a work piece with EDM process [5].

3. RESEARCHES ON THE SURFACE OF THE MACHINED WORK PIECE

Measurements of the surface were made both on the wire EDM and sinking EDM machined work pieces. The two processes are similar concerning the thermal and physical processes. The differences appear in the dielectric and in the material o the work tool. As a general characteristic in the two cases the material removal rate is created by successive craters as it appear in the figure 1.

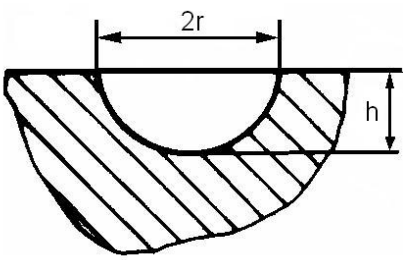


Fig. 1. Teoretical representation of the EDM crater.

The dimensions of the r – radius of the crater - and h – depth of the crater, depend directly of the parameters of the machining process.

$$h = C_H \cdot E_i^{\ p} \text{ [µm]} \qquad (1)$$

Where: C_H=190 for steel and steel alloys with Cr;
C_H=67 for hard alloys;

Expressing the E_i:

$$E_i = \frac{U_m \cdot I_m}{f} \text{ [W]} \qquad (2)$$

It obtains:

$$h = C_H \left(\frac{I_m \cdot U_m}{f} \right)^p \text{ [µm]} \qquad (3)$$

Most of the machined surfaces have a roughness (Ra) between 1,5 and 4 µm. In some cases the if the client request, the roughness of the surface can arrive at a value of 0,1 µm. Of course this would take time and implicit money.

3.1. Measurements of the surface roughness.

Some measurements were made on machined work pieces that were obtained by Wire EDM.

Some experiments were made by the collective to improve the knowledge that is necessary to obtain prescribed quality of the surface in a short time and with low costs.

For a higher hardness, the test pieces were thermal treated. (Table 1.)

The dimensions of the test pieces are:

- length L= 80mm;
- width l= 20mm;
- height h= 10÷50mm;

The roughness of the surface was measured on the middle of the height. For the same thickness of the work pieces the value of the roughness are oscillating between 1, 85 µm and 2, 70 µm as it can be seen in the figure 2.

Table 1: Values of the hardness of the metal

Material	OLC45	42MoCr11	OSC7
Obtained hardness	241 HB (21,2 HRC)	263 HB (24,7 HRC)	640 HB (61,9 HRC)

The roughness of the surface was measured on the middle of the height. For the same thickness of the work pieces the value of the roughness are oscillating between 1, 85 µm and 2, 70 µm as it can be seen in the figure 2.

For the work pieces that have thicknesses over 70 mm, it can be observed the difference between the roughness from the bottom and the middle of the work piece.

On a work piece with a thickness of 110 mm, the measurements were made from the bottom to the middle of the work piece and the roughness grows from 2, 7 µm up to 5, 5 µm as it can be seen in fig. 3

This phenomenon takes place because the nozzles for dielectric are placed at the top and at the bottom of the work piece and the pressure is not big enough to be able to wash all the particles.

In the industry the roughness that is obtained is very important. On this parameter depends the quality and the aspect of the product.

Today the new machines with the command and control system that assist the process make the work of the operator easier. Some of the machines have the capability to estimate the time that remains for the process, material removal rate and the roughness. Usually this parameters are not real. The roughness can modify concerning dielectric and the washing possibility of the machine as it is shown in the figure 3.

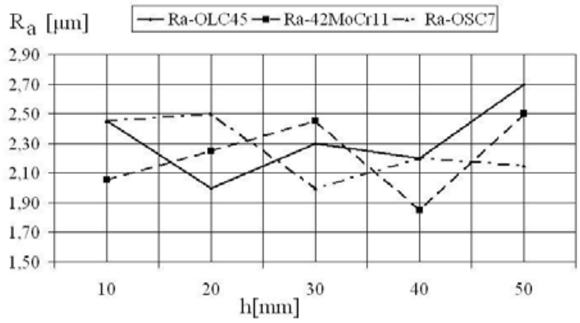


Fig. 2. Roughness variation depending on the material

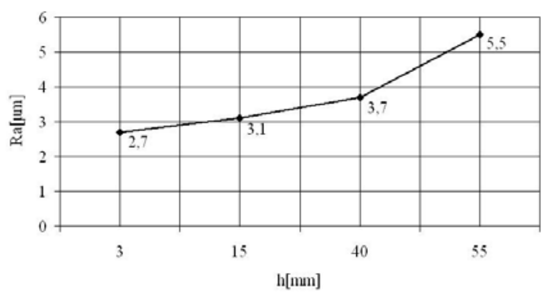
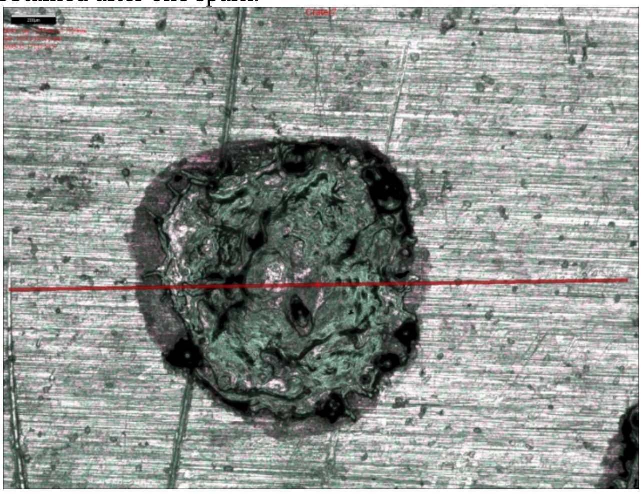


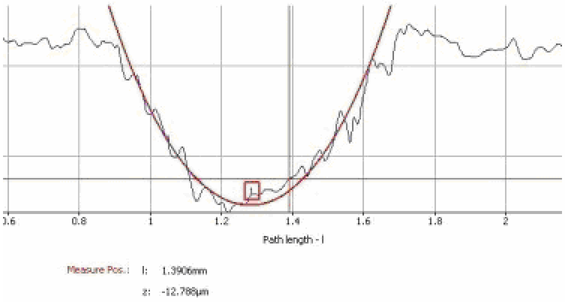
Fig. 3. Roughness variation depending on the material

3.2. Mathematical model of the crater

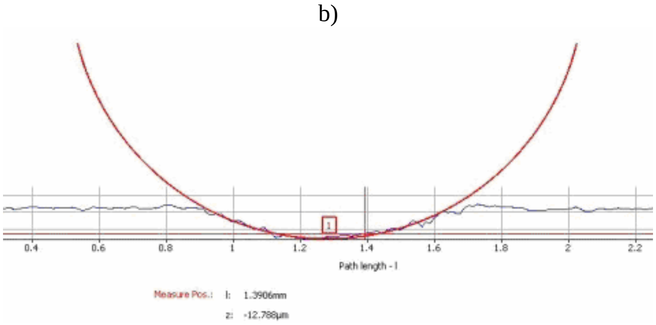
Building a mathematical model of the EDM process, would help us anticipate the dimensions of the crater that is obtained after one spark.



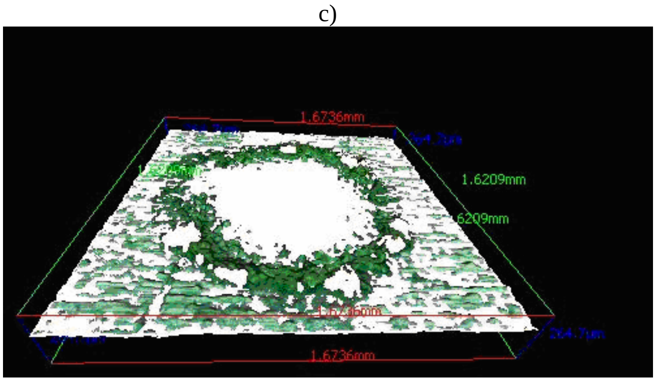
a)



b)



c)



d)

Figure 4: Crater measurements with Alicona microscope. a) – normal view of the single crater, b) – dimension of the crater radius measured with the InfiniteFocus sonfware (rcrater=766 µm), c) – real dimension of the crater radius reported to the measured surface dimension. d) – volume measurements of the crater.

Also they can't be studied because of the very short time in which the spark takes place.

These would be an important step in approximating the parameters that are necessarily for a specific roughness. EDM has today variously applications in the industry but it wasn't yet studied in detail and many of the phenomena are not good known.

In the figure 4 was measured one of the craters obtained with the normal removal rate of the material. In figure 4.d) is shown the volume measurement. For that the software offers the function to work with the volume of the object that is measured. For that it is necessary to chose a plane so that the soft could rapport the measurements. In this case the volume above the crater is V_{above}= 11513351 µm^3 and the volume above the surface V_{below}=21322934 µm^3. Two problems appear during the process. One is the exactly of the measurements that Alicona microscope is doing and another is the light reflexion of the processed surface. As in figure 4.a) can be seen appears some black points. Some of them are because the surface is too dark and the light from the microscope is not reflected and some of them because the surface reflect too much light. During the measurements all these reflections generates errors for the results.

To eliminate the errors, all the measurements will be reduced to estimate the dimensions of the crater to an ideal form of a spherical calotte. By knowing the radius and the depth of the calotte, it will result the volume of the removed material.

4. CONCLUSIONS

The article presents the main results obtained during the EDM process.

For the industry it would be important to prepare a bibliotheca with specified parameters for machining different materials. For example for the same kind of machining (roughing or finishing), in the tables of the machine-tools, the parameters are optimized but it is not specified the quality of the surface that can be obtained.

The dimensions of the crater influence directly the roughness of the surface. All these measurements were possible by using an electronic microscope (Alicona microscope).

Also a mathematical model will improve the knowledge of the phenomena and it will open the possibilities of using the process in different applications.

Our researches wants to show the importance of all parameters that can influence the quality of the process and in the future we will prepare a bibliotheca that will complete the CAM programs by having a larger table of materials and machining parameters. By generating a mathematical model will be possible to build for every machine type a bibliotheca of parameters.

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