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INFLUENCE OF MACHINED MATERIAL TYPE TO THE SURFACE ROUGHNESS WHEN USING WIRE ELECTRICAL DISCHARGE MACHINING

VPLYV DRUHU OBRÁBANÉHO MATERIÁLU NA DRSNOSŤ POVRCHU PRI ELEKTROEROZÍVNOM REZANÍ

Abstract

In the manufacturing process of complex components we use unconventional or progressive machining methods which can efficiently and with great precision achieve the desired result. We are talking about electro discharge/erosive machining. From an economic perspective, these technologies are used in manufacturing of high precision and complex parts, where it is necessary to achieve accuracy to the thousandth of a millimetre with the machined surface roughness Ra = 0.1 μm. These technologies can be used to machine all conductive materials and materials that are difficult to machine by conventional methods, such as sintered carbide and hardened steel. Most commonly used progressive machining methods are sinker EDM and wire EDM. [2]

Abstrakt

Pri výrobe zložitých súčiastok využívame nekonvenčné, alebo progresívne metódy obrábania, ktoré dokážu efektívne a s veľkou presnosťou dosiahnuť požadovaný výsledok. Hovoríme o elektroerozívnom obrábaní. Z ekonomického hľadiska sa tieto technológie používajú pri výrobe veľmi presných a zložitých súčiastkach, kde je potrebné dosiahnuť presnosť až na tisíciny milimetra s drsnosťou obrobeného povrchu až Ra = 0,1μm. Týmito technológiami sa dajú obrábať všetky vodivé materiály, a materiály ktoré sú bežnými metódami ťažko obrobiteľné, ako napr. spekané karbidy a kalené ocele. Najčastejšie používané progresívne metódy obrábania sú elektroerozívne hĺbenie a rezanie.

1 INTRODUCTION

Physical foundations of electro-erosive cutting

Charged particles in electric fields gain kinetic energy, which is together with the output work transmitted to the surface of electrodes. This results in converting electrical energy into heat in discharge. The affected area on the surface of the workpiece material is rapidly heated, melts and partly evaporates. Pressure of metal vapour from the molten metal causes eruptions. This creates a crater; its proportions depend on the machining material characteristics and the parameters of the system. Discharges repeat with some specific frequency, gradually emerging craters overlap, until the entire

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surface is machined. Especially important is so-called spatial discharge density, which is the cause of small cavities on the surface of the electrodes, where their volume, diameter and depth correspond exactly to the size of the discharge. Machining takes place at two electrodes immersed in the working media. This medium is dielectric, i.e. liquid with high electrical resistance. The onset of discharge occurs at the strongest voltage electric field. Due to the action of this field are free negative and positive ions put into movement, they accelerate and take a high speed. In this state begins between the electrodes electrical current flow and between the electrodes origins a discharge, which raises a number of other particle collisions. A plasma zone is produced, which reaches very high temperatures (3,000 to 12,000° C). [4]

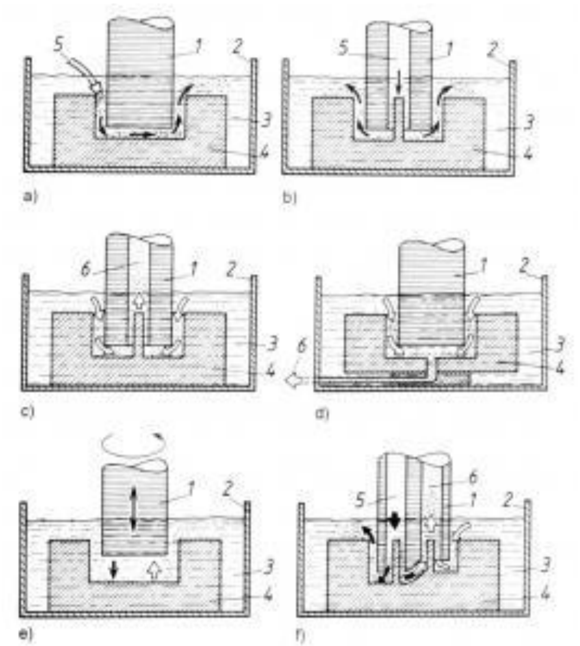

Fig. 1 Dielectric supply between the workpiece and tool electrode.
a) internal purge, b) internal pressure purge, c), d) suction; e) pulse; f) combined 1 - tool electrode, 2 - working bath, 3 - dielectric, 4 - workpiece, 5 - dielectrics inlet, 6 - suction of dielectric

2 MATERIALS AND METHOD

Tools for electric discharge machining

Electro-erosive cutting is mainly used when manufacturing tools and moulds. Tool electrode performs in the electro process an active role. Specific requirements are needed such as: high thermal and electrical conductivity, sufficient mechanical strength, small size and shape tolerance, achieving a high removal of particles of the workpiece at a low electrode wear, reasonable price. Electrodes have negative shape of the machined area. They consist of working part - directly entering the machining process, and mounting part - used for fixing and mounting electrodes.

a) b)

Fig. 2 EDM machine. [3]
a) Fanuc robocut α-ic b) Charmilles robofil 290

Machined materials

EDM machine is used for cutting and carving of simple and complex shape elements into the instrument boards before and after thermal treatment. We used following materials for these experiments [5]:

Steel 11 730 - Steels grade 11 have prescribed purity (sulphur and phosphorus content). Their features are given by the carbon content which is not exceeding 0.7 % - the higher is the content, the stronger and harder is the steel, but the toughness, ductility and malleability is decreasing.

Steel 12 842 hardened to 56 HRc - stainless steels (according to STN 42 0074 and 42 0075 belonging to class 12 to 16) are steels intended for heat treatment.

Copper - most commonly occurs in nature bound to sulphur, to which it has high affinity (chalcopyrite is the most common - $CuFeS_2$, further bornite - Cu_3FeS_3).

Brass - brasses are alloys of copper (Cu) with 5 to 40 % zinc (Zn). Excellent plasticity and workability with good corrosion resistance is combined in them.

Duralumin - high strength of aluminium alloys is related to their hardening, it is a sequence of heat treatment steps, causing precipitation of finely dispersed intermetallic compounds that prevent dislocation movements and thereby cause an increase in strength. This may reach up to 700 MPa.

Machine setting - syntax of the programme

The programme, which defines the geometry of the workpiece, must start with a block, containing G92 (beginning coordinates), which therefore must be placed before the first block describing the geometry segment. Function G92 defines the position of the wire at the beginning and during the programme, considering the beginning of defined program. Implicitly location of the wire at the start is identical with the start position of the program [3].

Generator setting

In the first roughing cut is in the generator set the command REX (REX, E2, H10, E2 - standard roughing, H10 - height of cut material).

The CLE offset value is left in both sections and also when finishing the set at zero.

For the purposes of measuring power straight cut must be made. After a roughing cut, generator must be set for finishing cut. This procedure is repeated for each of selected materials.

Monitored and measured values

Table 1 Duralumin.

Carried cut	Roughness of the cutting materials - Ra		
	Sample 1	Sample 2	Sample 3
Roughing cut	3.63	3.51	3.79
Finishing cut	2.45	2.49	2.62

Table 2 Copper.

Carried cut	Roughness of the cutting materials - Ra		
	Sample 1	Sample 2	Sample 3
Roughing cut	2.83	2.18	2.40
Finishing cut	1.23	1.24	1.12

Table 3 Brass.

Carried cut	Roughness of the cutting materials - Ra		
	Sample 1	Sample 2	Sample 3
Roughing cut	2.09	2.47	2.31
Finishing cut	1.76	2.19	1.48

Table 4 Steel 11 730.

Carried cut	Roughness of the cutting materials - Ra		
	Sample 1	Sample 2	Sample 3
Roughing cut	2.54	2.64	2.64
Finishing cut	1.64	1.83	1.61

Table 5 Steel 12 842 hardened to 56 HRc.

Carried cut	Roughness of the cutting materials - Ra		
	Sample 1	Sample 2	Sample 3
Roughing cut	2.46	2.44	2.44
Finishing cut	1.70	1.97	1.54

Table 6 Average roughness of cut materials.

Carried cut	Duralumin	Copper	Brass	Steel 11 730	Steel 12 842
Roughing cut	3.64	2.47	2.29	2.6	2.45
Finishing cut	2.52	1.2	1.81	1.69	1.74

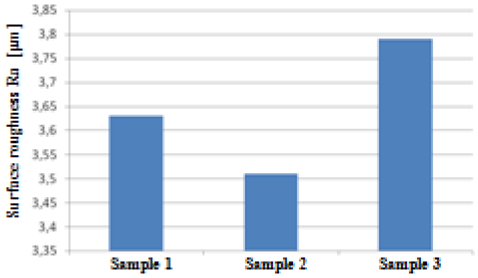

Diagram 1 Roughness Ra of roughing cut - duralumin.

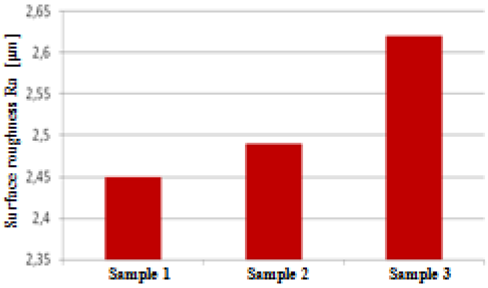

Diagram 2 Roughness Ra of finishing cut – duralumin.

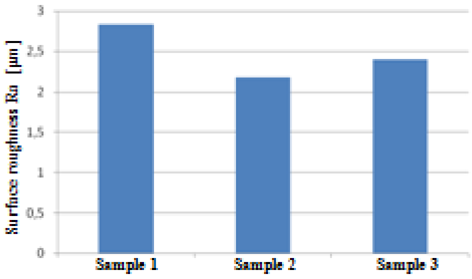

Diagram 3 Roughness Ra of roughing cut - copper.

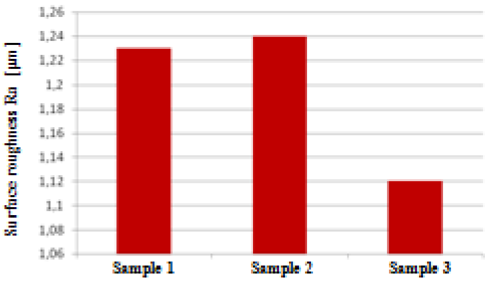

Diagram 4 Roughness Ra of finishing cut – copper.

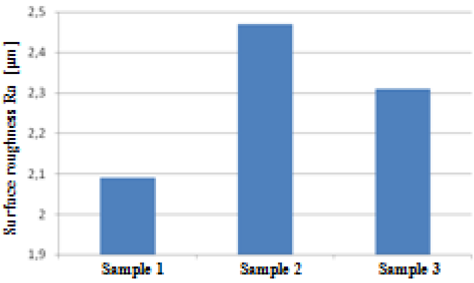

Diagram 5 Roughness Ra of roughing cut - Brass.

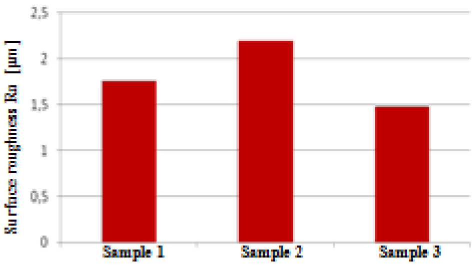

Diagram 6 Roughness Ra of finishing cut - Brass.

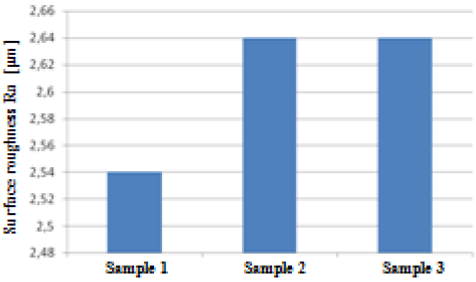

Diagram 7 Roughness Ra of roughing cut - Steel 11 730.

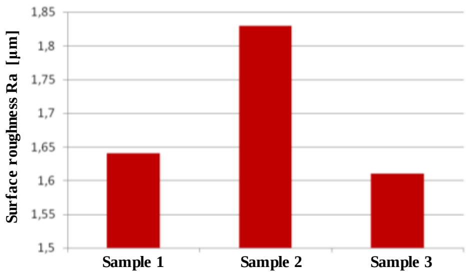

Diagram 8 Roughness Ra of finishing cut – Steel 11 730.

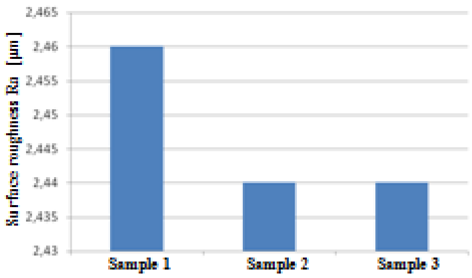

Diagram 9 Roughness Ra of the roughing cut - Steel 12 842.

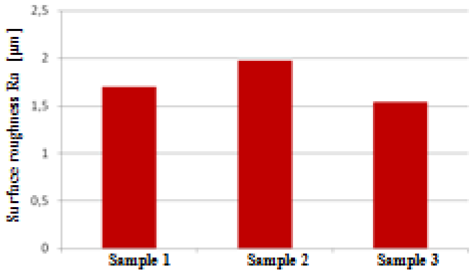

Diagram 10 Roughness Ra of finishing cut - Steel 12 842.

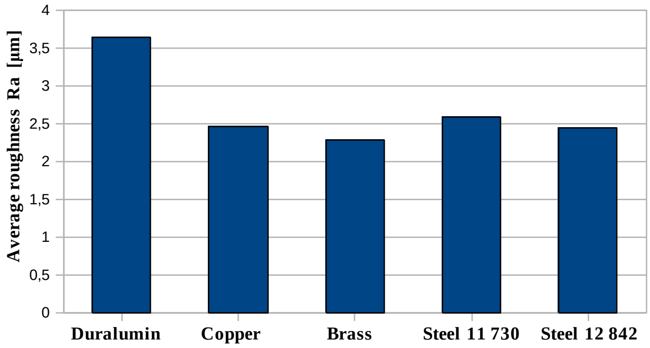

Diagram 11 Average roughness Ra values of roughing cut.

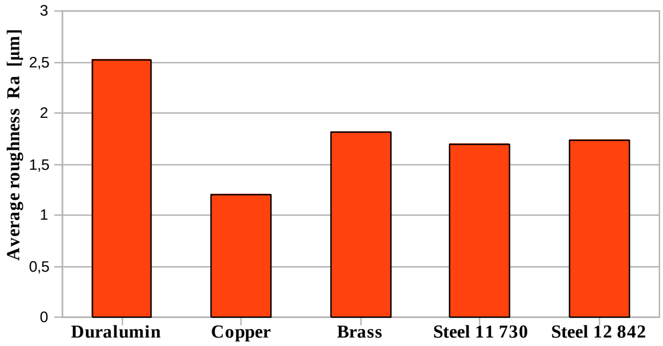

Diagram 12 Average roughness Ra values of finishing cut.

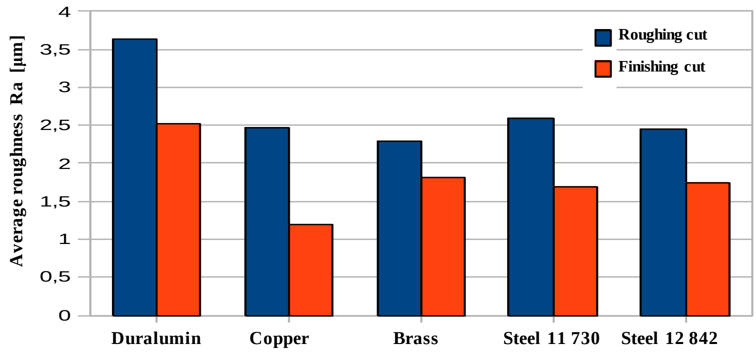

Diagram 13 Comparison of roughness Ra for roughing and finishing.

3 CONCLUSION

In our work we looked at designing appropriate cutting conditions and technology for selected materials.

Roughness of duralumin surface machined by roughing cut varies from 3.51 to 3.79 µm, (Diagram 1). We conclude that when using a material with lower melting point the roughness is due to easier melting and evaporation of material greater than when using materials with higher melting point. This also applies to finishing cut. as shown in Diagram 2, where the measured roughness of treated samples ranged from 2.45 to 2.62 µm.

Roughing cut on copper is shown in Diagram 3, where it is seen that copper has a higher melting temperature. which was reflected in the overall reached roughness. It ranges from 2.18 to 2.83 µm.

Finishing copper cut in compare to finishing duralumin cut shows significantly improved quality of the surface. which represents values from 1.12 to 1.24 µm.

Brass is an alloy of copper and zinc, the roughness of machined surfaces of all samples approximates the results of copper and one could conclude that the roughness of the roughing cut is better as with copper, as shown in Diagram 5. On Diagram 6 can be seen the measured values after finishing cut, but when compared to values in copper, these values are higher. They range from 1.48 to 2.19 µm. When cutting steel 11 730 by using roughing cut, on all samples was measured approximately the same roughness. This ranges from 2.54 to 2.64 µm as shown in Diagram 7. This is approximately true also for finishing cut, but on a sample nr.2 was achieved roughness of only 1.83 µm as shown in Diagram 8, which resulted in insufficient flow of dielectric.

As in the previous case, the roughing cut steel to 12 842 measured values of roughness of the cut surface ranged about the same level and difference is only 0.01 µm as shown in Diagram 9. By using finishing cut was achieved roughness ranging from 1.54 to 1.97 µm as can be seen from the Diagram 10.

The average roughness of materials when the roughing cut was used is illustrated in Diagram 1, where are all roughness figure at a similar level except duralumin, which has an average roughness of 3.64 µm.

When was finishing cut used the roughness of brass. Steel 11 730 and steel 12 842 moves about the same level, around 1.75 µm. Duralumin shows a high roughness up to 2.52 µm. Copper had the best results with the surface roughness value 1.2 µm, as shown in Diagram 12 In common representation of finishing and roughing cuts can be the differences between these cuts seen (Diagram 13). It is clear that softer materials like copper or duralumin show large differences between cuts. For materials with higher melting temperature aren’t those differences so significant.

Information learned confirms that for reaching the surface quality by the Wire EDM cut is necessary to properly adjust the cutting machine with a continuous influx of dielectrics, it is further important to monitor its conductivity, periodically check the contacts and prevent short circuits in order to achieve the most efficient cutting process. The results achieved by our experiments show that even with identical settings of cutting conditions are softer and more plastic materials Ra values greater than the tough and hard materials Ra. This is due better cohesion and a stable crystal lattice, resistant to change at higher temperatures.

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