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INFLUENCE OF ELECTRODE MATERIAL ON THE SURFACE LAYER CONDITIONS AFTER EDM DIE–SINKING

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3 ## ABSTRACT

This paper deals with the study of the influence of electrode material on the surface layer quality after EDM sinking. Graphite and Copper electrodes were used for EDM sinking of three materials from Tool Steel of Czech grade 19 096,
4 19 662 and 19 802. The surface layer quality of samples was analyzed for surface roughness, surface topography and residual stresses. The experimental results showed that the samples machined by Graphite electrode had a better surface layer quality than those machined by Copper electrode. All samples had lower values of roughness and thinner heat affected zone (HAZ) with Graphite electrode. Whereas, Copper electrode caused lower tensile residual surface stresses than Graphite electrode with roughing and finishing conditions specially for hard materials.

Keywords

EDM sinking, roughness, residual stress.

1. INTRODUCTION:

Electro-discharge machines (EDMs) are generally employed in die sinking. Dies are used for manufacturing of cars, electrical applications and electronic equipment. The geometrical accuracy of EDM die sinking is determined by the tool electrode wear and the working gap width. Both of which are affected by the working conditions such as pulse generator setting, properties of dielectric and thermo-physical properties of electrode material [1]. It can be say that the first affected factor is the physical or chemical deposition of electrode materials[2].

EDM processes are known for being stochastic and relatively slow. The optimal working conditions change continuously during machining, and drift away from the working point may cause a process degeneration and a damage to the electrodes [3].

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Therefore substantial effects have been made in the area of process optimization. The optimization of the working conditions of feeding and planetary motion of an electrode to get the specified final surface roughs of large scale dies in the minimal machining time was investigated [4]. Another optimization control algorithms have been developed and implemented to improve the overall performance of EDM die sinking [3]. AGIE has since long introduced Adaptive Control Optimization (ACO) algorithms as well as Adaptive Control Constraint (ACC) regulators [5,6]. Fuzzy controllers have been used to optimize the EDM AGIE die sinkers. Effects of electrode wear tool shape on optimum electrical conditions and white layer of EDM roughing of cavities were studied [7,8,9].

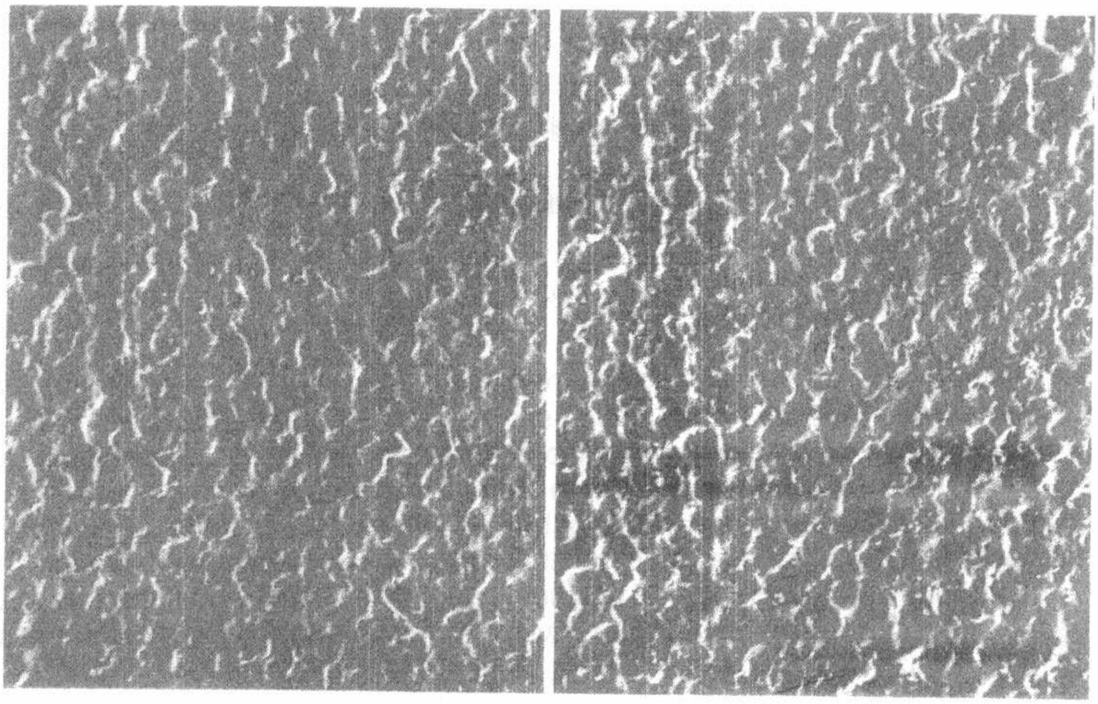
The aim of this investigation is to study the influence of differences in the physical and chemical deposition of electrode material on the surface layer conditions. Where Copper and Graphite electrodes were used for EDM sinking of different materials mostly used in practice. Surface texture and residual stresses of the machined surface layer were investigated .

2. EXPERIMENTAL WORK:

Three materials from tool steels of Czech grade SN 19 096, 19 602 and 19 802 were machined by EDM sinking. The chemical compositions of these materials are shown in Table 1. The different samples, each 80 X 12 mm in size and 10 mm thick, were prepared. All samples were annealed in a vacuum furnace to relive stress just before EDM sinking. One mm. thin layer was removed by EDM sinking from each face of all samples under roughing and finishing conditions. EDM machine, AGIE Elox Mondo 2, with two different electrodes, Graphite and Copper, was used for EDM sinking with roughing and finishing working conditions. In the case of Graphite electrode the roughing and finishing draught (Vw) were equal 70and 2 cubic mm/min. respectively. For Copper electrode, the value of Vw was 1.5 for roughing and finishing conditions. The values of roughness Ra and Rz on along and across lays of sinking surfaces were measured by AGIE machine. TESLA BS 300 scanning electron microscope (SEM) was used to obtain the topography of the machined surfaces. Residual stresses were measured to a depth of 0.1 mm below the machined surface using the deflection mechanical method (etching method).

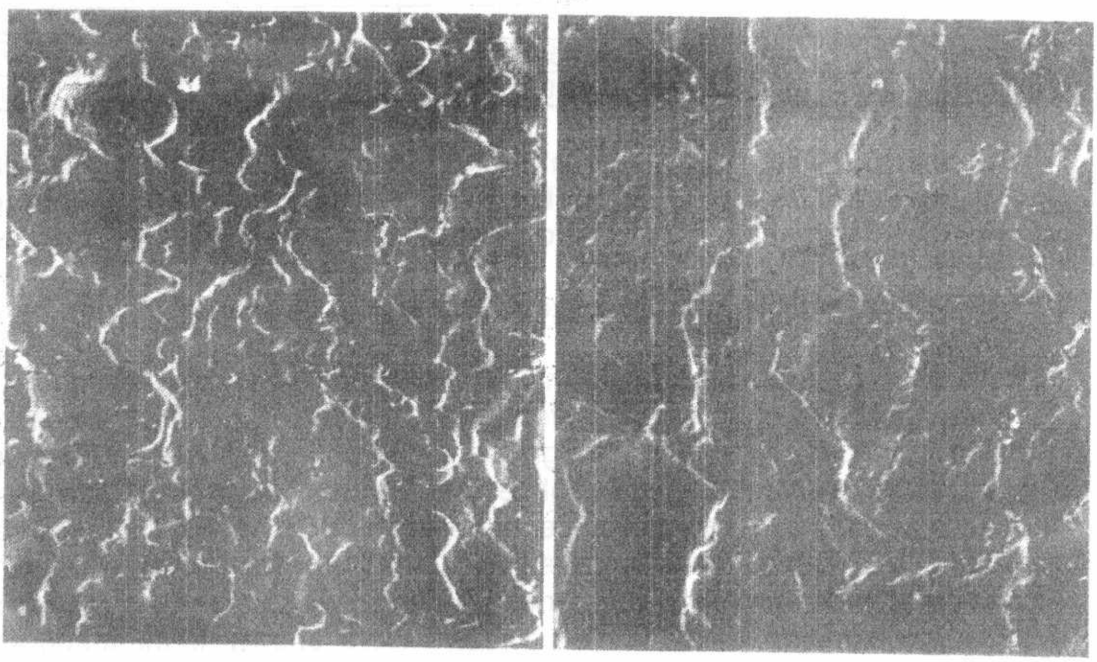
Material of Samples	**Chemical Composition (%)**									
	C	Mn	Si	Cr	Ni	Mo	W	V	P	S
19 096	0.47: 0.57	0.40: 070	0.15: 0.30	Max. 0.25					Max. 0.035	Max. 0.035
19 662	0.50: 0.60	0.50: 0.90	0.30: 0.60	0.50: 0.90	1.50: 1.90	0.15: 0.30		0.10: 0.25	Max. 0.03	Max. 0.03
19 802	0.80: 0.90	Max. 0.45	Max. 0.45	3.80: 4.60		Max. 0.50	9.50: 11.0	2.00: 2.70	Max. 0.035	Max. 0.035

Table.1: Chemical composition of investigated samples materials



Graphite electrode Copper electrode

Fig. 1. SEM observation of surface layer topography of steel 19 662 after EDM sinking by Graphite and Copper electrodes with Finishing conditions.



Graphite electrode Copper electrode

Fig. 2. SEM observation of surface layer topography of steel 19 662 after EDM sinking by Graphite and Copper electrodes with roughing conditions

3. RESULTS AND DISCUSSION:

The examinations can be subdivided into three sections:
1. Surface roughness.
2. SEM observation of surface topography.
3. Residual stresses distribution.

3.1. Surface roughness :

The different values of surface roughness, Ra and Rz, of all samples along and across lays of the machined surfaces by Graphite and Copper electrodes with roughing and finishing conditions are shown in Table 2. From these results it can be shown that there were differences between the values of surface roughness for all samples. Roughness values Ra and Rz of the surfaces machined by using Graphite electrode were lower than those by using Copper electrode with roughing and finishing conditions. A higher differences between the values of surface roughness were more clear in the case of samples from tool steel 19 802.

Electrode		Graphite				Copper			
Condition		Roughing		Finishing		Roughing		Finishing	
Lay		Along	Across	Along	Across	Along	Across	Along	Across
19 096	Ra	3.33	2.81	1.49	1.53	5.95	6.74	1.54	1.55
	Rz	20.1	17.5	9.7	9.1	32.6	37.6	9.6	9.9
19 662	Ra	3.64	3.41	1.36	1.7	5.26	6.35	1.63	1.71
	Rz	19.1	18.9	9.1	11.2	32.2	36.4	8.8	10.3
19 802	Ra	3.5	2.78	1.35	1.4	5.68	6.25	1.91	1.76
	Rz	19.8	18.7	7.8	8.7	31.3	34.6	13.3	11.1

Table 2: Surface roughness values of test samples after EDM sinking using Graphite and Copper electrodes with roughing and finishing conditions.

3.2. SEM observation of surface topography :

SEM observed surface topography of all samples with magnification 300X. In general there were some burrs formed by molten metal and oxides on all sinking surfaces. There was no significant differences between the topography of surfaces machined by Graphite or Copper electrodes with finishing conditions as shown, for example material 19 662, in Fig.1. In the case of roughing conditions, there were significant differences between the surfaces machined by Graphite and Copper electrodes for all samples. As shown in Fig. 2, for the same material 19 662, craters were shown in the topography of surface layers of samples machined by Copper electrode are wider and smoother than those machined by Graphite electrodes with roughing conditions. A good agreement between these results and surface roughness values obtained in Table 2.

3.3. Residual stresses

In general , residual surface stresses of all samples after EDM sinking by Graphite and Copper electrodes with roughing and finishing conditions were tensile stresses and then converted to zero through the depth 0.05 mm below the machined surface. The highest values of tensile stresses obtained at 0.005 mm below the machined surface of all samples with different conditions are shown in Fig. 3. It can be seen that, all samples machined by Graphite electrode had a higher tensile residual surface stresses than those machined by Copper electrode due to the high pulsating energy used with Graphite electrode. EDM finishing working conditions caused higher tensile stresses than roughing conditions. Tensile residual surface stresses increased with the increase of the workmaterial hardness.

For machining steel 19 096, tensile residual stress 637 MP and 860 MP were obtained by using Graphite electrode with roughing and finishing conditions respectively as shown in Fig.4. On the other side, lower values of tensile residual stress about 260 MP were obtained by using Copper electrode with roughing and finishing conditions and decreased to zero through 0.02: 0.03 mm below the machine surface.

For machining steel 19 662, tensile residual stresses about 500 MP were obtained by using Graphite electrode and decreased to zero through depth 0.02 mm below the machined surfaces as shown in Fig.5. Whereas the Copper electrode caused tensile residual stresses about 300 MP decreased to zero through depth 0.05 mm.

For machining steel 19 802, tensile residual stresses were the highest values about 1100 MP by using Graphite electrode while a lowest values about 200 MP were obtained using Copper electrode as shown in Fig.6. These high differences could be due a higher hardness and complex structure of these materials.

CONCLUSIONS:

From the experimental results, it can be concluded that :

1. EDM sinking of samples with Graphite electrode had lower values of surface roughness Ra and Rz than those with Copper electrode.
2. Surfaces topography of samples machined by Graphite electrode had a thinner heat affected zone (HAZ) than those machined by Copper electrode.
3. Graphite electrode caused higher values of tensile residual surface stresses than Copper electrode with roughing and finishing conditions. Tensile residual surface stresses increased with the increase of the hardness of work-material. The samples machined with roughing conditions had lower tensile stresses than those machined with finishing conditions.

Fig.3.Maximum values of tensile residual surface stresses after EDM sinking of all samples

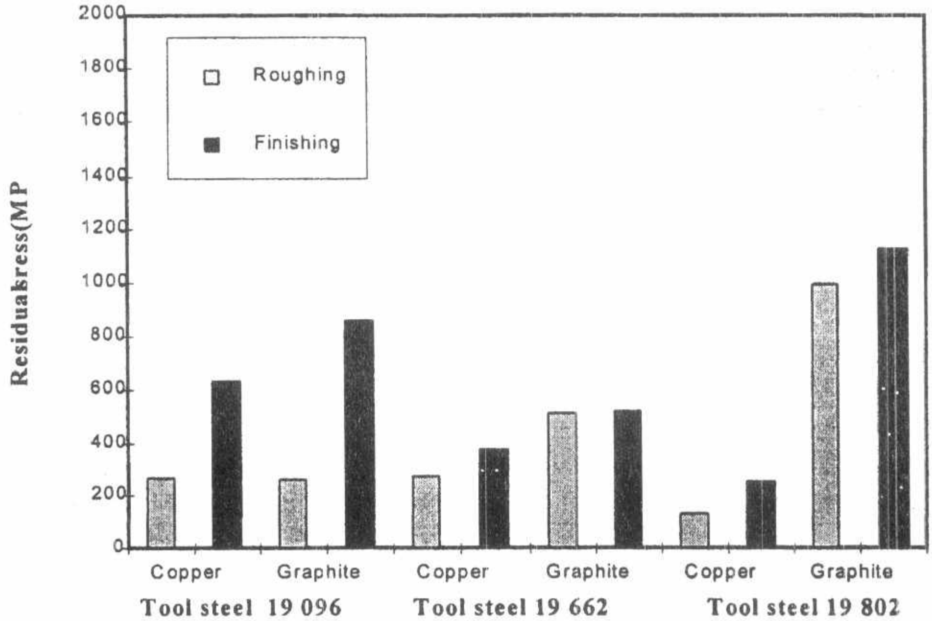


Fig.4. Residual stresses of tool steel 19 096 after EDM sinking by Graphite and Copper electrodes.

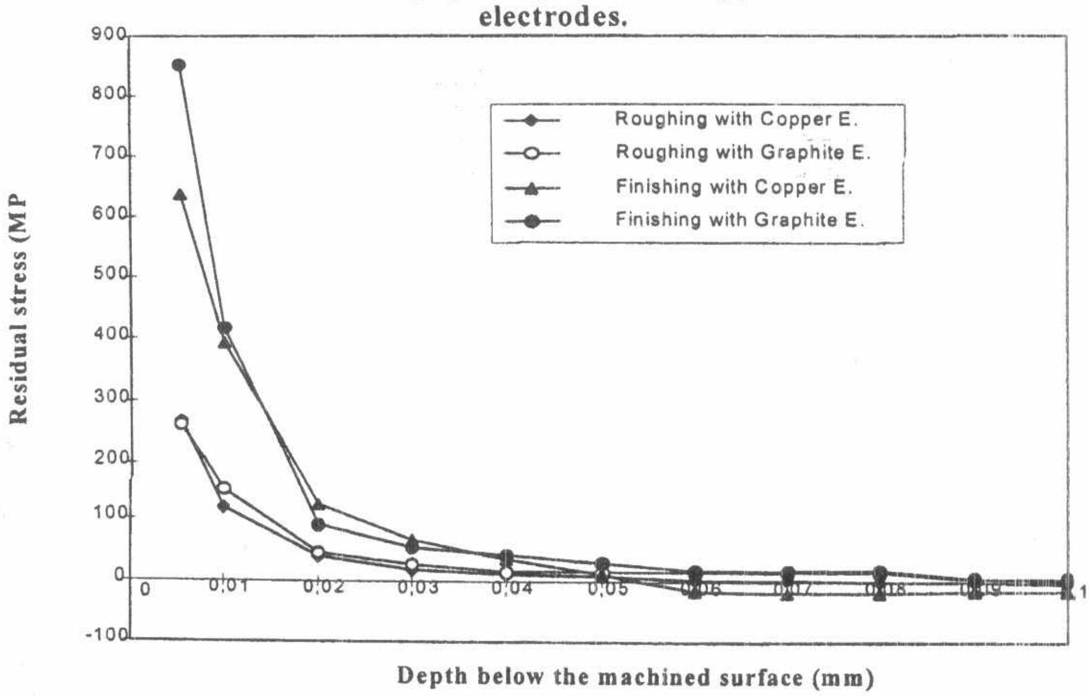


Fig. 5. Residual stresses of tool steel 19 662 after EDM sinking by Graphite & Copper electrodes.

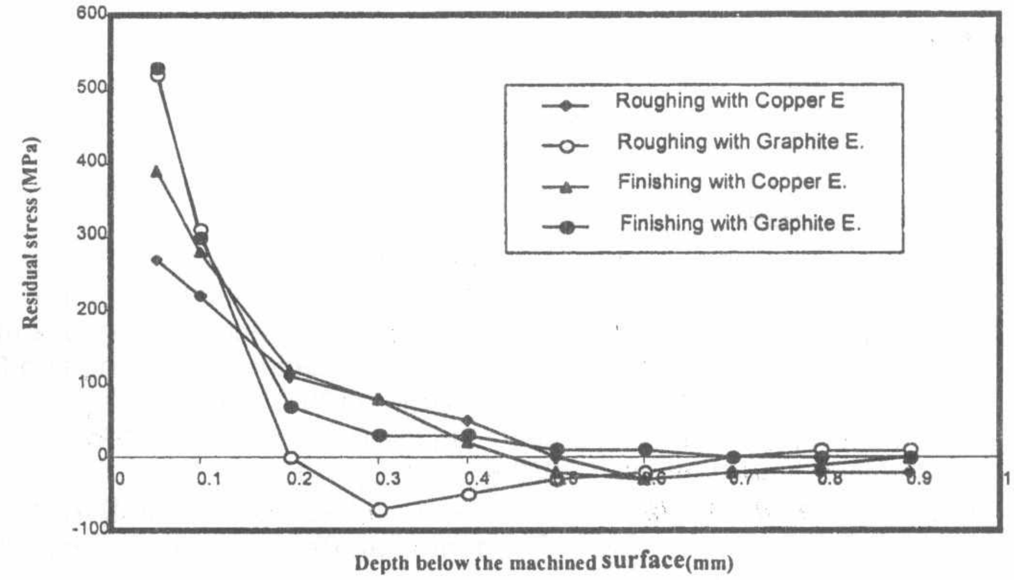
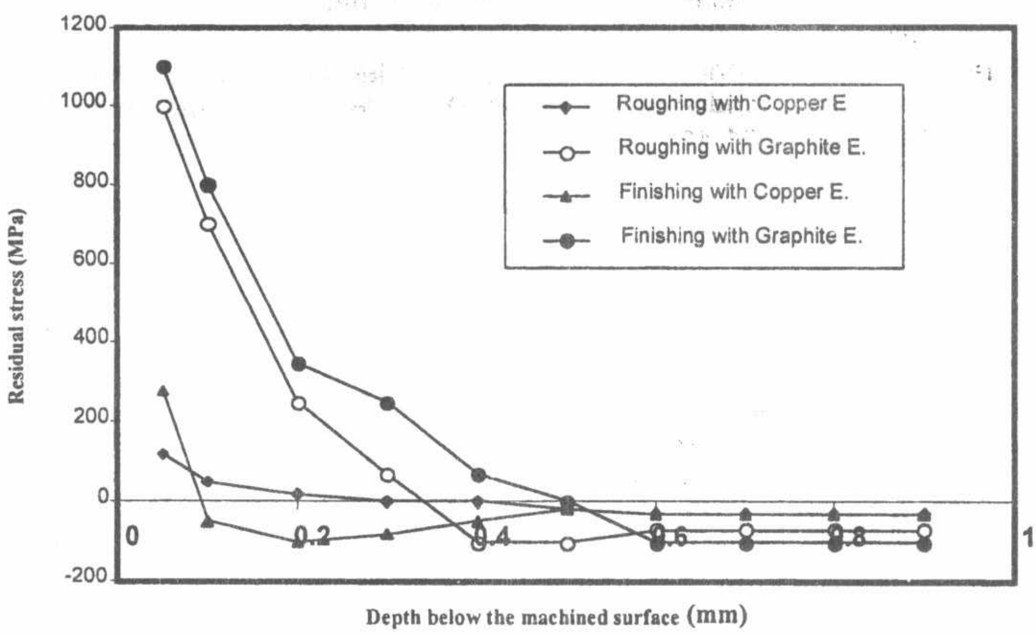


Fig. 6. Residual stresses of tool steel 19 802 after EDM sinking by Graphite and Copper electrodes.



4. From the economical point of view, Graphite electrode is preferred because of its higher productivity. The time of EDM rough sinking with Graphite electrode was equal 20% of the time with Copper electrode. The fine sinking time with Graphite was equal 50% of that with Copper electrode.

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