ANALYSIS OF GRAPHITE ELECTRODES USED IN EDM FOR TOOL STEEL MATERIALS MACHINING

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Abstract: Electrical discharge machining process (EDM) is a process for removing material by the thermal of electrical discharge. Some of the melted and all of the evaporated material is then quenched and flushed away by dielectric liquid and the remaining melt recast on the finished surface. The recast layer is called as white layer. Beneath the recast layer, a heat affected zone is formed. The quality of an EDM product is usually evaluated in terms of its surface integrity, which is characterized by the surface roughness, existence of surface cracks and residual stresses. Two types of EDM electrode materials were chosen, Dura graphite 11 and Poco graphite EDMC-3. Two grades of tool steels are chosen as test materials, DIN 1.2080 and DIN 1.2379. Different machining methods were chosen ‘‘rough, medium, and soft’’, it was found that the Dura graphite 11 exhibits more surface cracks upon DIN 1.2379 less micro-cracks appeared on the surface than on DIN 1.2080 while the higher surface roughness appeared in DIN 1.2080 using Dura Graphite 11 electrode, also Residual stresses were studied upon the surface and it was found that POCO Graphite EDMC-3 electrode results higher residual stresses compared with Dura Graphite 11 electrode. Also Soft EDM machining exhibits higher residual stresses as a result of higher pulse on duration time.

Key words: EDM, Graphite Electrodes, SR, Heat Discharge, Tool steel.

1.Introduction:

Electrical Discharge Machining (EDM) is one of the most effective methods for removing material from electrical conductive materials. When machining a workpiece with EDM, a recast layer is formed at the surface of the workpiece [1]. The recast layer shows white color after etching so it is called the white layer. The white layer is the result of the solidification of a melted zone and is known to exhibit high hardness, good adherence to the bulk and good resistance to corrosion. However, it contains a lot of microcracks, which causes a problem for certain applications. The microstructure and the properties of the melted zone after solidification are quite different with respect to those of the workpieces and tool electrodes used in de-ionized water [2]-[5]. EDM process can be performed in decarbonization for example EDM process in deionized water. Graphite is widely used as electrode material in EDM, this is due to its low density and good electrical along with its machinability [5]-[6]. This research was studied the effect of electrode to EDM process in deionized water.

Accordingly, the current study is based upon these two parameters, and specifies pulse currents of 15, 30 and 50 A with pulse-on times of 20, 100, 180 ls. Using two grades of electrode materials (Dura Graphite 11 and Poco Graphite EDMC-3) as test electrodes. After completion of the EDM machining process, the surface integrity of the sample material is examined using Scanning electron Microscopy (SEM) then measuring residual stresses using X-ray Diffraction (XRD).

2.Literature Review

K. Furutani et al. (2002)[7] applied EDM to produce a molybdenum disulphide (MoS2) coating on steel bearing surfaces and the undulating surface machining improved. [8] K. Furutani (2003) created a TiC coating with a hardness of 1900 HV through the PMEDM method. The Ti powder with size smaller than 38 µm was used in a dielectric of mixed oil (EDF - K). [9] V.S.Ganachari et al. (2013) used the Taguchi method combined with the gray relational analysis (GRA) method to optimise some parameters of PMEDM technology. Aluminium (Al) and silicon carbide (SiC) powders were mixed in the dielectric fluid and the parameters of PMEDM technology were used to achieve the best quality surface machining. [10] Ved Parkash et al. (2013) mixed Cu powder with graphite powder in the dielectric fluid which significantly reduced the erosion of the electrodes. TWR with graphite powder declined compared to the Cu powder. The reduction of electrode erosion contributed to increased durability of the electrode and improved the machining accuracy. [11] Khalid Hussain Syed et al. (2013) used Al powder mixed in pure dielectric fluid water to machine mould steel W300 with EDM. They found that variable white layer thickness (WLT) on the surface of the billet did not decrease compared with machining without powder in the solution. When the amount of powder increased, the variable white layer thickness decreased. [12] B. Govindharajan et al. (2014) showed that mixed powder with Gr and Ni in the dielectric fluid using the EDM method increased the productivity of dissection materials (MRR), decreased TWR, and the precision machining and quality of the machined surface was enhanced. [13] Gurtej Singh et al. (2014) used Al powder mixed in the dielectric fluid at different concentrations to examine the changes in the SKD61 steel surface roughness after processing by EDM. Results showed that the addition of Al powder in the dielectric fluid reduced the surface roughness values and higher concentrations of the powder led to a decrease in the undulating surface values. [14] The authors studied the effect of tungsten powder mixed in the dielectric fluid in the EDM method on the OHNS steel surface quality after machining. Results showed that a large amount of tungsten powder (up to 2.89 % from 0.25 %) mixed in the dielectric fluid entered the machining surface and increased the hardness of the microscopic surface by 100 %. This increased the durability of the worn surface machining. [15] Vipin Kumar et al. (2014) showed that changes in the powder material and the size of the powder have a strong influence on MRR and Ra in EDM machining of EN31 steel. They expanded the influence of a variety of materials and their concentrations on the productivity and quality of surface machining. [16] M.A. Razak et al. (2015) compared the influence of the concentration and size of SiC powder mixed in the dielectric fluid on MRR, TWR and Ra in EDM. Compared with machining by EDM, the productivity and quality of surface machining in PMEDM increased with reduced machining time. [17] Bleys et al. (2006) attained an undulating surface of Ra less than 1µm with small sparks of energy and reversed polarity.

3.Experimentation

Two grades of electrode materials have been chosen; Dura Graphite 11 is widely used in the industries because they can be easily and cheaply prepared. Graphite has a very high melting point. Truly, graphite does not melt at all, but transform directly from solid to gas at a temperature thousands of degrees (3200 ———————————— C) higher than the melting point of Copper. This temperature resistance makes graphite an ideal electrode material.

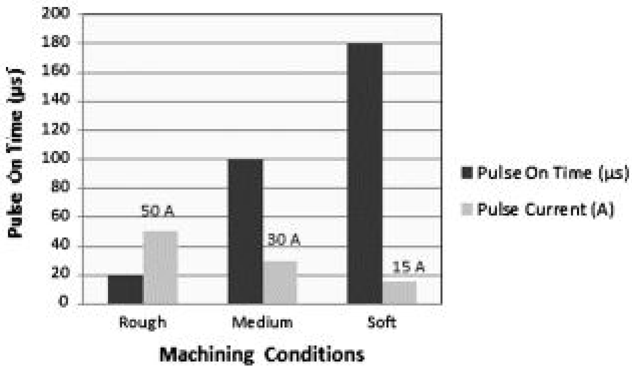

Figure:1 Machining conditions for graphite testing

To prepare the EDM specimens, the base specimens were machined by EDM to remove the unnecessary material at various machining conditions ‘‘rough, medium and soft’’ according to pulse current (A) and pulse-on duration time (ls) presented in Fig. 1, then scanning the specimen with scanning electron microscope (SEM) to study the effect of electrode material upon the test material to avoid the surface roughness and cracks, then residual stress measurement using x-ray diffraction.

Table1: Properties of Electrodes

Physical characteristics of POCO graphite EDMC-3.	Physical characteristics of Dura graphite 11 graphite.
Average particle size (lm) <5 Compressive strength (MPa)= 206 Electrical resistivity (lX m) =3.2 Melting point (^{0} C) =1100 Thermal conductivity (W/m K) =135	Average particle size (lm)= 10 Compressive strength (MPa)= 83.4 Electrical resistivity (lX m) =11 Melting point (^{0}C) =3000 Thermal conductivity (W/m K) =120

4.Results and discussion

After the EDM process the test materials were examined using scanning electron microscope to observe the surface cracks, roughness, and then X-ray diffraction to examine the residual stresses generated after the three machining conditions using the test electrodes.

4.1 SEM structures of surface

The characteristic morphology of a surface which has experienced EDM machining, is due to the extensive amount of heat generated by the discharge current, which causes melting and evaporation of the material, then fast cooling. It is seen after rough machining, the surface is rougher and the machined surface contains lots of globules, melted drops and craters, and reduces with medium and soft machining. This is due to very high temperature gradient produced due to the thermal energy in the work-piece erosion happens from the surface and the debris particles remain on the work-piece surface. Surface morphology observations using Dura Graphite 11 and POCO graphite EDMC-3 electrodes have been presented as follows in Figs. 2–7.

Fig. 8 shows the surface roughness observations. It was found that it is approximately the same for DIN 1.2080 and DIN 1.2379, in both electrodes, the surface roughness increase as the pulse current increase. This is because at rough machining whenever peak current increases more intensely discharges which effect on the surfaces, more quantity of molten and floating metal are suspended in the gap between tool and work-pieces resulting increase the surface roughness. Also it is clear that Dura graphite exhibits higher surface roughness upon DIN 1.2080 surface during all machining conditions and this is due to Dura graphite 11 composition, it is a compressed graphite powder which erodes easily during machining, and also due to the higher carbon content in DIN 1.2080

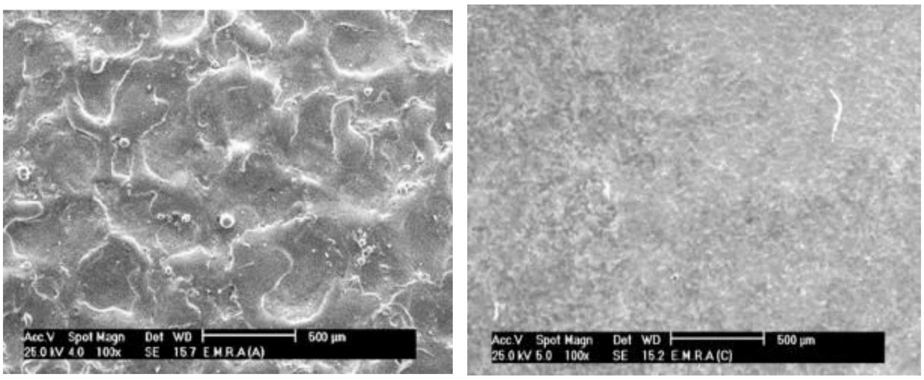

Figure 2: Dura graphite 11 rough and soft machining DIN 1.2379.

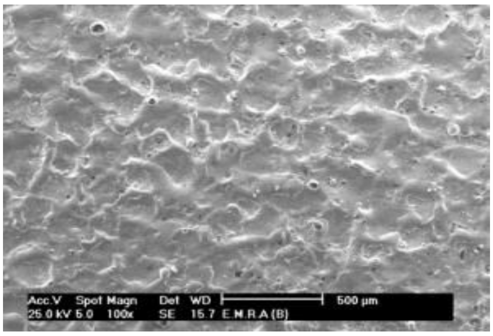

Figure 3: Dura graphite 11 medium machining DIN 1.2379.

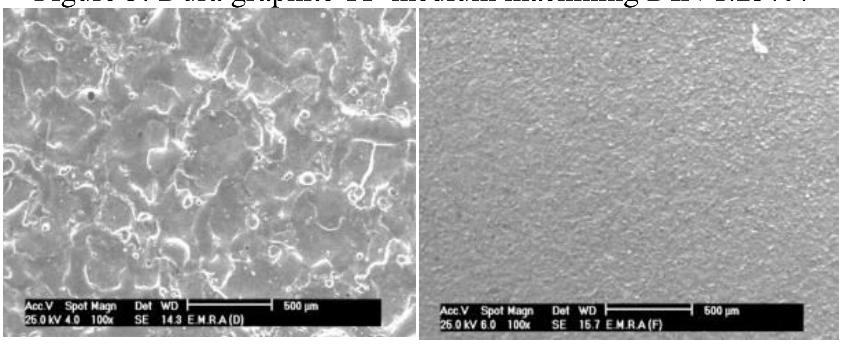

Figure 4: POCO graphite 11 rough and soft machining DIN 1.2379.

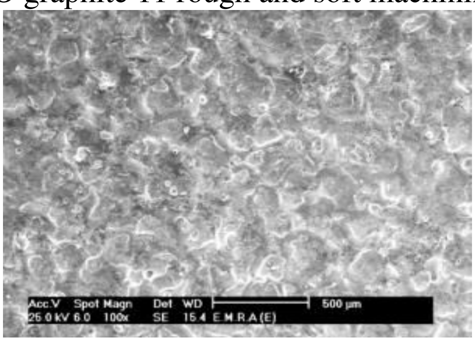

Figure 5: POCO graphite 11 medium machining DIN 1.2379.

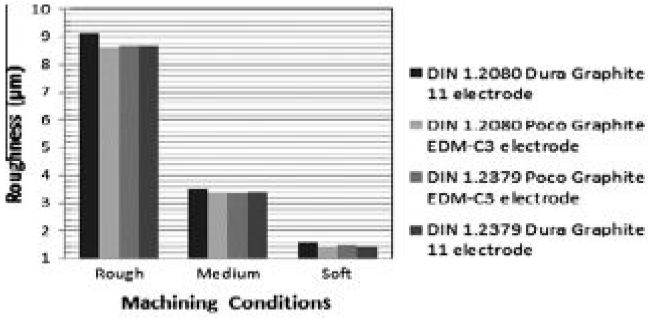

Figure 6: Surface roughness observations.

It can be seen that the regression model is fairly well fitted with the observed values. The response ranges from 26.25 MPa to 1239 MPa and the ratio of maximum to minimum is 47.2.

4.2 Surface crack propagation

The Residual Stress tends to increase considerably with soft machining using Poco graphite electrode. It is clear from the figure that the lower residual Stress can be obtained using rough machining with Dura graphite electrode. Residual Stresses Observations found that soft machining in both electrode and materials results higher residual stresses compared with medium and rough machining and this is due to higher pulse on duration time in soft machining, and POCO Graphite EDMC-3 electrode exhibited higher residual stresses compared with Dura Graphite 11 electrode.

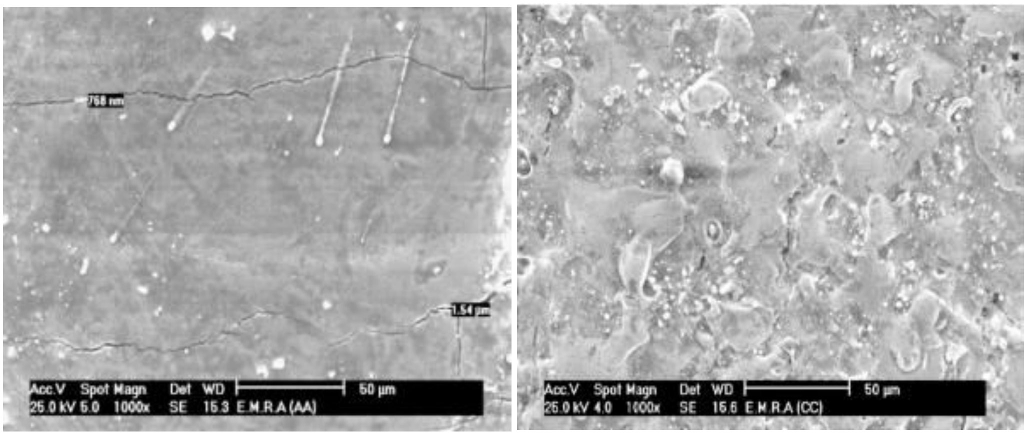

Figure 7: Surface crack Dura graphite 11 rough and soft machining DIN 1.2379.

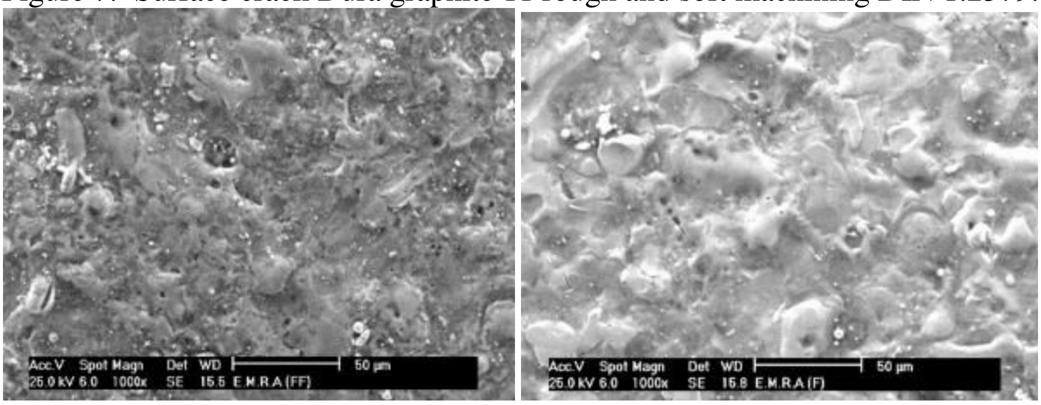

Figure 8: Surface crack Dura graphite 11 medium&POCO medium

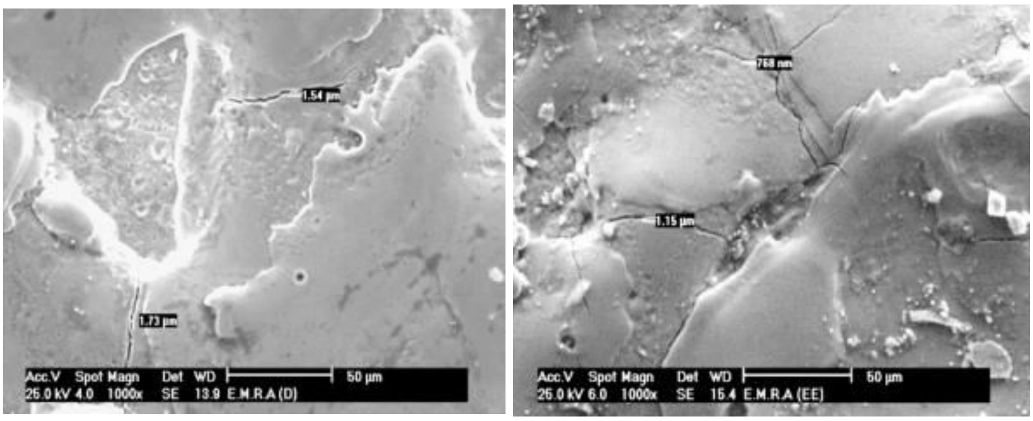

Figure 9: Surface crack POCO graphite 11 rough and soft machining DIN 1.2379.

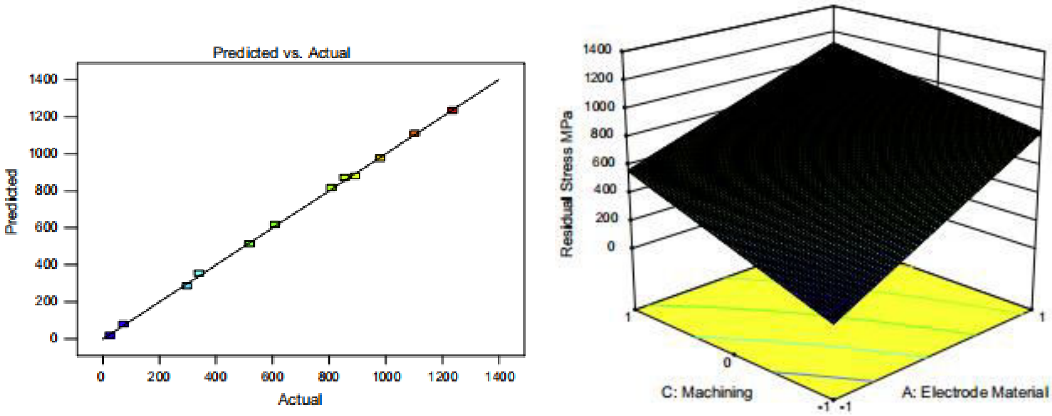

Figure 10 ;Predicted vs. Actual values of Residual stress.

5. Conclusions

It was found that Dura graphite exhibited higher surface roughness upon DIN 1.2080 surface during all machining conditions and this is due to its composition, it is a com pressed graphite powder which erodes easily during machining, and also due to the higher carbon content in DIN 1.2080 which solidifies upon the surface during solidification and not flushed away. Rough EDM machining exhibited more micro-cracks as a result of higher pulse current. Soft machining in both electrodes and materials exhibited higher residual stresses compared with medium and rough machining and this is due to higher pulse on duration time in soft machining. POCO Graphite EDMC-3 electrode exhibited higher residual stresses compared with Dura Graphite 11 electrode. As a result that POCO graphite EDMC-3 composition which is a high quality graphite infiltrated with copper.

6. References

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