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EFFECT OF INPUT PARAMETERS ON THE DEPTH OF HEAT AFFECTED ZONE (HAZ) AISI H13 STEEL ELECTRİCAL DİSCHARGE MACHİNİNG PROCESS (EDM)

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Abstract

The importance of surface integrity of electric discharge machined components has been recognized by the industry and it is still continues to be the major concern among the researchers. This paper presents a study of the relationship between EDM input parameters (duty cycle, pulse-on time and tool polarity) and surface integrity. This study shows that, in both cases of tool polarity (positive and negative), with increasing pulse on-time and duty cycle, the rate of hardness decline in the layers near the machined surfaces is augmented and the depth of the heat affected zone is increased, also in the negative polarity the amount of hardness decline and depth of the heat affected zone is small. Also, according to the results of the EDX analyze, In the positive polarity, the rate of penetration of the carbon diffusion is higher than the negative polarity

Keyword: Pulse Duration, Duty Cycle, Polarity, Micro Hardness, Heat-Affected Zone (HAZ).

1. Introduction

Today, the technology required manufacturing and machining of high hardness and strength of materials, new machining processes, machining is replacing the traditional process. One of the most important and most useful of these processes, electrical discharge machining (EDM) is. Machining Electrical Discharge is a process where by applying a voltage pulse and the pulse between the tool and the work-piece is immersed in liquid dielectric and the sparks between them per pulse, the operation of chip removal and machining is done in [2, 1]. AISI H13 steel at high temperatures due to good wear resistance, high hardness and toughness, making molds like hot mold forging, extrusion, casting, etc. are used

The nature and structure of the electrical discharge machining by the quality of the output parameters is very important. General nature of these levels will be reviewed by two important factors. One of these components is to represent the tissue surface machining is the postal heights and metallurgical properties of the second component of the changes in the surface layers of the work piece aims. Figure 1 details the surface of a work-piece in electrical discharge machining process of the show.

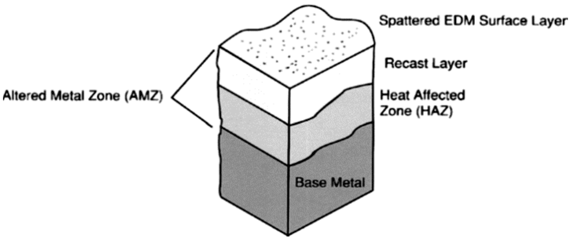

Fig.1. Created among the machining operations [10].

Several studies concerning the effect of input parameters on work-piece surface quality and output characteristics of the process (EDM) has been performed. W. Tebni and et al and [4] , changes in chip removal rate , surface roughness and surface changes in electrical discharge machining process work pieces of steel (50CrV4, X200Cr15) tools taking into account the effect of copper and graphite (flow rate , time to clear pulse and pulse- off time) have been studied . They have concluded that increasing the discharge energy, increased surface roughness and work-piece surface quality will drop. H. Kokubo and et al [5], the effect of the dielectric (kerosene and de ionized water) and pulse polarity and different tools on the volume of material removed from the white layer thickness and electrical discharge machining steel AISI created in the process 1049 review and have reported with increasing polarity of the pulse duration for both instruments, melting depth and volume of material removed increases. Philip. T .Eubank and et al [6], the electrical discharge machining process modeling the cathode and the anode to the conclusion that, when an electric discharge plasma channel formation on the anode, the anode begins to melt, and then along the canal plasma reaches the cathode. This phenomenon causes the plasma channel radius larger than the negative pole and the positive pole of the electric current density decreases Shargrmayy is input to the anode surface.

Also A. Descoeudres [7] formed plasma channel characteristics in electrical discharge machining process have been studied. The results indicated that the temperature difference between the anode and cathode of an electrical discharge machining process is so much hotter than the surface of the cathode surface temperature have been reported. In the case of negative polarity, the temperature difference decreases work-piece surface temperature and depth zone is affected by the machining operation. Khoshkish and et al [8], the influence of the electrode material, current density and pulse duration on the output characteristics of EDM process includes chip removal rate, tool wear and surface roughness in the machining of AISI D3 tool steel are placed. Based on the results of their research, sex electrolysis has the most influence on tool wear, tool making graphite electrode tool wear rate is lowest. The study also found that increasing the pulse duration and flow rate, the surface roughness increases Sadeghi and et al [9] examined the effect of electrical discharge machining parameters of Wire (Wire Cut) on output parameters have 2601 in machining steels. Using experimental design approach, the impact of input parameters, including flow rate, pulse off time, the open circuit voltage and the voltage gap metal removal rate and surface roughness on the volume have been evaluated. Their findings show that the four-parameter set, the current and pulse off-time greatest impact on the volume of metal removal rate and surface smoothness leave while the open circuit voltage and voltage do not influence the two properties. The purpose of this research was to study the influence of the Pulse-on time, duty cycle and Tool Polarity of the device and the heat-affected zone of the depth changes of electrical discharge machining of carbon on the surface machined by EDM.

2. Materials and Methods

First, the bar provides cutting operations, basic machining and grinding were performed and 16 samples of cylindrical steel with a diameter of 20 mm and height 20 mm were prepared, then, to achieve a hard case (HRC52-45) Operation hardening steel samples was carried out with precision. Also in preparation for the operation of 16 copper cutting tool, machining and polishing was done with a diameter of 18 mm and a cylindrical brass instruments and a height of 20 mm were prepared. Table 1 shows the dimensions of the tool and the work-piece material and ready to show.

Table 1. Sex and the dimensions of the tool and the work-piece.

Diameter (mm)	Length (mm)	Material
18	20	Cu tool (electrode)
20	20	AISI H13 Tool Steel work-piece

In these experiments, the pulse duration (three levels) and duty cycle (four levels) as independent input variables were considered as a means of polarity.

All specimens by spark Tehran - Ikram CNC-EDM)) Iso Pulse in machining operations was under 20 minutes. To create the same conditions in all experiments, washing, immersion washing method was used. The electrical discharge machining operations to depth study of the heat-affected zone (HAZ), the first machining parts Precision Wire Cutting EDM machine (01/0) mm and a height of 8 mm from the surface being machined, cut and then cut into pieces with evenly placed under the bed and grinding operations of all levels of size (1/0) mm lifting, then by OLYMPUS-LM700 micro hardness of the layers close to the surface machining by micro hardness tests were taken. The EDX analysis of the surface layers of the machining was done by scanning electron microscope Cam Scan MV2300. Optical microscope image of the device to provide light microscope Olympus PMG3 was used. Table 2 lists the input variables of the experiment and changes their displays.

Table 2. Input parameters and test conditions.

Dielectric	**Kerosene**
Pulse duration (sμ)	50, 15.2
Voltage (V)	200
Ampere (A)	16
Duty cycle (%)	20,30,40,50
01/0 the distance between the tool and the work-piece (mm)	
Polarity Tool	+ / -

3. Results and Discussion

3.1. Information about the surface integrity

Given the parameters of the pulse duration (Ti), duty cycle (the ratio of the pulse duration, pulse on and off the whole time) and the polarity of the tools are, the more influence they have on each of the output parameters separately will be discussed.

3.2. Effect of pulse duration on the machined surface of the carbon

Percent composition of surface layers of steel (H13) before and after processing by EDX (by SEM) were evaluated Table 3 reports the results of SEM analysis of the sample surface before machining operations and the amount of carbon in the surface layers of Table 4 shows the EDM machining operations. Table 4 shows the amount of carbon in the surface after machining operation where it increased significantly. This can be justified because of increased Carbon: After the formation of the plasma channel, and also the phenomenon of melting and evaporation of bulk boiling phenomenon (as that is the most basic mechanism of chip removal in EDM process), the electrodes occur at the junction of the plasma channel. On the one hand, and on the other hand, hydrocarbon dielectric breakdown and evaporation, melting and vaporization of the electrode is suitable for the temperature and pressure of the constituent atoms of the elements in the surface layers liquid dielectric of the work piece and the utility and increase the amount of carbon in the samples are. In the EDM, the pulse duration increases, due to increased spark energy increases the temperature of the plasma channel. Given the direct relationship between temperature and atomic diffusion coefficient with increasing temperature, the higher the penetration rate of diffusion of carbon atoms into the surface layer increases.

Table 3. Results of EDX analysis of the sample surface before machining steel.

El.	Mo	Fe	Mn	Cr	V	Si	C
wt.%	97/78	0/38	4/48	0/78	0/96	0/07	1/18

Table 4. Percentage change in the carbon steel surface after machining (based on analysis EDX).

Pulse duration (Microseconds)	**Duty cycle (percent)**	**Polarity type device**	**Percent carbon surface**
2	30	+	0/08
2	20	-	0/23
50	30	+	0/15
50	20	+	0/24
50	20	-	0/1

3.3. Polarity effect on the amount of carbon machined surface

The results of EDX analysis shows that the amount of carbon in the surface polarity is positive when negative polarity is selected tool. It's because it can be explained by the negative polarity of the work-piece surface temperature is less than positive polarity [7], it reduces the penetration of the work-piece surface in atomic negative polarity and thus reduces the carbon is the work-piece surface.

3.4. The impact of the carbon cycle work in the machined surface

As these results show, the duty cycle increases the amount of carbon to the surface of the work-piece is reduced due to the reduced thickness of this phenomenon can be re-frozen layer (white layer) while increasing the duty cycle of the work-piece surface linked (Fig.3) and EDM duty cycle increases due to increasing process efficiency, higher percentages of molten material into the dielectric fluid delivery and volume of material removed increases.

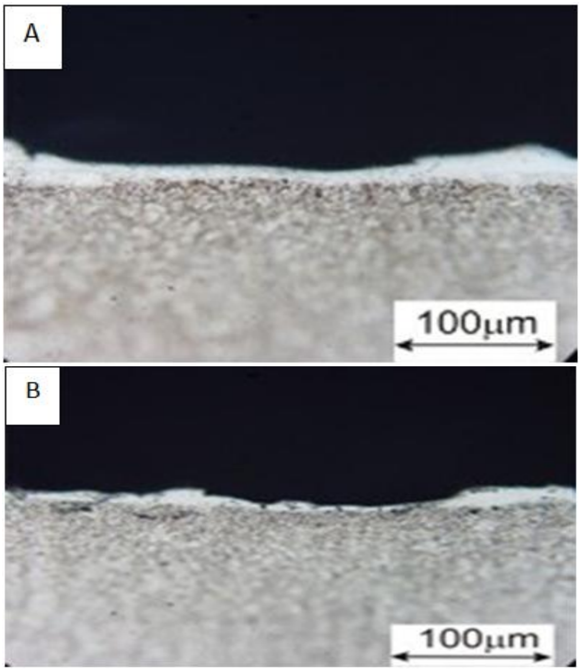

Fig. 2. Optical microscope image of the machined surface (white layer) with a magnification of 500X (Duty cycle = 30%, Polarity (+)) A) Ti = 50µs B) Ti = 15µs

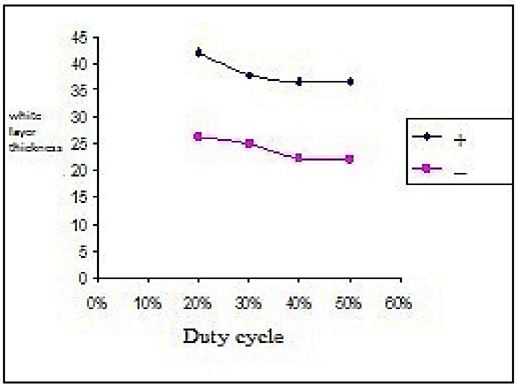

Fig. 3. Changes in the white layer thickness

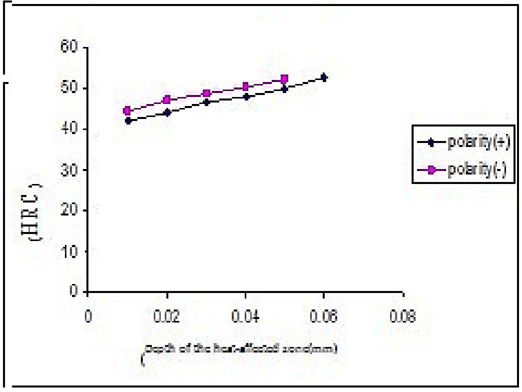

Fig. 4. Distribution of hardness with increasing duty cycle (Ti = 2µs). Sectional area of the work-piece after machining operations (Ti = 15µs, Duty cycle = 30%)
A: maximum depth zone (HAZ) of negative polarity, B: Maximum depth zone (HAZ) in the positive polarity, C: before machining the work-piece hardness (52 HRC))

3.5. Effect of polarity on the tool hardness and depth zone (HAZ)

As Figures 6 and 7show an increase in the pulse duration, depth of lower hardness (zone HAZ) in the machining tool in both polarities (positive and negative) increases. This is because it can be explained by increasing the pulse duration due to higher energy sparks, above the work-piece surface temperatures and more fluid due to dielectric break down, the carbon concentration at the surface of the work-piece increases. Environment by increasing the percentage of carbon, the carbon atoms of the crystal lattice of iron and austenite formation of this layer increases. The increase in percentage carbon austenite to martensite transformation rate during the quenching process reduces the martens tic transformation at the end of the work-piece surface, the higher amount of primary austenite remains [11]. Work-piece surface temperature also increases with increasing pulse duration, makes the heat back on at a higher temperature zone (HAZ) is performed, this phenomenon is more severe losses and thus increase the depth of the layer increases the heat-affected is the pulse duration.

3.6. Effect of duty cycle on hardness and depth zone (HAZ)

Figure 5-8 Effect of duty cycle on changes in the surface hardness of machined parts for the show. As can be observed with increasing duty cycle, decrease the heat-affected zone hardness greater depth increases.

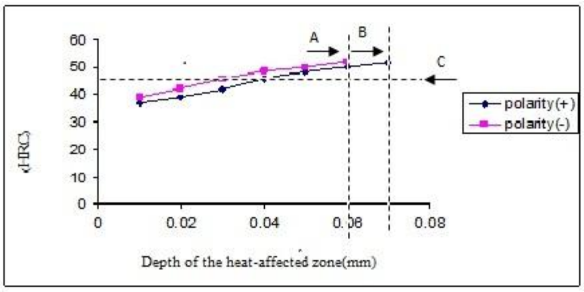

Fig. 5. Distribution of hardness in the cross-section of the work-piece after machining operations
(Ti = 50µs, Duty cycle = 20%)
A: maximum depth zone (HAZ) of negative polarity, B: Maximum depth zone (HAZ) in the positive polarity, C: before machining the work-piece hardness (52 HRC))

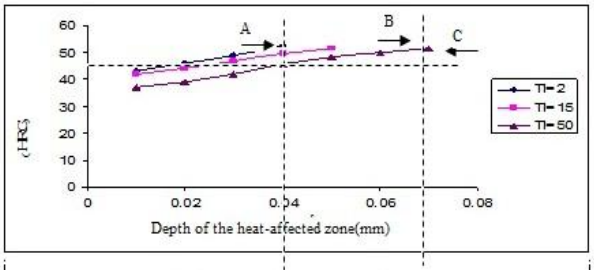

Fig. 6. Distribution of hardness in the cross-section of the work-piece after machining operations
(Polarity (+), Duty cycle = 20%)
A: maximum depth zone (HAZ) at Ti = 2μs, B: Maximum depth zone (HAZ) at Ti = 50μs, C: before machining the work-piece hardness (52 HRC))

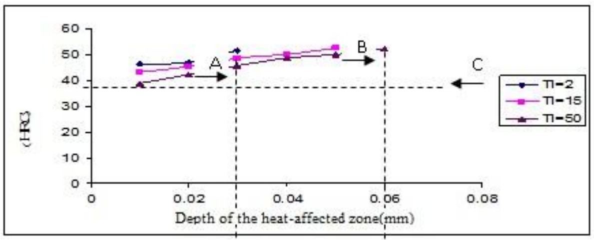

Fig. 7. Distribution of hardness in the cross-section of the work-piece after machining operations
(Polarity (-), Duty cycle = 20%)
A) Maximum depth zone (HAZ) at Ti = 2μs, B: Maximum depth zone (HAZ) at Ti = 50μs, C: before machining the work-piece hardness (52 HRC))

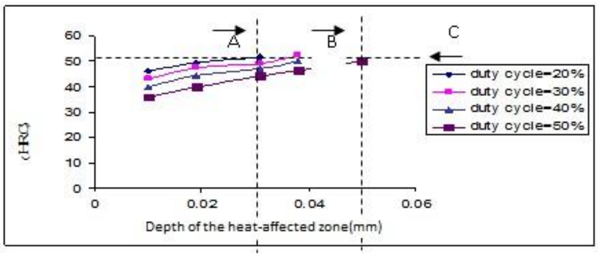

Fig. 8. Distribution of hardness in the cross-section of the work-piece after machining operations
(Polarity (-), Ti = 2μs)
A: maximum depth zone (HAZ) at duty cycle = 20%, B: Maximum depth zone (HAZ) at duty cycle = 50%, C: before machining the work-piece hardness (52 HRC))

That's why it can be said that the duty cycle increases, due to increased machining time and increase the useful discharge time, energy and greater work-piece surface temperature increase due to the size and depth of the pits on the surface of molten created work-piece (Fig. 9), the greater the depth of the work-piece surface is affected. Also, due to the higher temperature of the work-piece surface and heat treatment at temperatures higher back, fell hard in the heat-affected zone in this area is more and spread.

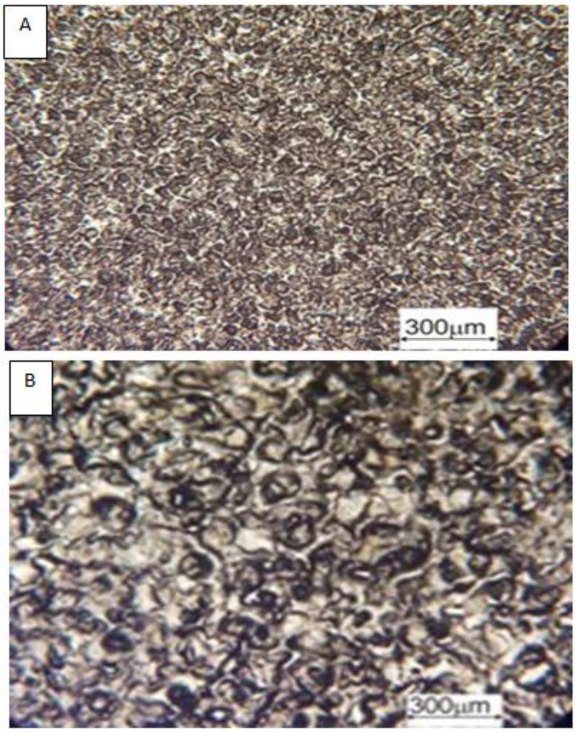

Fig.9. Optical microscope image of a steel work surface with a magnification of 100X
(Polarity (-,Ti = 15μs)
A) Duty cycle = 20% B) Duty cycle = 30%

4. Conclusion

1. By increasing the pulse duration decrease in the layers close to the surface more difficult and depth zone (HAZ) increases.
2. The depth of the heat affected zone is less negative in polarity.
3. By increasing the pulse duration of the kerosene disintegration of carbon from the surface of the work-piece increases.
4. Comparison between the results of (EDX) of the samples before and after machining, representing a significant increase of the carbon surface after machining operations are examples.
5. In case of negative polarity of carbon from the surface layers of the kerosene disintegration decreases.
6. The depth of the heat affected zone increases with increasing duty cycle.

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