MACHINABILITY OF CRYOGENICALLY TREATED WORKPIECE (AISI M2 HSS) IN EDM PROCESS

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Abstract: *The present experimental investigations are to evaluate the machinability of cryogenically treated AISI M2 HSS with copper as Tool in EDM process. The Experiments are performed to study the effects of input parameters such as Discharge current, Pulse on time, Duty cycle and Gap voltage on MRR, TWR and Radial overcut. Nowadays use of cryogenic treatment in machining is increasing day-by-day because the properties necessary for Tool we get after cryogenic treatment, except impact strength. After Cryogenic treatment there is improvement in the properties of the material such as electrical properties, thermal properties, brittleness and hardness. In this present investigation deep cryogenic treatment was done at -185°C for 36 hours on work piece (AISI M2 HSS) without tempering. Compared to conventional tool and work piece, the cryogenically treated work piece shows average increase 3.56% in MRR, the TWR is about 12.76%. The Radial overcut for cryogenic treated work piece is more than conventional EDM. The SEM images shows that machined surface of conventional EDM surface is better than cryogenically treated work piece.*

Keywords: *EDM, Deep Cryogenic Treatment, MRR, TWR, RSM.*

1. INTRODUCTION

Electro Discharge Machining and is an electro-thermal non-traditional machining Process, in which the Tool and workpiece both should be electrically conductive.[1] The several decades continued research on the EDM is to reduce the EW, SR & to increase MRR. It has been found in the literature that cryogenic treatment changes certain mechanical properties like as hardness, wear resistant, fatigue strength, elastic modulus, impact strength, tensile strength as well as electrical and thermal properties of the material changes.[2,3,4,6]

It has been found that there is increase in the MRR and reduction in the TWR and SR, when electrode is cryogenically treated compared to untreated electrode in EDM Process.[3,6] Other studied the cryogenic treatment of both tool as well as work piece.[7]

The significant of this research is to study the effects cryogenic treatment of work piece in electrical discharge machine (EDM). This is because every material have their own characteristic that lead to different result. In this work the deep cryogenic treatment is performed on the work piece and work piece is used without tempering and its responses are compared with the conventional EDM.

2. EXPERIMENTAL SET-UP

The experimental set-up used to carry out this investigation is as shown in Fig. 1, the tool is fix in the spindle and work piece can be hold by vice. The side flushing method is used to remove the debris between the spark zone and in this investigation Commercial grade EDM oil were used as dielectric.

The work piece used is AISI M2 HSS tool steels because of its wide range of applications in tool industries and tool is made of solid Copper of 3mm diameter.

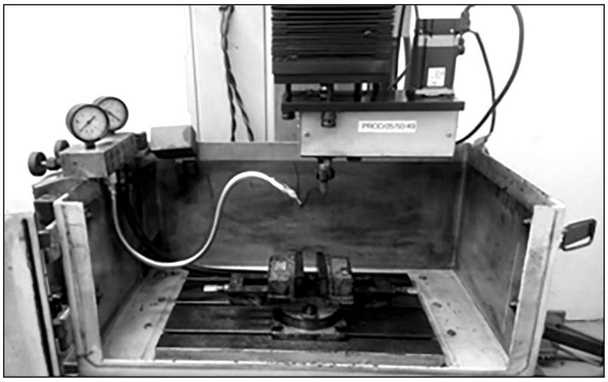

Fig 1. Experimental Setup

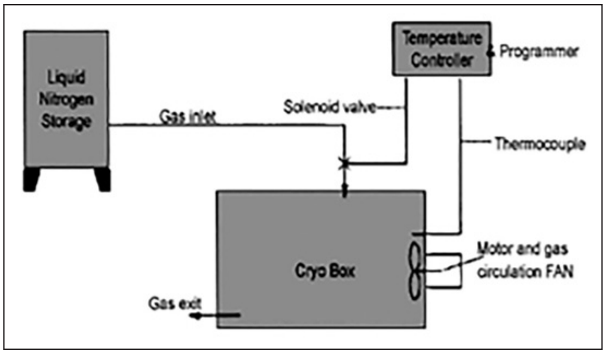

Fig 2. Block Diagram of Cryogenic Treatment Equipment [7]

Table 1: Feasible Limits of Process Parameters

Parameters	Units	-α	LEVEL			+α
		-2	-1	0	1	2
Discharge current	Ampere	3	4	5	6	7
Pulse on time	μs	100	200	300	400	500
Duty cycle	%	31	44	57	70	83
Gap voltage	Volt	50	55	60	65	70

2.1 Cryogenic Treatment

Fig. 2 shows the block diagram of the cryogenic treatment equipment. There are three stages of cryogenic treatment, namely cooling stage, holding stage and warming stage. So cooling at the rate of 2°C/min, holding stage is at -185°C holding for 36 hours followed by warming at the rate of 2°C/min.

The cryogenic treatment is performed on the workpiece with liquid nitrogen as coolant at -185°C. After cryogenic treatment the workpiece is kept at room temperature for one day after warming stage and then EDM process is carried out.

2.2 Design Matrix

To carry out the experiments with four parameters such as discharge current, pulse on time, duty cycle and gap voltage a CCD matrix is used and each parameters studied at the five levels and output parameters are MRR, TWR and Radial overcut. The matrix contain total 31 experiment for each case (conventional EDM and cryogenically treated workpiece) and each experiment is run for 30 min and responses are taken as an average of three shown in Table 1.

3. RESULTS AND DISCUSSION

Fig. 3 shows surface plot for MRR of cryogenically treated Work piece the MRR as a function of

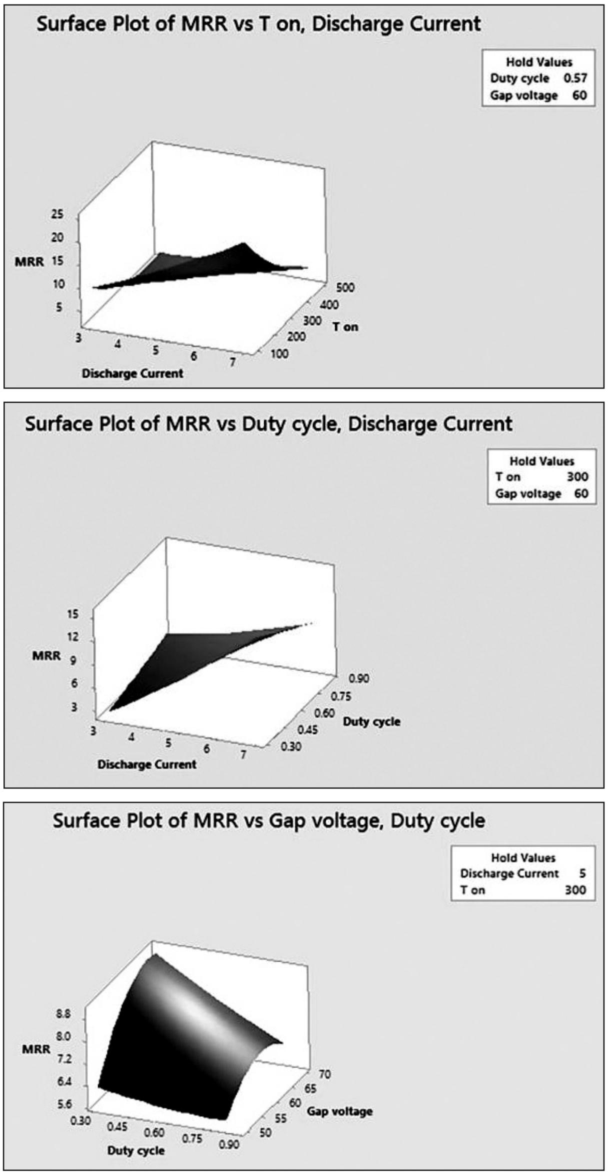

Fig 3. Surface Plot for MRR of Cryogenically Treated Work Piece

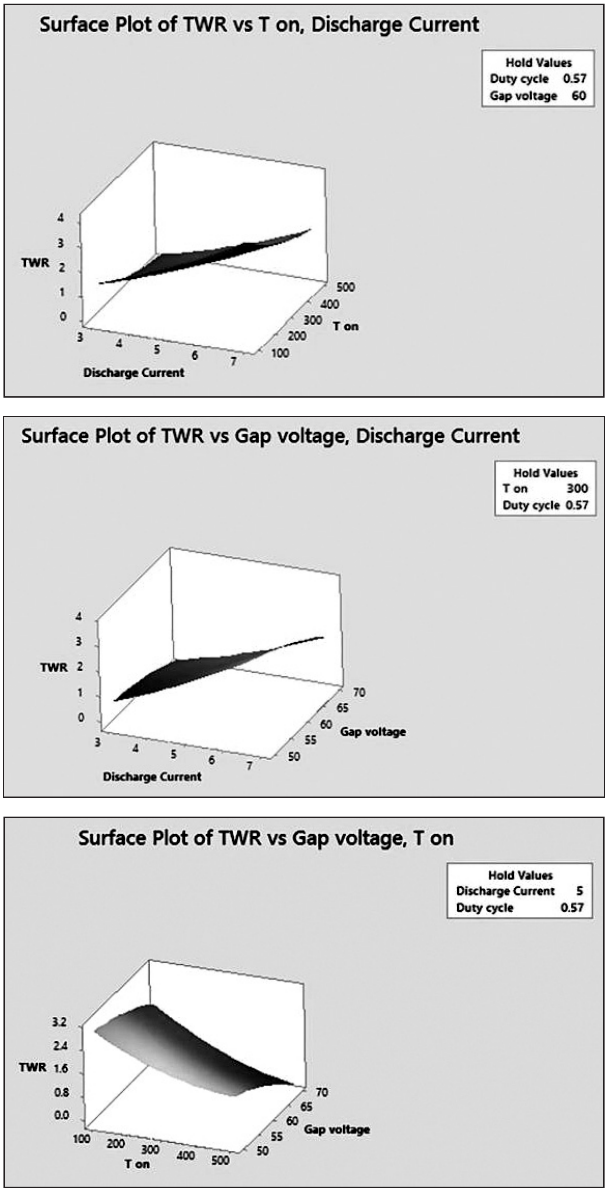

Fig 4. Surface Plot for TWR of Cryogenically Treated Work Piece

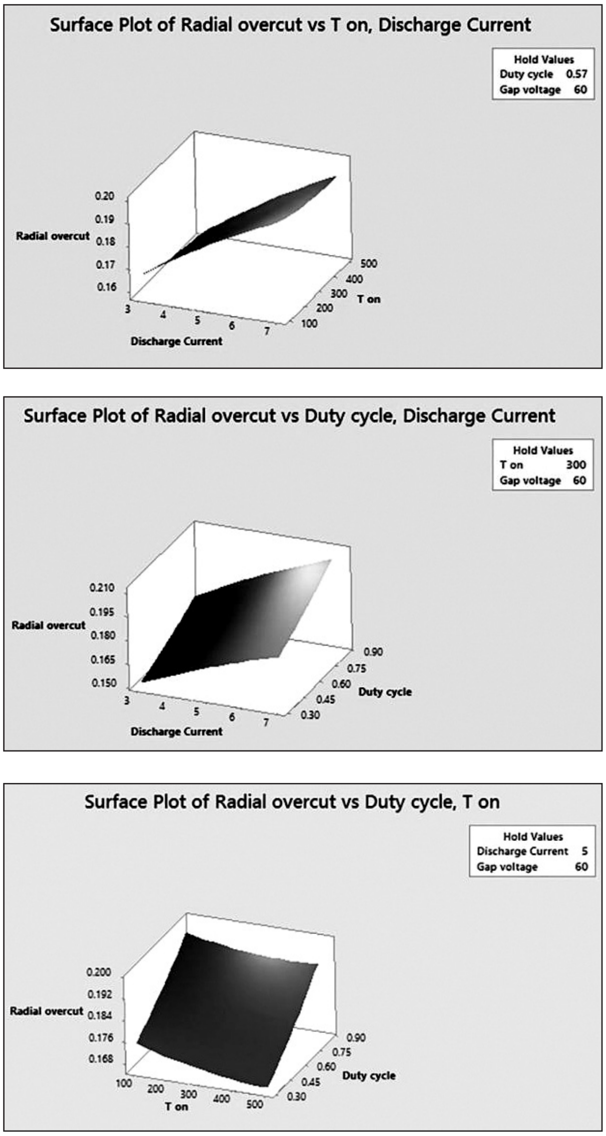

Fig 5. Surface Plot for Radial Overcut of Cryogenically Treated Work Piece

discharge current, Pulse on time, duty cycle and Gap voltage. The graph describes with the increase in the discharge current & decrease in the pulse on time the MRR is increasing. Increase in the discharge current and pulse on time implies increase in the energy input therefore the heat produce is high resulting higher MRR where as with the high pulse on time materials removes from the tool and work piece interface and this debris accumulates in the spark zone, Due to the lower spark off time, because of this low spark off time the melted material cannot flush away from the spark zone. This leads to decrease in the MRR.

Fig. 4 show surface plot for TWR of cryogenically treated Work piece the TWR as a function of discharge current, Pulse on time, duty cycle and Gap voltage. The graph describes, with the increase in the discharge current & decrease in the pulse on time the TWR is increasing. Increase in the discharge current and pulse on time implies increase in the energy input therefore the heat produce is high resulting higher TWR where as with the high pulse on time materials removes from the tool and work piece interface and the volume of material removes from the electrode accumulates in the spark zone, Due to the lower spark off time, because of this low spark off time the melted material cannot flush away from the spark zone. This leads to decrease in the TWR.

Fig. 5 shows surface plot for Radial overcut of cryogenically treated Work piece the Radial

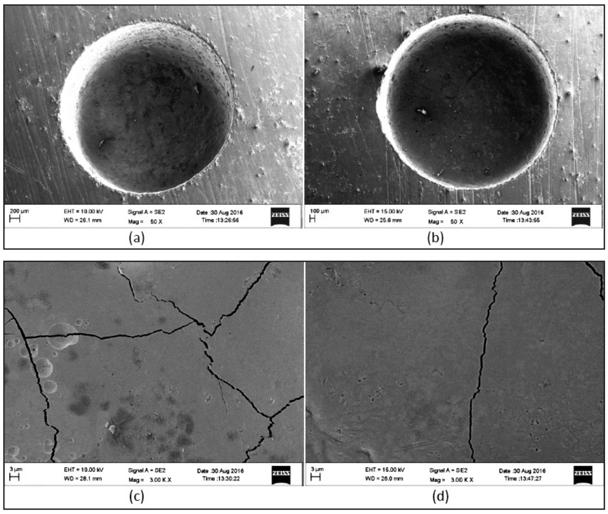

Fig. 6.1. SEM Images of Work Piece [(a): Machined Cavity by Conventional EDM (50x), (b): Machined Cavity by Cryo Treated Work Piece (50x), (c): Machined Surface of Conventional EDM (3kx), (d): Machined Surface by Cryo treated work piece (3kx).]

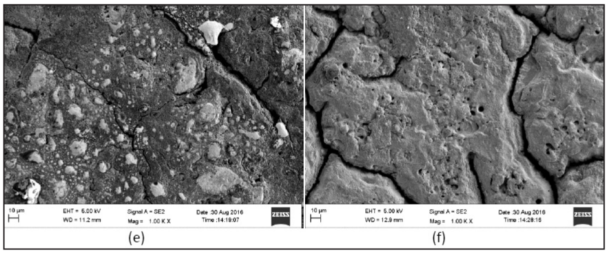

Fig 6.2. SEM Images of Tool [(e): Conventional Tool Surface After Machining (1kx), (f): Cryo Treated Work Piece Machined Tool Surface After Machining (1kx)]

overcut as a function of discharge current, Pulse on time, duty cycle and Gap voltage. The graph describes, with the increase in the discharge current & the pulse on time the Radial overcut is increasing. Increase in the discharge current and pulse on time implies increase in the energy input therefore the heat produce is high resulting higher Radial overcut. It can be observed that with increase in the Duty cycle, radial overcut of the work piece increases. Higher the Duty cycle lower is the spark off time, as spark off time decreases the intensity of the spark increases. The lower the spark off time it will give tool and work piece very small time to cool down, heated because of pulse on time. Due to this increase in the radial overcut is observed.

Fig. (a) and (b) clearly shows that the cavity machined by conventional EDM is good than that of cryogenic treated workpiece. From Fig. (c) and (d) we clearly see that the intensity of crack is same and from Fig. (e) and (f) we see that the intensity of oxide formation is more on tool in conventional EDM than by cryogenically treated workpiece. Comparatively from these SEM images it can be concluded that conventional EDM is preferred over cryogenically treated workpiece.

4. CONCLUSION

Based on the results obtained in the present investigations the following conclusions can be drawn

- The cryogenically treated work piece shows 3.56% increase in the MRR and 12.76% increase in TWR.
- The Radial overcut for cryogenic treated work piece is more than that of conventional tool and work piece.
- The increase in the MRR and Radial overcut perhaps due to the increase in the brittleness, electrical and thermal properties of the workpiece and increase in TWR is likely because tool is untreated and it will form larger oxides but the heat is very high in between tool and workpiece so it will erodes faster.
- SEM images shows cryogenically treated workpiece is having finer surface compared to conventional workpiece. The conventional electrode and work piece having high oxide formation because of this low MRR. In other cases the formation of oxide is low, hence increase in the MRR.

5. ACKNOWLEDGEMENT

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