

Experimental Investigation of EDM of AISI 4340 for Surface Integrity

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ABSTRACT: Electric discharge machine is a non-conventional machining process and is used for those hard materials that are difficult to machine such as heat treated tool steels, super alloys, ceramics, heat resistance steel being used for die and mould making, aerospace and automobile industries. The present experimental investigation for optimization of EDM parameters studies the process parameters that are influencing the surface integrity of the work piece. A combined approach is used for the optimization of parameters and performance characteristics based on Taguchi method. The design of experiments is based on Taguchi's L16 orthogonal array. The machining parameters are current, pulse on time and voltage which are considered for study of the surface of AISI 4340 as work piece and tungsten-copper as electrode. Finally, the results show that the machined surface is mainly influenced by higher levels of EDM parameters.

KEYWORDS: EDM, Surface Integrity, Cracks Induced, AISI 4340

I. INTRODUCTION

EDM is achieved when discharge of sparks occurs between two closest points of the anode and cathode, by which intense heat is generated near the zone that melts and evaporates the materials in the sparking zone. For effectiveness of the process, the work piece and the tool are submerged in a medium of dielectric fluid. The material is removed due to localized heating and then vaporization of material during machining when the distance between the tool electrode and the work piece electrode is maintained as electrostatic field of sufficient strength is established which causes cold emission of electrons from tool electrode. After gaining sufficient velocity, the electron collides with the molecules of dielectric and breaks them into electrons and positive ions. The electrons thus produced are also accelerated and may ultimately dislodge to other electrons from the dielectric fluid molecules. EDM is a non-conventional process and hence it is used for better productivity and product quality. Surface of the machined work piece also plays a vital role in product quality.

Syed Asghar Husain Rizvi et al [1] in their research investigated the surface integrity of AISI 4340 and concluded that the cracks on the machined surface will increase with current but will reduce the cracks when pulse on time is reduced. Annamalai et al [2] in their research on surface roughness while machining AISI 4340 on EDM found that with increase in peak current, the surface roughness increases significantly. An investigation conducted by Muhamed Mehmedović et al [3], studied the effect of white layer which results in decrease of machined surface roughness compared to its expected value. Uniform thickness along the machined surface increases the micro hardness as compared to the raw material.

J. Krawczyk et al [4] in their research found that the white layer can be readily formed on the surface of heat treated forged steel rolls. To avoid such consequences it is necessary to uniformly distribute the precipitates of secondary cementite in the material structure. Harpreet Singh et al [5] from their concluded that the use of powder mixed electrolyte provide mirror like surface finish and increase in material removal rate. Subramanian Gopalakannan [6] observed that the output parameter surface roughness of EDM increases with increase in pulse current.

Pravin R. Kubade [7] found that both MRR and EWR are mainly influenced by peak current. Mr. Anand et al [8] concluded that material removal rate increases when intensity and duty cycle were increased, while with increase in

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pulse time the MRR decreases. Hence, for obtaining high values of material removal rate for OHNS tool steel one should use higher levels of intensity and duty cycle.

II. EXPERIMENTAL DESIGN AND SETUP

The current study is performed on AISI 4340 of size of 10 mm diameter and 8 mm thickness. The tool used is Tungsten-Copper rod of 2 mm diameter. The performance measures to be tested is surface integrity using current, pulse on duration and gap voltage as machining parameters. The machine tool used was S-70 ZNC EDM machine.

Table 1: The levels of EDM parameters

Parameters	Unit	Levels
Peak Current (I_p)	A	1 5 9 13
Pulse on Time (T_{on})	μ sec	15 20 30 40
Gap Voltage (V_g)	V	75 100 125 150

Scanning electron microscopy (SEM) is performed to analyze the surface integrity of the machined surface.

III. RESULTS AND DISCUSSIONS

3.1 Surface Integrity

A great influence of EDM parameter is observed on the surface of the machined work piece. The initial level of the EDM parameters induces small crater obtained is small. This is due to the fact that the intensity of spark at low level is less and thus the surface obtained is not rough. Moreover, and low heat gradients are developed at low level of parameters. Figure 1 presents the surface of sample 1 machined at low level of parameters.

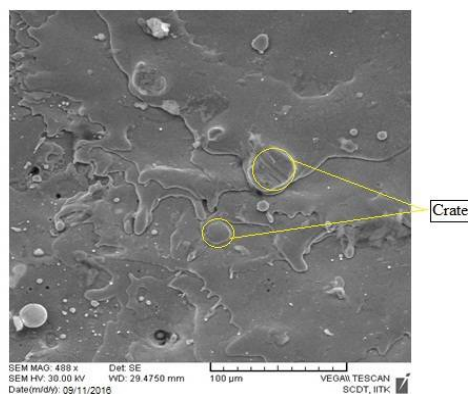


Figure 1: Surface Image of Sample 1

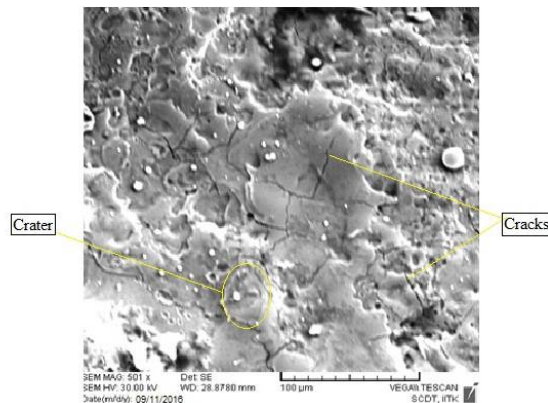


Figure 2: Surface Image of Sample 12

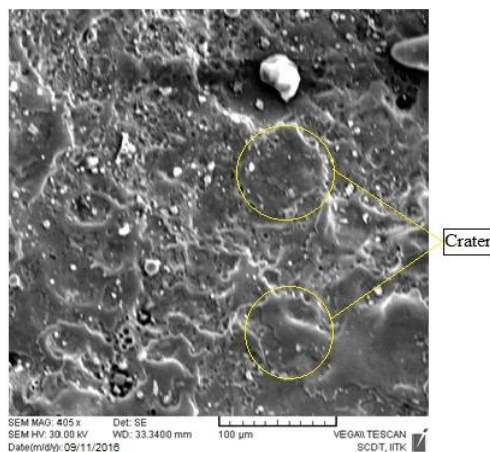


Figure 3: Surface Image of Sample 16

As we increase the levels of parameters, the intensity of spark increases and hence the surface starts to degrade. The figure 2 illustrates sample 12, showing the induced cracks on the surface which are due to high intensity of spark energy. The cracks are dispersed all over the surface and are mainly due to high current and voltage. This results in poorer surface finish.

On increasing the level of parameters, the surface finish gets poorer due to large craters formed by the high intensity sparks.

IV. CONCLUSIONS

The investigations conducted on AISI 4340 with tungsten-copper as electrode to find the relation between EDM parameters with surface integrity has following conclusions:

1. Small craters are obtained at lower levels of EDM parameters which are due to low intensity of spark and hence results in better surface finish.
2. As the levels of parameters are increased, the crater size increases due to increased intensity of spark.
3. Cracks are observed on the machined surface due to internal stresses caused by heating and sudden cooling of surface.

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