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Optimization of WEDM Process Parameters for Machining EN 8

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Abstract—This paper presents an investigation of WEDM process using Zinc coated brass wire as electrode on EN 8. WEDM is a thermal machining process that utilizes spark discharges to erode a conductive material. Optimum machining conditions were obtained with maximum cutting speed and minimum surface roughness as objective. It was observed that with increase in peak current, cutting speed and surface roughness increases. Response surface methodologies D optimality test was used to determine the optimal machining parameters, among which the peak current for cutting speed and the gap voltage for surface roughness were found to be the most significant. The obtained optimal machining conditions are peak current of 190 A, voltage of 15 V, Pulse on time of 112.62 µs, Pulse off time of 60 µs and Wire tension of 6 N which is validated by confirmation test.

Keywords—WEDM, Cutting speed, surface roughness, RSM

I. INTRODUCTION

Wire electrical discharge machining (WEDM) is one of the most extensively used non-conventional material removal processes. WEDM has evolved over time from being just used for manufacturing tools and dies to the machine of exotic space age alloys including Hastelloy, Inconel, titanium, Carbide, Polycrystalline diamond compacts and Conductive ceramics. It can machine anything regardless of its hardness, the only condition being the material should be electrically conductive. Parts that have complex geometry and tolerances don't require manufacturer to rely on different skill levels or multiple equipment. Substantial increases in productivity are achieved since the machining is unattended, allowing operators to do work in other areas. Most workpieces come off the machine as a finished part, without the need for secondary operations.

Himadri Majumder and Kalipada Maity (2018) investigated four WEDM responses using five key input parameters for machining Ni-Ti shape memory alloy. Pulse on time, discharge current, wire tension, wire speed and flushing pressure were considered as five distinct WEDM parameters, whereas arithmetic mean roughness, maximum peak to valley height, root mean square roughness, and micro-hardness were selected as the major responses to be investigated [1]. Bikash Choudhuri et al. (2018) made an attempt to model the performances of WEDM process on H21 tool steel using response surface methodology. Longer pulse on-time results in less consumption of wire but lower surface finish with more surface defects [2]. S. Banerjee et al. (2018) examined the influence of process parameters of WEDM on MRR of EN47 spring steel. The ANOVA result indicates that pulse-on time is the most influencing parameter whereas pulse off time and gap voltage are found to be quite remarkable parameters to control the MRR [3]. Neeraj Sharma et al. (2015) studied the effect of process parameters on the overcut while machining the HSLA steel on WEDM. RSM and GA approach provide a systematic and effective methodology for the modelling and the optimization [4].

WEDM is an efficient machining process for the fabrication of an intricate shapes with various advantages. Although most WEDM machine today have process control, but selecting and maintaining optimal setting is still an extremely difficult job which must be addressed. Objective of this work is to determine the optimal machining parameters with maximum cutting speed and minimum surface roughness. The response surface methodology was employed to reveal the effect of the machining parameters on the characteristics of the WEDM process. D optimality test was used to find the optimal machining parameters satisfying the multiple characteristics of the WEDM process.

II. EXPERIMENTAL SET-UP

Experiments have been conducted using ELEKTRA SPRINTCUT 734 WEDM. The WEDM machine is shown in Fig. 1. Zinc coated brass wire of diameter ϕ 0.25 mm was used to cut EN 8 workpiece.

Fig 1: WEDM Machine

2.1. Experimental procedure

The experiments were designed using response Surface Methodology. Total 32 runs were conducted designed with central composite design. The experiments has been conducted with five controllable factors namely peak current, gap voltage, pulse on time, pulse off time and wire tension. On the basis of preliminary experiments conducted by using one variable at a time approach the range of input parameters was selected. Machining parameters and their level chosen for this study are shown in Table 1. Experiments were carried out in single block.

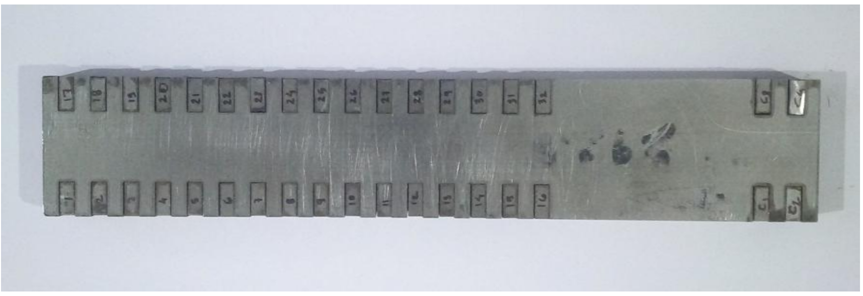

Fig 2: Workpiece after machining

Table 1. Machining Parameters and their levels

Factor		Unit	Levels 1	Levels 2	Levels 3	Levels 4	Levels 5
			-2	-1	0	1	2
Peak current	Ip	Amp	190	210	230	250	270
Gap voltage	V	Volt	15	20	25	30	35
Pulse on time	Ton	µSec	110	115	120	125	130
Pulse off time	Toff	µSec	40	45	50	55	60
Wire feed rate	WF	N	6	7	8	9	10

III. RESULT AND DISSCUSSION

The analysis was made using the popular software specifically used for design of experiment applications known as MINITAB 16. In present study, it is desirable to maximize Cutting speed and to minimize surface roughness.

3.1. Analysis of cutting speed

The peak current determine the status of input energy in the WEDM process. From the surface plot it can be seen that increase in peak current leads to an increase of cutting speed. Fig 2 shows that the cutting speed is directly proportional to the peak current. Cutting speed decreases with increase in voltage.

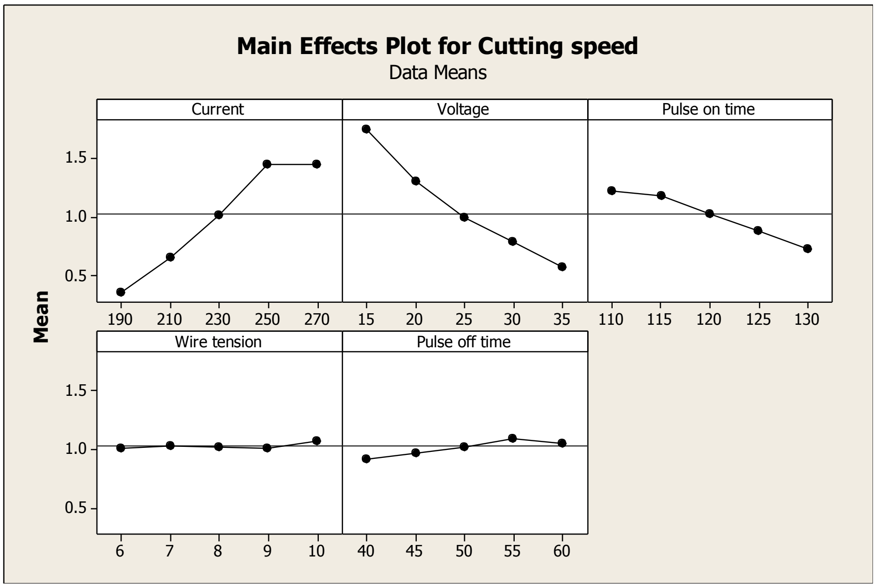

Figure 2. Main Effect Plot for cutting speed

3.2. Analysis of surface roughness

The discharge energy increases with the pulse on time and peak current and larger discharge energy produces a larger crater, causing a larger surface roughness value on the work piece. Fig 3 shows that the surface roughness is directly proportional to the peak current, but it is decreases with increase in voltage.

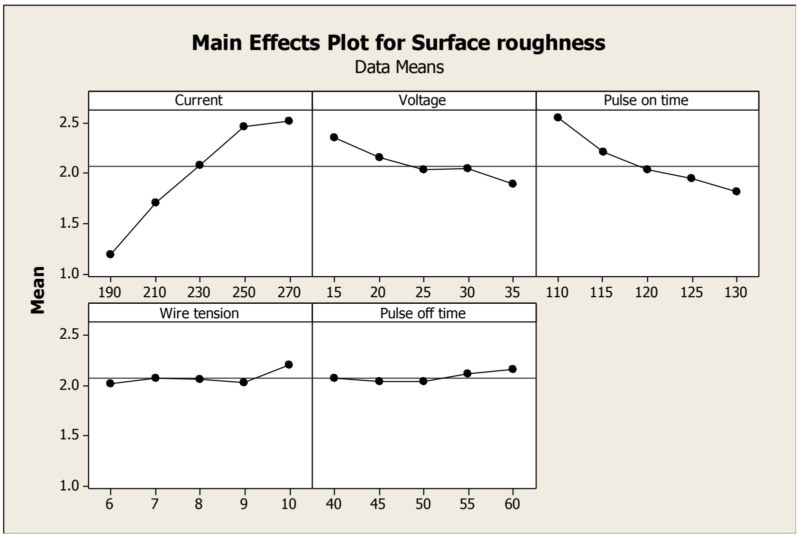

Figure 3. Main Effect Plot for surface roughness

IV. RSM's D-optimal Method

Response Optimizer helps to identify the factor settings that optimize a single response or a set of responses. For multiple responses, the requirements for all the responses in the set must be satisfied. Response optimization is often useful in product development when you need to determine operating conditions that will result in a product with desirable properties.

Table 2. Response Optimization for cutting speed and surface roughness

Parameters	Goal	Lower	Target	Upper	Weight	Import
MRR	Maximum	0.36	2.15	2.15	1	1
EWR	Minimum	1.19	1.19	2.83	1	1

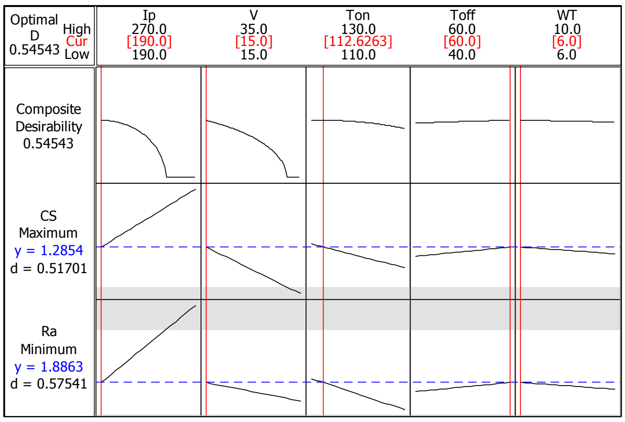

Figure 4. Optimization Plot for cutting speed and surface roughness

From the plot it is observed that the composite desirability is obtained as 0.5454 reflecting the setting of input variables marked by red color will provide optimum responses value

- Global Solution

Peak current = 190 Amp
Gap voltage = 15 Volt
Pulse on time = 112.62 µsec
Pulse off time = 60 µsec
Wire tension = 6 N

- Predicted Responses

Cutting speed = 1.2854 mm/min,
Surface Roughness = 1.8863 µm

V. CONCLUSION

WEDM experiments were successfully performed on EN 8 using zinc coated copper wire. The cutting rate and surface roughness are evaluated. It is observed that increase in peak current drastically reduces the machining time to at the same time surface roughness is high. From the response surface optimizer, the optimum value of cutting speed is 1.2854 mm/min and surface roughness is 1.8863 µm at peak current = 190 Amp, Gap voltage = 15 V, Pulse on time = 112.62 µsec, Pulse off time = 60 µsec, Wire tension = 6 N which is validated by confirmation test.

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