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Study of Process Parameter of WEDM for Machining D2 Tool Steel using Molybdenum Wire Electrode

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ABSTRACT: This paper investigates the Wire Electric Discharge Machining (WEDM) of D2 tool steel with molybdenum wire as a wire electrode. Efforts were taken for the prediction of the performance characteristics of WEDM process. The effects of five parameters, namely, Peak current, Gap voltage, Pulse on time, pulse off time and Wire tension were selected as process parameters to study the Cutting rate and Surface roughness. The objective was to study the effect of input parameter individually on the final outcome. Response surface methodology was used to design the experiments and the performance characteristics in WEDM operation were studied. The experimental result indicate that peak current is the most significant factor. At high values of current cutting speed and surface roughness were found high.

KEYWORDS: WEDM, Cutting speed, surface roughness, RSM

I. INTRODUCTION

With the industrial and technological growth, development of harder and difficult to machine materials, which find wide application in aerospace, nuclear engineering and other industries owing to their high strength to weight ratio, hardness and heat resistance qualities has been witnessed. New developments in the field of material science have led to new engineering metallic materials, composite materials and high tech ceramics having good mechanical properties and thermal characteristics as well as sufficient electrical conductivity so that they can readily be machined by non-conventional machining process like spark erosion. The Wire Electrical Discharge Machining process is employed widely for making tools, dies and other precision parts. The WEDM has many advantages, such as non-contact with the workpiece during the machining process and ability to machine any conductive material, regardless of its hardness. Hence, it does not create any vibration during machining as compared to other conventional machining. The quality of the product mainly depends upon the material and process parameters. Optimization of process parameter plays a vital role to increase the quality of the product. Hence, many authors have presented their works on the optimization of process parameters for various machining processes

II. RELATED WORK

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.

III. METHODOLOGY

During this study, series of experiments on the D2 tool steel were conducted to examine the effect of input machining parameters, such as peak current, gap voltage, pulse on time, pulse off time and wire tension on cutting rate and surface roughness. In this experimental work, molybdenum of diameter ϕ 0.25 mm was used under servo control.



Fig. 1 WEDM Machine

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.

Table. 1 Machining Parameters and Levels

Factor		Unit	Levels 1	Levels 2	Levels 3	Levels 4	Levels 5
			-2	-1	0	1	2
Peak current	Ip	Amp	15	17	19	21	23
Gap voltage	V	Volt	190	210	230	250	270
Pulse on time	Ton	μ Sec	110	115	120	125	130
Pulse off time	Toff	μ Sec	40	45	50	55	60
Wire feed rate	WF	N	6	7	8	9	10

IV. EXPERIMENTAL RESULTS

In this study the machining parameter such as I_p , V , T_{on} , T_{off} and WT were studied to evaluate cutting rate and surface roughness. Total 36 experiments were conducted out of which 32 are as per DOE and 4 for confirmation purpose. Work piece cut after the machining are shown in figure 2.

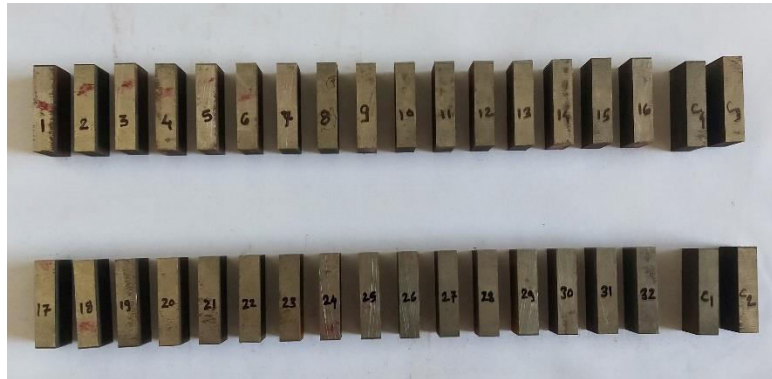


Fig. 2 Workpiece after Machining

Analysis of Cutting rate

Pareto chart for cutting rate shows that the peak current is most significant parameter followed by voltage, pulse on time, pulse off time and wire tension.

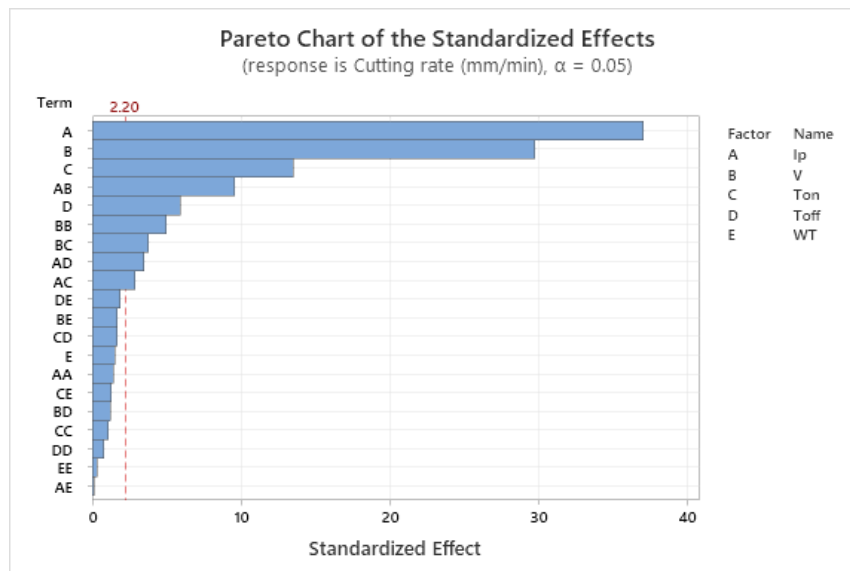


Fig. 3 Pareto chart for Cutting rate

Regression Equation in Uncoded Units

$$\begin{aligned} \text{Cutting rate (mm/min)} = & -3.20 + 0.881 I_p - 0.0488 V + 0.0453 T_{on} + 0.0552 T_{off} - 0.339 WT + 0.00301 \\ & I_p * I_p + 0.000105 V * V - 0.000377 T_{on} * T_{on} - 0.000277 T_{off} * T_{off} - 0.00296 WT * WT - 0.002693 I_p * V - 0.00340 \\ & I_p * T_{on} + 0.00410 I_p * T_{off} + 0.00074 I_p * WT + 0.000434 V * T_{on} - 0.000141 V * T_{off} - 0.000949 V * WT - 0.000808 \\ & T_{on} * T_{off} + 0.00295 T_{on} * WT + 0.00445 T_{off} * WT \end{aligned}$$

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0476080	99.58%	98.82%	91.78%

Analysis of surface roughness

Surface roughness was measured with Taylor Hobson surtronic 3 series surface roughness tester. Pareto chart for surface roughness shows that the peak current is most significant parameter followed by voltage, pulse on time, pulse off time and wire tension.

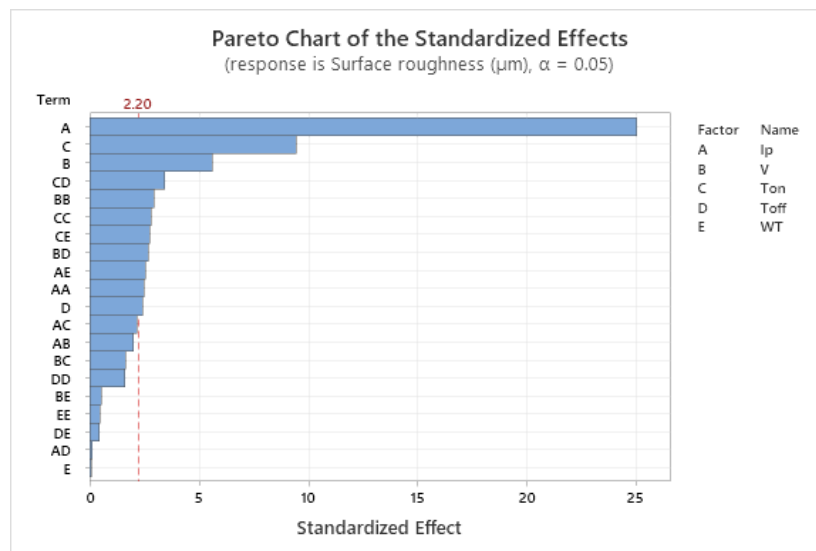


Fig. 4 Pareto chart for Surface roughness

Regression Equation in Uncoded Units

Surface roughness (μm) = $10.5 + 1.325 I_p - 0.0462 V - 0.335 T_{on} + 0.321 T_{off} - 0.871 WT - 0.00815 I_p * I_p + 0.000095 V * V + 0.001513 T_{on} * T_{on} + 0.000863 T_{off} * T_{off} - 0.0063 WT * WT - 0.000865 I_p * V - 0.00393 I_p * T_{on} + 0.00019 I_p * T_{off} - 0.02122 I_p * WT + 0.000290 V * T_{on} - 0.000473 V * T_{off} + 0.000458 V * WT - 0.002564 T_{on} * T_{off} + 0.00989 T_{on} * WT + 0.00164 T_{off} * WT$

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0476080	99.58%	98.82%	91.78%

V. CONCLUSION

The WEDM machining experiment were conducted on D2 tool steel using molybdenum wire electrode. The cutting rate and surface roughness were evaluated. It was observed from the experimental result that cutting rate increases with increase in peak current at the same time large amount of electrons are removed from electrode surface that create larger craters on work piece surface that lead to rough surface. It was found that current is most significant factor for cutting speed and voltage significantly affects the surface roughness. For WEDM process, peak current is found to be most significant parameter followed by gap voltage.



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