Experimental Investigation of Surface Roughness by the Application of Taguchi Method in Electric Discharge Machining

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Abstract
Aim of the experimental investigation was to determine the effect of electric discharge machining parameters on surface roughness of oil hardened non shrinkable (O6) steel. Though vast research has been done to improve the surface finish of hard metal machined by EDM, optimal choice of parameters for best performance measures is still challenge. The experiments were carried out on adequate range of machining parameters. Selected input parameters for this study were peak current, pulse-on-time, and pulse-off-time. Pure copper electrode with positive polarity in dielectric medium was used to perform the investigation. The optimal machining parameters peak current (8 Amp), pulse on (45 µs) and pulse off (9 µs) were originated by using Taguchi method and ANOVA analysis. Design of experiment approach was used to model the experimental data. It is found that interactions between Peak current, pulse on, Voltage Gap and Flushing Pressure have significant effect on the surface roughness.

Keywords
EDM, OHNS (O6), Surface Roughness (SR), Taguchi Method

I. Introduction

EDM has its widespread application in tool and die making industry because of its ability to machine hard materials with intricate shapes. The process involves material removal by the erosive effect of electrical discharges between tool and workpiece. Due to high temperature between material and dielectric, causing vaporization of metal, it is necessary to evaluate EDM parameters to attain better surface finish for economic considerations. OHNS steel is most commonly used in manufacturing for tool and dies, mainly because of its high wear resistance, high strength and high hardness. OHNS (O6) steel has following chemical composition by weight: C 1.02%, W 1.31%, Si 0.197%, Cr 0.682%, Mn 0.522%, Ni 0.0808%, S 0.0508%, Cu 0.0548%, Mo 0.00416%, Al 0.0195%, V 0.0031% Rest is iron with additives.

To understand the OHNS response towards surface roughness by EDM machining were explored in this experimental study. Sameh S. Habib (2014) showed the effect of EDM process parameter in maching of hot work tool steel 2714 using taguchi method. He found that for both copper and graphite electrodes, average machining voltage has minor affect on surface roughness and MRR. D.C. chen et al. (2013) described about the application of taguchi design to optimize the EDM parametes for the machining of A6061-T6 aluminum alloy. They concluded that peak current and duty cycle are primarily cause for surface roughness. Adem cicek et al. (2012) presented the results of experimental work carried out in EDM of AISI 316 austenitic stainless steel for surface roughness and roundness error in drilling by the application of taguchi method. They concluded that cutting speed had a considerable effect on the surface roughness. V.D. Patel et al. (2011) presented the effect of a copper and brass electrode material on mild steel workpieces during machining by EDM. The experiment found that by increasing the discharge current with copper electrode there was more material removal rate (MRR) while brass gives good surface finish and normal MRR. M. K. Pardhan et al. (2009) discussed the effect of process parameters on surface roughness in EDM of AISI D2 tool steel by RSM approach. They concluded that lower value of surface roughness is directly proportional to linear effect of pulse current and pulse on time. A.G. Jaharah et al (2008) represented the effect of copper electrode performance in EDM of AISI H13 harden steel. They completed their study by concluding that higher peak current values and pulse on time are mainly responsible for high surface roughness values.

II. Experiment Details

O6 steel was used as work object. SR was measured using the surface roughness-testing machine; model SURFCOM, The equipment has stylus, having a tracing length of 4.0mm was used for measurement. The values of Surface Roughness (SR) were measured in terms of Ra value. Commercial available EDM machine was used to perform the experiments.

Fig. 1: Experimental Setup

Experiments were conducted based on Taguchi's orthogonal array L_9 and ANOVA method. The three factor i.e. Current, Pulse ON and Pulse OFF were selected for conducting experiment with three levels each. The electrode used was square shape of brass a 12 mm. Selected parameters and their levels are shown in Table 1.

Table 1: Electrical Parameters and Their Levels to be used in EDM

S.No.	Input parameters, units		Levels		
			1	2	3
1.	Current (I_p) Amp	A	4	6	8
2.	Pulse -On-Time (T_{ON}) µs	B	15	30	45
3.	Pulse -OFF-Time (T_{OFF}) µs	C	5	7	9

In the present work SR was measured after conducting total 27 numbers of experiments. Fig shows the OHNS steel after machining in EDM.

Fig. 2: OHNS Steel After Machining With EDM

III. Results and Discussions

After the completion of all the 27 experiments, the following results were obtained for SR by machining of OHNS steel on EDM. The S/N ratio and the mean of mean values for DOE approach were calculated by putting the values of MRR in Minitab software.

Table 2: Results of MRR

I_p	T_{ON}	T_{OFF}	SNRA1	MEAN1
4	15	5	-10.4489	3.33
4	30	7	-11.1261	3.6
4	45	9	-11.799	3.89
6	30	9	-13.9446	4.98
6	15	7	-13.7684	4.88
6	45	5	-14.2698	5.17
8	15	9	-16.5732	6.74
8	30	5	-15.9315	6.26
8	45	7	-16.5215	6.7

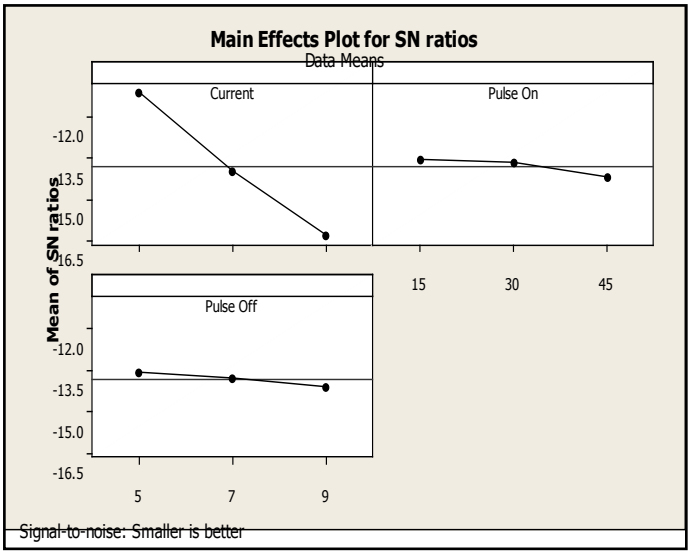

Fig 3: Main Effect Plot Graph of S/N ratios of Surface Roughness

Table 3: ANOVA for S/N ratio of MRR

Source	Seq SS	DOF	Adj MS	%contribution
Current	40.9683	2	20.4842	96.93
Ton	0.6452	2	0.3226	1.53
Toff	0.4639	2	0.2320	1.10
Residual error	0.1859	2	0.0930	0.44
Total	42.2633	8	21.1318	100

Table 4: Ranking of Parameters for MRR

Level	Current	T_{ON}	T_{OFF}
1	-11.12	-13.60	-13.55
2	-13.99	-13.67	-13.81
3	-16.34	-14.20	-14.11
Delta	5.22	0.60	0.56
Rank	1	2	3

By machining of OHNS steel on EDM, it can be noted that Current has the largest effect on the surface roughness. The pulse off has the smallest effect on the surface roughness. To attain better surface finish, surface roughness has to be minimized. From above main effect plot, it can observed that for the three levels of peak currents the surface roughness is declining linearly and at current level 8amp the Surface roughness value is the lowest (-16.5). Similarly Surface roughness also diminishes with increased levels of both, pulse on time and pulse off time. At pulse on time (45 µs) the SR value observed was the least i.e. -14.4 also for Pulse off time (9 µs) the smallest SR value (14.2) was monitored. Thus the optimum condition for surface roughness observed were, A3, B3, and C3 i.e. Current (8 amp.) and Pulse-on (45 µs). Interaction plot fig 4 which is the combination of all three parameters interacting with each other at different levels gives the idea that peak current, pulse on time and pulse off time had their considerable effects on OHNS steel surface roughness while machining with EDM.

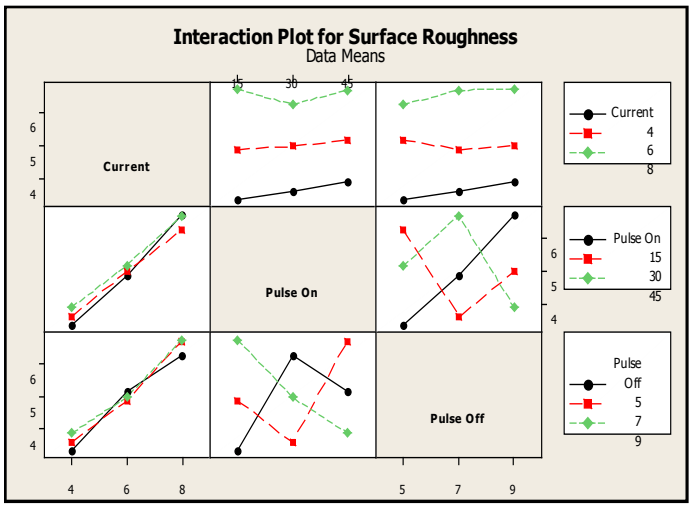

Fig. 4: Interaction Plot Graph for Surface Roughness

IV. Conclusion

Effect of machining parameters on the surface roughness values of OHNS steel by EDM have been examined experimentally. It was found that peak current is the key factor affecting surface finish for both finishing and roughing operations. For OHNS steel optimum machining condition for better surface finish during machining on EDM were Current (8 A), Pulse-on (45 µs), and Pulse-off (9 µs) with positive polarity.

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