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EXPERIMENTAL ANALYSIS OFELECTRIC DISCHARGE MACHINING PROCESS PARAMETER EFFECT ON SURFACE ROUGHNESS OF AISI L2 STEEL

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Abstract- Aim of the experimental investigation was to determine the effect of electric discharge machining parameters on surface roughness of AISI L2 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, voltage gap and flushing pressure. Pure copper electrode with positive polarity in dielectric medium was used to perform the investigation. The optimal machining parameters peak Current (10 ampere.), Pulse-on-time (250 µs), voltage gap (20 volt) and flushing pressure (0.3 kg/cm2) were originated by using Taguchi method and ANOVA analysis. It was found that interactions between peak current, pulse on, voltage gap and flushing pressure have significant effect on the surface quality.
Keywords: Electrical Discharge Machining, AISI L6, Surface Roughness (SR), Taguchi

1. INTRODUCTION

Technology advanced industries like aeronautics, automobiles, nuclear reactors, missiles, turbines and so on requires high strength temperature resistant alloys that have properties similar to higher strength, good corrosion resistive, toughness and high hardness. With rapid development in the field of materials it has become essential to develop cutting tool materials and processes that are safe and convenient to machine such materials.EDM is one of most popular the non-traditional machining processes for the material removal. In EDM there is no physical contact left between the work-piece and the cutting tool thus machining of harder metals with less harder cutting tools became easy. EDM has the ability to cut complex inner shapes in hardened materials with negligible cutting forces.

AISI L2 Silver Steel is a precision ground bar that finds numerous uses in the tool room as well as in general engineering due to its physical characterstics. The chromium content in silver steel adds to the strength and hardness. Being in the spheroidised condition, it offers maximum response to hardening and the chromium content ensures deep hardening.

EDM is one of the most popular non-traditional material removal processes and has became a basic machining method for the manufacturing industries of aerospace, automotive, nuclear, medical and die-
mould production. The experimental study of the EDM of 40CrMnNiMo864 tool steel (AISI P20) tool steel provided important quantitative results for obtaining possible high surface finish quality. Surface roughness increased with increasing pulsed current and pulse time.Low current and pulse time with high pulse pause time produced minimum surface roughness that means good surface finish quality [1].

EDM is one of the non-traditional machining techniques which is widely used to machine harder materials. Its unique feature of using thermal energy to machine electrically conductive parts regardless of hardness has been its distinctive advantage for manufacturing of mould, die, automotive, aerospace and surgical components. The effects of EDM parameters on drilled-hole quality such as taper and surface finish are evaluated. Microwave-sintered magnesium nano composites (reinforced with 0.8 and 1.2 wt. % of nano alumina) were used as work materials. Experiments were conducted using Taguchi methodology to ascertain the effects of EDM process parameter. Pulse-on time and the servo speed are identified as major response variables. Micro structural changes and the effects of nano particle reinforcement in the drilled hole were studied through SEM micrographs [2].

Experiments were performed to determine parameters effecting surface roughness (SR) along with structural analysis of surfaces with respect to material removal parameters. Experimental work was conducted on Mild steel with copper, brass and graphite as tool electrodes with kerosene oil as dielectric fluid. The data compiled during experimentation has been used to yield responses in respect of material removal rate (MRR) and SR. Optical microscope was used to understand the mode of heat affected zone (HAZ), which alternatively affects structure of machined workpiece and hence tool life. While investigating electric discharge machining (EDM) surface by micrographs, it was observed that molten mass has been removed from surface as ligaments and sheets. In some cases, it is removed as chunks, which being in molten state stuck to surface. All three specimens machined by different electrodes showed different pattern of HAZs [3].

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Machining of EN-19 was carried out using rectangular shaped tungsten copper electrode to study the influences of EDM input parameters on surface roughness. The selected EDM input variables were input current (5-45 Amperes), pulse time (10-90 sec.), duty cycle (3-7), Gap voltage (6-18) and Flushing pressure (0.1-0.5). Regression analysis was carried out to ensure a least squared fitting to error surface in Minitab 15 environment. Regression analysis has been performed to find out the relationship between input factors and surface [4].

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. Experimental investigation were carried out on adequate range of EDM input variables while machining of oil hardened non shrinkable steel. 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. It was found that peak current is the key factor affecting surface finish for both finishing and roughing operations [5].

The optimization of process parameters of Electric Discharge Machining on RENE80 nickel super alloy material by using aluminum as a tool electrode was investigated. Taguchi method was used to formulate the experimental layout, ANOVA method was used to analysis the effect of input process parameters on the machining characteristics and find the optimal process parameters of EDM [6].

The effect of machining parameters of EDM using different tool electrodes such as copper and brass on titanium based alloy was studied. Input parameters included were peak current, gap voltage and duty factor. Taguchi designs of experiment were adopted to conduct the experiments. Micro-structural analysis and XRD were performed on the machined surfaces to analyze the deposition effect of tool and work material [7].

2. EXPERIMENT DETAIL

For Carrying out experimental study EDM model Electra EMS- 5535 was used. Electrode tool used was made of Copper having length 100 mm and diameter of 12 mm and the dielectric fluid was kerosene oil. Selected parameters and their levels are shown in Table 1.

Table 1: Electrical parameters and their levels

Parameters	Units	Range	Levels		
			1	2	3
Current (A)	Ampere	0-40	10	20	30
Pulse-on time (B)	µs	50-500	100	250	500
Voltage Gap (C)	V	0-50	10	20	30
Flushing Pressure (D)	kg/cm^2	0-2	0.3	0.7	1.5

Machining material was AISI L2 Silver Steel round bar of length was cut down into 27 pieces each having 30mm length. The pilot operations resulted in obtaining range values for peak Current, Pulse on, Voltage Gap and Flushing Pressure. Thereafter, experiment procedure was done on the remaining 27 samples based on Taguchi's orthogonal array L9 ands ANOVA method.

3. RESULTS AND DISCUSSIONS

After the completion of all the 27 experiments, the following resultswere obtained for SR by machining of AISI L2 steel on EDM. TheS/N ratio for DOE approach werecalculated by putting the values of SR in Minitab software.

Table 2 : Results for SR

A	**B**	**C**	**D**	**SR**	**S/N ratio**
10	100	10	0.3	2.54	-8.0967
10	250	20	0.7	3.24	-10.2109
10	500	30	1.5	2.48	-7.8890
20	100	20	1.5	2.25	-7.0437
20	250	30	0.3	2.96	-9.4258
20	500	10	0.7	2.18	-6.7691
30	100	30	0.7	1.98	-5.9333
30	250	10	1.5	3.15	-9.9662

30	500	20	0.3	2.40	-7.6042

The results were analyzed using ANOVA for identifying the significant factors affecting the performance measures as shown in Table 3.
From the ANOVA table it is clear that the pulse on time had major contribution i.e. 81.0% contribution on Surface roughness to machining of Silver steel by EDM. Other input parameters such as peak current,voltage gap and flushing pressure are relatively having less contribution on surface roughness attribute.

Table 3: Anova For S/N Ratio Of Sr Of Silver Steel

Source	**SS**	**DOF**	**Adj MS**	**Contribution**
Current	1.7857	2	0.89286	10.2%
Pulse On	14.2274	2	7.11368	81.0%
Voltage	0.5670	2	0.28352	3.2%
Flushing	0.9882	2	0.49408	5.6%
Total	17.5683	8		100%

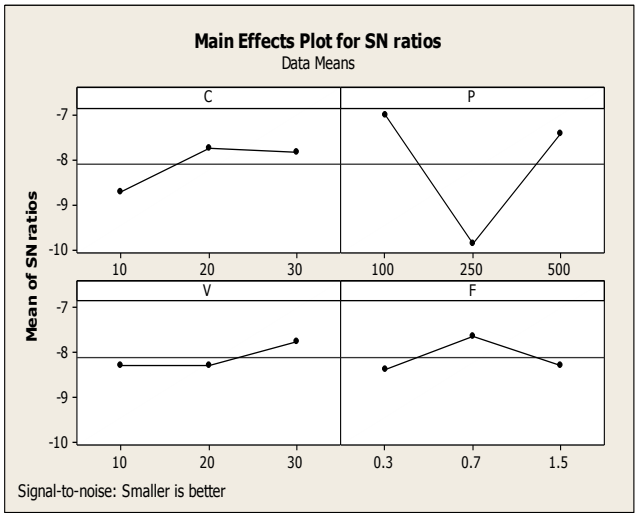

Fig 1: Main effect plot graph of S/N ratios of SR

From the figure 1, it can be observed that the mean value of S/N ratio increases by increasing the peak current from 10 to 20 amp and then decreses a little from 20 to 30 amp. Also, the mean of S/N ratio decreases by increasing the value of pulse ON from 100 to 250µs afterthat immediately increases from 250 to 500µs. The mean of S/N ratio remains approximately constant from 10 to 20 V and then decreases by increasing voltage gap from 20 to 30 V.The mean of S/N ratio increases by increase in the flushing pressure from 0.3 to 0.7 kg/cm^2. Further increase in the flushing pressure from 0.7 to 1.5 kg/cm^2, the mean of S/N ratio decreases.

Table 4: Response table for S/N ratio of SR

Levels	Current (A)	Pulse On (B)	Voltage Gap (C)	Flushing Pressure (D)
1	-8.732	-7.025	-8.277	-8.376
2	-7.746	-9.868	-8.286	-7.638
3	-7.835	-7.421	-7.749	-8.300
Delta	0.290	2.843	0.537	0.738
Rank	2	1	4	3

The interaction plot, fig 2 is the combination of all the four input parameters interacting with each other at different levels gives the idea that Peak current, pulse on, Voltage gap and flusing pressure had their considerable effects on SR of AISI L2 steel.

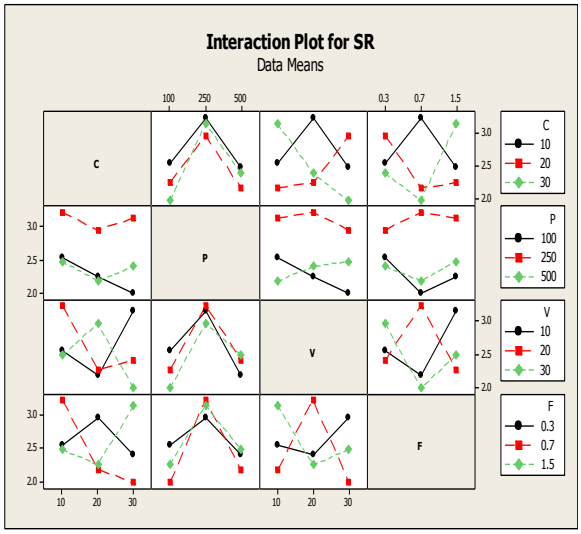

Fig. 2: Interaction Plot Graph for SR

4. CONCLUSION

Finally, it can be concluded that optimization of machining of AISI L2 Silver Steel by electrical discharge machining is technically feasible and has the potential of becoming a cost effective and time saving alternative to conventional methods currently being used by the tool and die making industry.Effect of machining parameters on the surface roughness values of AISI L2 silver steel by EDM have been examined experimentally. It was found that pulse on time is the key factor affecting surface finish for both finishing and roughing operations. For special purpose silver steel optimum machining condition for better surface finish during machining on EDM were Current (10 amp.), Pulse-on (250 µs), voltage gap (20 volt) and flushing pressure (0.3 kg/cm^2).

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