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EXPERIMENTAL INVESTIGATION ON THE EFFECT OF PROCESS PARAMETERS FOR MACHINING OF AISI L2 STEEL IN EDM

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ABSTRACT

The main purpose of this paper is to investigate the machining performance of EDM for machining of AISI L2 silver steel. Four varying input parameters such as peak current, pulse on time, voltage gap and flushing pressure were selected to optimize the two response variables i.e. metal removal rate & micro hardness. For design of experimentations and to analyze the results, ANOVA and Taguchi L9 OA were used. Mean effect plot and S/N ratio graphs had been used to optimize the machining parameters. The optimized values of these factors have revealed that by increase in peak current and low pulse on time increases the metal removal rate while keeping high Peak current and high pulse on time were observed to be optimum conditions for hardness. Hence peak current is chief factor affecting the MRR and micro hardness.

Keywords: ***EDM, Hardness, MRR, Taguchi***

I. INTRODUCTION

Machining of materials is very important operations for the process and manufacturing industries. In earlier days, machining of materials in these industries was done with the help of Lathe machines and various other conventional machining methods. These methods require harder cutting tools for machining of different materials. Moreover, these methods are not capable enough for machining of complex materials.

With rapid development in the field of materials a need has arise to develop cutting tool materials as well as processes that are safe and convenient enough to machine such materials. To overcome this problem, an English Scientist, Joseph Priestly first of all discovered EDM in late Eighteenth century. In 1943, Russian scientists, B.R. Lazarenko and N.I. Lazarenko founded that erosive effects of EDM technique could be controlled and can be used for machining purposes. They invented the relaxation circuit and a simple servo controller tool that helped to maintain the gap width between the tool and workpiece. As in EDM there is no physical contact left between the workpiece and the cutting tool, machining of harder metals with less harder cutting tools became easy. EDM machining process has the ability to cut complex inner shapes in hardened

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materials with negligible cutting forces. EDM provides distortion-free precise machining and manufacturing of the tool. EDM is mostly used in aeronautics, automobiles, nuclear reactors, missiles, turbines industries.

AISI L2 Silver Steel is available as a centre-less round steel bar with dimensions that ranges from 1m to 3m in length and 20mm to 25mm in diameter. This steel is a precision ground bar that finds numerous uses in the tool room as well as in general engineering. 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. Silver steel bar is a popular tool room material due to its characteristics. Chemical composition of AISI L2 steel is shown in Table 1.

Table 1. Chemical composition of AISI L2

Alloying Element	**Composition by weight by percent**
Carbon	1
Silicon	0.5
Chromium	0.5
Tungsten	0.6
Manganese	0.7-0.8
Vanadium	0.8-0.9
Iron	Remaining

II. LITERATURE REVIEW

Can Cogun and Akaslan S. [1] explained in their research work, the wear ratio or relative wear (ratio of "volume of the tool electrode material removed/volume of the work part material removed") is the main concern in machining many materials. It is known that the tool and work materials and their geometry, machining current, pulse time, pause (off) time, dielectric flushing conditions, pulse waveforms and machining voltage polarity are the effective parameters on wear ratio. Most of these works are directed towards finding the optimum machining conditions, materials and geometries for the maximum machining rate with minimum tool wear.

Katsushi Furutani et al. [2] described that the influence of the discharge current and the pulse duration on the titanium carbide deposition process by electrical discharge machining with titanium powder suspended in working oil. In using a green compact or a semi-sintered electrode made of metal powder, such as titanium alloy or tungsten carbide powder, a surface of the electrode is crumbled by discharge and the powder is always supplied on the work piece. The tribological behaviour of a deposited bronze layer by EDM with a powder compact electrode has been tested. Then hardness of the deposition and the matrix is measured.

V.D. Patel et al. [3] determined the performance of 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. Detailed analysis of structural features of machined surface was done by using Scanning Electron Microscope (SEM) and optical microscope to understand the mode of heat affected zone (HAZ).

K. Ponappa et.al. [4] mentioned that 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. The process parameters such as pulse-on time, pulse-off time, voltage gap and servo speeds were optimized to get better surface finish and reduced taper. 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.

Singh Kamaljit and Kalra C. S. [5] discussed the effect of EDM process parameter on machining of OHNS Steel using Taguchi L9 orthogonal array. They have noted that flushing pressure has the largest while Voltage gap has the smallest effect on the hardness of OHNS steel by machining on EDM. Moreover, it was identified that machining of OHNS steel on EDM, Current set largest effect on the MRR and Pulse ON has the smallest effect on the MRR.

Chandramouli S, Shrinivas Balraj U and Eswaraiah K [6] mentioned about the optimization of process parameters of Electric Discharge Machining on RENE80 nickel super alloy material by using aluminum as a tool electrode. Taguchi method is used to formulate the experimental layout, ANOVA method is used to analysis the effect of input process parameters on the machining characteristics and find the optimal process parameters of EDM.

Singh Hira and Choudhary [7] discussed the effect of machining parameters of EDM using different tool electrodes such as copper and brass on titanium based alloy. 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.

III. EXPERIMENTAL DETAIL

The experimental study was carried out on commercially available EDM model Electra EMS- 5535. Copper having length 100 mm and diameter of 12 mm was preferred as electrode and kerosene oil was used as the dielectric fluid. Selected parameters and their levels are shown in Table 2. Machining material was AISI L2 Silver Steel round bar of length 2 meter and diameter 25mm. Initially the round bar was cut down into 42 pieces each having 30mm length. A series of Pilot operations were conducted on 15 pieces with desirable response output i.e. higher MRR and hardness. These pilot operations resulted in obtaining range values for Current, Pulse on, Voltage Gap and Flushing Pressure. Thereafter, experiment procedure was done on the remaining 27 samples that were machined by the help of copper electrode in the EDM.

Fig. 1. Copper electrode used for machining.

Table 2: Electrical parameters and their levels

S.No.	**Input Parameters**	**Levels**		
		1	**2**	**3**
1.	Current (Amp)	10	20	30
2.	Pulse-on time (μs)	100	250	500
3.	Voltage Gap (V)	10	20	30
4.	Flushing Pressure (Kg/cm^2)	0.3	0.7	1.5

The workpiece pf AISI L2 steel were machined using EDM with 9 combinations of machining parameters as specified in Table 3. The effects of all parameters i.e. peak current, pulse-on time, voltage gap and flushing pressure were evaluated using ANOVA. A confidence interval of 95 % has been used for the analysis. The material removal rate (MRR) was calculated measuring difference between weight before machining and after machining and divide by the time taken for the machining and this equation is represented as below.

$$MRR = \frac{W_{\text{before machining}} - W_{\text{after machining}}}{T_{\text{machining tme}}}$$

Fig. 2. Present the pictorial view of Silver steel work-piece before machining and after machining. Minitab 15 was used to find out signal to noise ratio (S/N ratio), main effect plots and ANOVA table giving percentage contribution of each parameter on MRR and Micro hardness of machined samples.

Table 3: Execution of experiments with various interactions

Exp. No.	**Peak Current**	**Pulse-on time**	**Voltage Gap**	**Flushing Pressure**
1	10	100	10	0.3
2	10	250	20	0.7
3	10	500	30	1.5
4	20	100	20	1.5
5	20	250	30	0.3
6	20	500	10	0.7
7	30	100	30	0.7
8	30	250	10	1.5
9	30	500	20	0.3

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Fig. 2. AISI L2 steel sample before and after machining.

IV. RESULTS AND DISCUSSIONS

After the completion of all the 27 experiments, the following results were obtained for metal removal rate and hardness by machining L2 steel in EDM. The S/N ratio and the mean of mean values calculated for the values of MRR are shown in Table 4.

Table 4: MRR and S/N ratio for AISI L2 steel

S. No	Current	Pulse On Time (Ton)	Voltage gap	Flushing Pressure	MRR	SN Ratio
1	10	100	10	0.05	0.055	-25.411
2	10	250	20	0.08	0.039	-21.629
3	10	500	30	0.15	0.025	-16.319
4	14	100	20	0.19	0.164	-12.255
5	14	250	30	0.30	0.113	-13.936
6	14	500	10	0.13	0.260	-17.956
7	20	100	30	0.38	0.357	-8.473
8	20	250	10	0.20	0.477	-13.319
9	20	500	20	0.20	0.289	-13.910

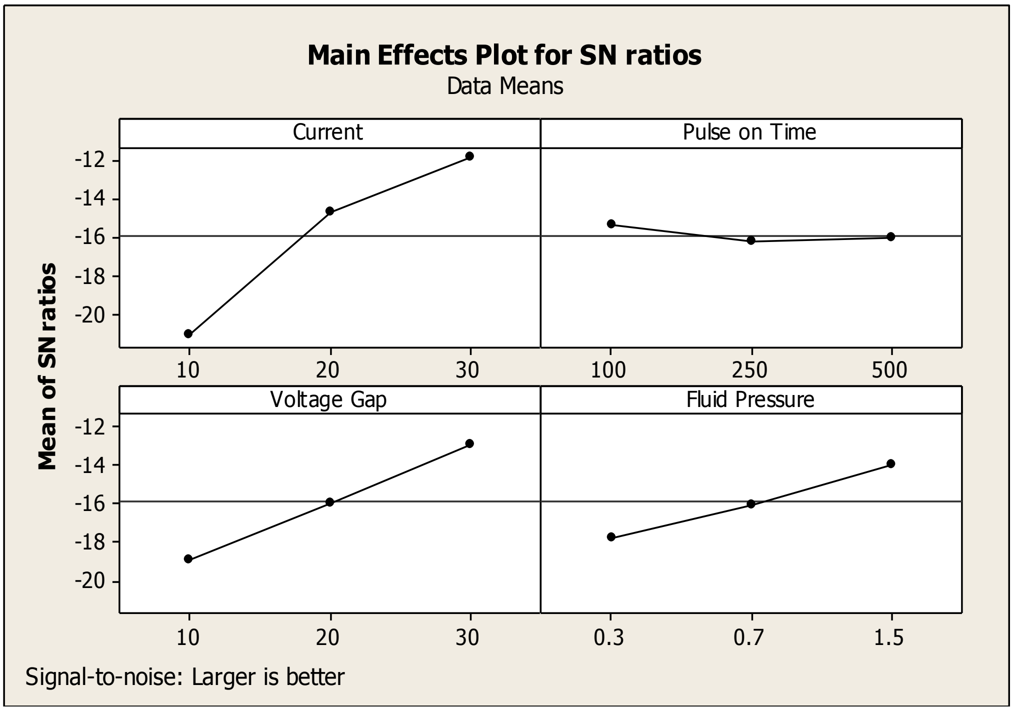

Fig. 3. Main Effect Plot Graph of S/N ratios of MRR

Table 5: ANOVA for S/N ratio of MRR

Source	SS	DOF	Adj MS	%contribution
Current	0.042716	2	0.021358	57.77
Pulse on time	0.007602	2	0.003801	10.28
Voltage gap	0.018953	2	0.009477	25.63
Flushing pressure	0.004671	2	0.002336	06.32
Total	0.073943	8		100

Table 6: Ranking of parameters for MRR

Level	Current (A)	Pulse on time (B)	Voltage gap (C)	Flushing pressure (D)
1	-21.12	-15.38	-18.90	-17.75
2	-14.72	-16.29	-15.93	-16.02
3	-11.90	-16.06	-12.91	-13.96
Delta	9.22	0.91	5.99	3.79
Rank	1	4	2	3

It can be observed clearly from graph that while machining of L2 steel in EDM the Current has the largest effect on the MRR and Pulse ON has the smallest effect on the MRR. From above main effect plot, it can be identified that optimum condition for MRR were, A3, B1, C1 and D3 i.e. Current (30 amp.), Pulse-on (100 μs), voltage gap (30 volt) and flushing pressure (1.5 kg/cm^2).

The S/N ratio and the mean values of hardness of machined surface after machining of AISI L2 steel in EDM is listed in Table 7.

Table 7: Hardness Value and S/N ratio

S. No	Current	Ton	Voltage gap	Flushing pressure	Hardness (VHN)	S/N ratio
1	10	100	10	10	276	48.79
2	10	250	20	20	270	48.54
3	10	500	30	30	240	47.58
4	20	100	20	30	250	47.94
5	20	250	30	10	256	48.15
6	20	500	10	20	245	47.77
7	30	100	30	20	266	48.51
8	30	250	10	30	243	47.69
9	30	500	20	10	271	48.67

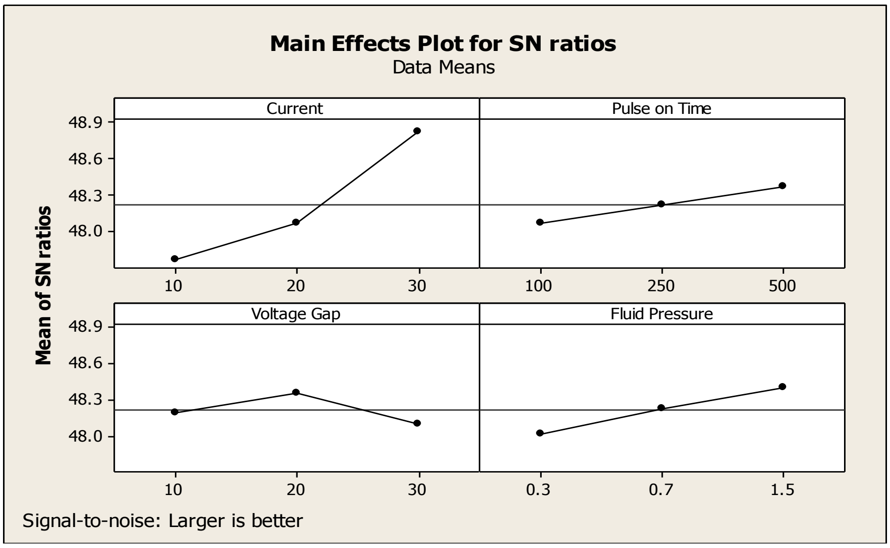

Fig. 4. Main Effect Plot Graph of S/N ratios of hardness

Table 8: ANOVA for S/N ratio of hardness

Source	SS	DOF	Adj MS	%contribution
Current	1580.22	2	790.111	80.10
Pulse On	121.56	2	60.778	6.16
Voltage gap	89.56	2	44.778	4.54
Flushing Pressure	181.56	2	90.779	9.20
Total	1972.89	8		100

Table 9: Ranking of parameters for hardness

Levels	Current (A)	Pulse on (B)	Voltage gap (C)	Flushing pressure (D)
1	47.77	48.06	48.19	48.01
2	48.06	48.22	48.36	48.23
3	48.82	48.37	48.10	48.40
Delta	1.05	0.31	0.25	0.39
Rank	1	3	4	2

It is noted that current has the largest effect on the hardness of AISI L2 steel by machining on EDM. The Voltage gap has the smallest effect on the hardness. From above main effect plot, it may be observed that optimum condition for hardness of machined hole were, A1, B3, C2 and D4 i.e. Current (30 amp.), Pulse-on (500 µs), voltage gap (20 volt) and flushing pressure (1.5 kg/cm^2).

V. CONCLUSIONS

In present work AISI L2 Silver Steel samples were machined by EDM by varying the parameters after that the experimental outcome were optimized; the following conclusion were found from the optimize results:

1. For AISI L2 Silver Steel optimum machining condition for material removal rate (MRR) with positive polarity, Current (30 amp.), Pulse-on (100 µs), voltage gap (30 volt) and flushing pressure (1.5 kg/cm2).
2. For AISI L2 Silver Steel optimum machining condition for with positive polarity for hardness are, Current (30 amp.), Pulse-on (500 µs), voltage gap (20 volt) and flushing pressure (1.5kg/cm2).

REFERENCE

[1] Cogun Can and Akaslan S. (2007), The effect of machining parameters on tool electrode edge wear and machining performance in Electric Discharge Machining (EDM), KSME International Journal, Vol. 16, pp. 46-59.

[2] Furutani Katsushi, Sato Hiromichi and Suzuki Masayuki (2009), Influence of electrical conditions on performance of electrical discharge machining with powder suspended in working oil for titanium carbide deposition process, International Journal of Machine Tools & Manufacture , Vol.40, pp.1093–1101

[3] Patel V.D., Prof. Patel C. P. and Patel U.J. (2012), Analysis of different tool material on MRR and Surface Roughness of Mild steel in EDM, International Journal of Engineering Research and Applications, Vol. 1, pp. 394-397.

[4] Ponappa K, Aravindan S, Rao p. V, Ramkumar J and Gupta M (2010), The effect of process parameters on machining of magnesium nano alumina composites through EDM, Int. J. Adv. Manuf. Technol. Vol.46, pp.1035–1042.

[5] Singh Kamaljit and Kalra C S (2013), An experimental investigation: Machining of OHNS steel by EDM, Journal of Engineering, Computer & Applied Sciences, Vol. 2, No. 6, pp. 39-42.

[6] Chandramouli S, Shrinivas Balraj U and Eswaraiah K (2014), Optimization of Electrical Discharge Machining Process Parameters Using Taguchi Method, International Journal of Advanced Mechanical Engineering. ISSN 2250-3234 Volume 4, Number 4 (2014), pp. 425-434

[7] Singh Hira and choudhary (2016), Effect of machining parameters on surface roughness in electrical discharge machining of titanium alloy grade-5 (Ti-6Al-4V), International Conference on Latest Developments in Materials, Manufacturing and Quality Control (MMQC-2016), ISBN No: 978-93-5312-858-7, pp-21-31.