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Investigation on the Effect of Process Parameters For EN31 material By EDM using full factorial method

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Abstract: This paper presents the results of experimental work carried out in electrical discharge machining (EDM) of EN31 using tool materials namely aluminium The machining process was carried out at three different supply current levels (17Amps, 21Amps, 28Amps) , pulse-on time (45µsec, 55µsec, 65µsec), and pulse off time (30µsec, 45µsec, 60µsec) their influence on surface roughness, material removal rate, tool wear rate. The optimal setting of the parameters are determined through experiments planned, conducted and analyzed using the full factorial method.

Key words: Electrical discharge machining (EDM) . Material removal rate, surface roughness, tool wear ratio. Full factorial method, and Design Expert7.01.

1. INRODUCTION:

Electric discharge machining is a non conventional machining process and has found its wide application in making moulds, dies, and in aerospace products and in surgical equipments[1]. The process is based on removing material from a part by means of a series of repeated electrical discharges between tool called the electrode and the work piece in the presence of a dielectric fluid. The electrode is moved toward the work piece until the gap is small enough so that the impressed voltage is great enough to ionize the dielectric. [3] The material is removed with the erosive effect of the electrical discharges from tool and work piece. EDM does not make direct contact between the electrode and the work piece. [4] In this work, a study focused on the electric discharge machining of the EN-31 alloy steel, whose field of applications is in constant growth. Consequently, an analysis on the influence of current and pulse on, pulse off, over surface roughness, material removal rate, tool wear ratio will performed. [2]

2. EXPERIMENTAL MATERIALS

Workpiece material: The workpiece material was a EN-31 The electrode materials was Aluminiam . The chemical composition of electrode materials which is show in Table 1.

Major properties of EN-31

Material	Thermal conductivity (W/mk)	Density (g/cc)	Electrical resistivity	Specific heat capacity (J/g-‘c)
EN-31	46.6	7.81	o.oooo218	0.475

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Aluminium electrode.

Material	Boiling point (K)	Thermal conductivity (W/m-K)	Melting point (K)
Aluminium	2792.15	237	933.47

Fig:1:- Electro Discharge Machine used for performing experiments

The EDM machine is mfg by JOEMARS series Z 50 JM-322. To start at determine try-out of suitable parameter relative in EDM process, such as polarity, duty factor, on time, off time, open circuit voltage, discharge current and electrode materials type. The detailed machining conditions used in this investigation were given in Table 2. Finally, the experiment result comparative the optimal parameters of material removal rate, surface roughness And tool wear ratio.

3. EXPERIMENTAL SETUP

Electric power supply
Dielectric system (Kerosene Fluid is used.)
Work piece (EN-31)
Electrode (Tool)(Aluminiam)

TECHNICAL SPECIFICATION

Table size	600 X 300 mm
X, Y, Z Travel	300/200/200mm
Max. Electrode weight	60 Kg
Max. Workpiece Weight	550 Kg
Tank size	830X500X300 mm
Weight of machine	1050 Kg

Table 2: Experimental conditions

Work piece	EN-31
Electrodes	Al
Polarity	(+)
Pulse On-time	45 ,55 ,65(μs)
Pulse Off-time	30 , 45 ,60(μs)
Peak current	17 ,21 ,28(Amp)

Surface Roughness

Surface topography or surface roughness ,also known as surface texture are terms used to express the general quality of a machined surface, which is concerned with the geometric irregularities and the quality of a surface Roughness measure as the arithmetic average, Ra (μm). The Ra will be measured using a surface roughness tester from Mitutoyo, Model: SJ 201P

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Fig. 2 Surface roughness tester.

The material MRR is expressed as the ratio of the difference of weight of the work piece before and after machining to the machining time and density of the material as shown in eq (1).

$$MRR = \frac{(W_{tb} - W_{ta})}{D \times t} \qquad (1)$$

Where,
W_{tb} weight before machining of w/p (gm), W_{ta} weight after machining of w/p (gm), D density of work-piece material (gm/mm^3) & t time consumed for machining (min)

TWR is expressed as the volumetric loss of tool per unit time, expressed as

$$TWR = \frac{(W_{tb} - W_{ta})}{D \times t} \qquad (2)$$

Where,
W_{tb} weight before machining of tool (gm), W_{ta} weight after machining of tool (gm), D density of tool material (gm/mm^3) & t time consumed for machining (min).

In our investigation the (3 X 3)full factorial The analysis of variance (ANOVA) is performed to identify the statistical significant process parameters. Then optimal levels of process parameters are obtained from the analysis.

Table 3: Coding levels of process parameters

Experimental variable	Level		
Parameters	1	2	3
Peak current	17	21	28
Pulse on time	45	55	65
Pulse off time	30	45	60

Table 3: experimental Responses

Experiment no.	MRR	TWR	SR
1	17.363	1.029	8.894
2	49.407	6.962	15.593
3	37.885	5.438	14.139
4	19.867	3.591	11.373
5	27.996	4.582	12.814
6	19.127	2.871	11.147
7	20.649	4.129	10.256
8	13.503	1.045	9.57
9	18.197	2.886	10.577
10	21.968	2.931	11.078
11	38.611	5.262	13.565
12	32.261	3.826	12.647
13	11.535	2.058	7.346
14	25.566	5.092	12.817
15	33.414	4.189	12.673
16	29.789	5.227	13.847
17	15.974	2.824	11.418
18	22.254	2.257	13.548
19	16.044	2.956	10.428
20	23.292	2.626	10.565
21	17.853	2.056	11.82
22	24.63	3.957	12.146
23	37.49	5.848	14.625
24	43.038	6.985	14.972
25	21.108	5.181	11.776
26	27.636	5.773	13.164
27	21.675	4.779	12.455

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Fig 3 experiment specimen by EDM Machine

4. RESULTS AND DISCUSSION:

The weight of the work piece and tool is measured on precise weighing machine having least count of 0.001 gm. Work piece density is taken 0.00789 gm/mm^3. For each and every Experiment the tool surface finish up to 2.35 micron on polishing machine and then start machining.

Analysis table for without CNT MRR

parameter	DF	Sum of seq.	Mean squares	F ratio	Percentage contribution	
Peak current	2	1603.04	801.523	135.28	68.48%	
Pulse on time	2	386.34	193.171	32.604	16.50%	Significant
Pulse off time	2	233.39	116.695	19.696	9.96%	
Error	20	118.49	5.924	1	5.06%	
Total	26				100%	
Std.dev = 2.43			Adj R-squared=0.9342		Pred- R-squared = 0.9078	

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parameter	DF	Sum of seq.	Mean squares	F ratio	Percentage contribution	
Peak current	2	41.19	20.599	88.799	58.61%	
Pulse on time	2	21.82	10.912	47.041	31.05%	Significant
Pulse off time	2	2.61	1.309	5.642	3.72%	
Error	20	4.63	0.231	1	6.60%	
Total	26				100%	
Std.dev = 0.48			Adj R- squared =0.9142		Pred R-squared = 0.8797	

parameter	DF	Sum of seq.	Mean squares	F ratio	Percentage contribution	
Peak current	2	44.00	22.002	36.198	46.61%	
Pulse on time	2	31.43	15.717	25.859	33.30%	Significant
Pulse off time	2	6.79	3.398	5.590	7.20%	
Error	20	12.15	0.6078	1	12.87%	
Total	26				100%	
Std.dev = 0.78			Adj R- squared =0.8326		Pred R-squared = 0.7653	

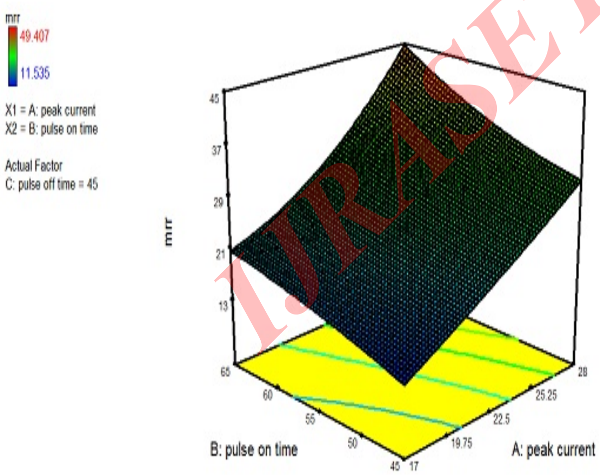

Fig 3 Ip vs pulse on time mrr graph

Figure: 3 Material removal rate in relation to the process parameters of Ip and pulse on time. It can be seen from the figure, the MRR tends to increase significantly with the increase in Ip for any value of pulse on time. However, the MRR tends to increase with increase in pulse on time, especially at higher Ip. Hence, Maximum MRR is obtained at high peak current 28 amps and high pulse on time 65 µs in this investigation. This is due to their dominant control over the input energy. Represents MRR as a function of pulse on time and pulse off time.. It is observed that the MRR values are low when Ton is low with higher pulse off time. From the analysis it is said that the interaction of pulse on time and pulse off time is significant. Although the influence of this two parameter is very less when

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compared with the effect of Ip on MRR.

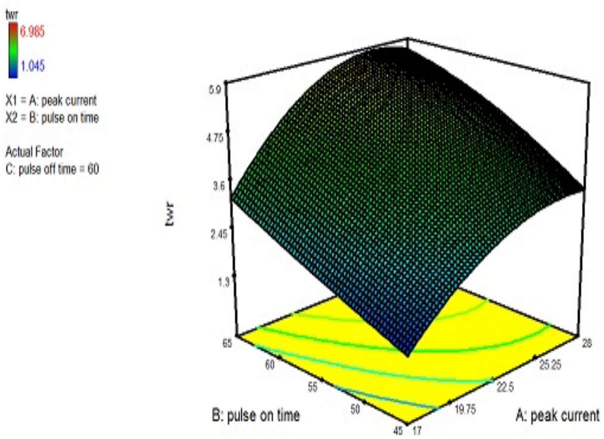

Fig 4 Ip vs pulse on time twr graph

The tool wear rate is decreasing, but discharge Current in the range of 17 to 28 A the tool wear rate is increasing. Because of Ip increases the pulse energy increases and thus more heat energy is produced in the tool work piece interface, leads to increase the melting and evaporation of the electrode. One can interpret that Ip has a significant direct impact on TWR. And pulse on time is directly proportional to the tool wear rate. And diameter of the tool has no significant effect on TWR.

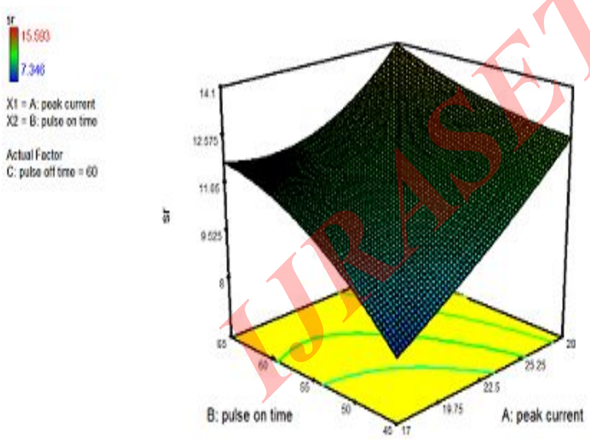

Fig 5 Ip vs pulse on time sr graph

The SR tends to increase significantly with the increase in Ip for any value of pulse on time. However, the SR tends to increase with increase in Ton, especially at higher Ip. Hence, minimum SR is obtained at low peak current and low pulse on time. This is due to their dominant control over the input energy, i.e. with the increase in Ip and pulse on time generates strong spark for longer time, which create the higher temperature and crater, hence rough surface in the work piece and low Ip creates small crater and therefore smooth surface.

Conclusion:-

- Process parameters do not have same effect for every response. Significant parameters and its percentage contribution changes as per the behavior of the parameter with objective response

Finding the result of MRR the most significant factor was found to be peak current followed by pulse on time and the least significant was pulse off time. The

- MRR increased linearly with the increase in current. For pulse on time the MRR first increased with linearly with increase in pulse off time, MRR decreased insignificantly.

- For SR the most significant factor was again current followed by pulse on time and lastly the pulse off time. SR increased significantly with the increase in current in a nonlinear fashion. For increase in pulse on time SR increased. SR is decrease with respect to increase in Pulse off time. Surface roughness shows a marked improvement with increase in pulse off time.

- In the case of Tool wear rate the most important factor is peak current then pulse on time and after that pulse off time.

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