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Experimental Investigation of Machining Parameters for EDM Using Rectangular shaped Electrode of En 31 steel

KEYWORDS

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ABSTRACT *The correct selection of manufacturing conditions is one of the most important aspects to take into consideration in the majority of manufacturing processes and, particularly, in processes related to Electrical Discharge Machining (EDM). It is a capable of machining geometrically complex or hard material components, that are precise and difficult-to-machine such as heat treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries. EN 31 steel that is usually supplied in a hardened and tempered condition. Good machinability, better polishability, it has a grooving rang of application in Plastic moulds, frames for plastic pressure dies, hydro forming tools These steel are categorized as difficult to machine materials, posses greater strength and toughness are usually known to create major challenges during conventional and non- conventional machining. The Electric discharge machining process is finding out the effect of machining parameter such as discharge current, pulse on time and voltage. Using Rectangular-shaped cu tool with JET flushing. A well-designed experimental scheme was used to reduce the total number of experiments. Parts of the experiment were conducted with the L18 orthogonal array based on the Taguchi method. Moreover, the signal-to-noise ratios associated with the observed values in the experiments were determined by which factor is most affected by the Responses of Material Removal Rate (MRR) and Tool Wear Rate (TWR).*

1.Introduction

Electro Discharge Machining (EDM) is an electro-thermal non-traditional machining Process, where electrical energy is used to generate electrical spark and material removal mainly occurs due to thermal energy of the spark.EDM is mainly used to machine difficult-to-machine materials and high strength temperature resistant alloys. EDM can be used to machine difficult geometries in small batches or even on job-shop basis. Work material to be machined by EDM has to be electrically conductive.

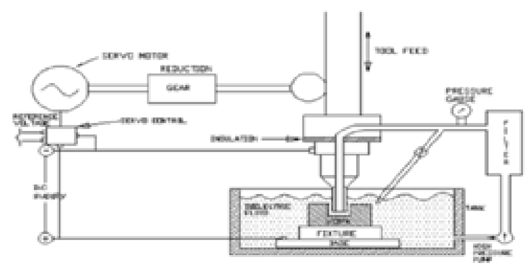

Figure 1.Set up of Electric discharge machining

1.3 Specification on EDM

Table 1. specification on EDM

Mechanism of process through a series of electric spark	Controlled erosion(melting and evaporation)
Spark gap	0.010- 0.500 mm
Spark frequency	200 - 500 kHz
Peak voltage across the gap	0-3.5 V
Metal removal rate (max.)	5000 mm^3/min
Specific power consumption	2-10 W/mm^3/min
Dielectric fluid deionized water etc.	EDM oil, Kerosene liquid paraffin, silicon oil
Tool material	Copper, Brass, graphite, Ag-W alloys, Cu-W alloys.
MRR/TWR	0.1-10
Materials that can be machined	All conducting metals and alloys.
Shapes	Microholes, narrow slots, blind cavities
Limitations	High specific energy consumption, non conducting materials can't be machined.

2. Experimental set-up

For this experiment the whole work can be down by Electric Discharge Machine, model CNC EDM ECOWIN MIC-432C, TAIWAN (die-sinking type) with servo-head (constant gap) and positive polarity for electrode was used to conduct the experiments. Commercial grade EDM oil (specific gravity= 0.763, freezing point= 94˚C) was used as dielectric fluid. With Jet flushing of Rectangular-shaped cu tool with a pressure of 0.2 kgf/cm^2 .Experiments were conducted with positive polarity of electrode. The pulsed discharge current was applied in various steps in positive mode.

Figure.2 Electric Discharge Machine, model CNC EDM ECOWIN MIC-432C, TAIWAN (die-sinking type)

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Figure 3.Control unit

2.1 Selection of the work piece and tool material

In this experiment using EN31 steel material this EN31 steel material is a pre hardened high tensile tool steel which offers ready machine ability in the hardened and tempered condition, therefore does not require further heat treatment. Subsequent component modifications can easily be carried out. EN31 steel that is usually supplied in a hardened and tempered condition. Good machine ability, better polish ability.

Table 2.Composition of EN31 steel material
Table 3. Properties of EN31 steel material

Properties	%
Thermal conductivity(W/m K)	46.6
Density(g/cc)	7.81
Electrical resistivity(ohm °C-cm)	0.0000218
Specific heat capacity(J/g-°C)	0.475

Elements	Composition (wt. %)
C	1.07
Si	0.32
Mn	0.58
P	0.04
S	0.03
Cr	1.12
V	-
Fe	Balance

Figure 4.EN31 material before machining and after machining

2.2 Taguchi design experiments in MINITAB

MINITAB provides both static and dynamic response experiments in a static response experiment; the quality characteristic of interest has a fixed level. The goal of robust experimentation is to find an optimal combination of control factor settings that achieve robustness against (insensitivity to) noise factors. MINITAB calculates response tables and generates main effects and interaction plots for:-

- Signal-to-noise ratios (S/N ratios) vs. the control factors.
- Means (static design) vs. the control factors.

Table.4 Machining parameters and their level

Machining parameter	Symbol	Unit	Level		
			Level 1	Level 2	Level 3
Voltage	V	V	1	2	3
Pulse on time	Ton	μs	20	200	2000
Discharge current	Ip	A	6	To	12

Table.5 Design matrix and Observation table

No.	Ip (A)	V (v)	Ton (μs)	Wt of workpiece(gm)		Wt of tool(gm)		Time (min)
				Wjb	Wja	Wtb	Wta	
1	6	1	20	133.3	131.2	4.64	4.62	5:12
2	6	1	200	131.2	129.4	4.62	4.58	5:15
3	6	1	2000	129.4	127.6	4.58	4.57	25:45
4	6	2	20	127.6	124.4	4.57	4.54	4:40
5	6	2	200	124.4	122.7	4.54	4.49	4:30
6	6	2	2000	122.7	120.9	4.49	4.47	20:00
7	6	3	20	120.9	117.8	4.47	4.43	3:15
8	6	3	200	117.8	116.0	4.43	4.36	3:47
9	6	3	2000	116.0	114.2	4.36	4.33	16:23
10	12	1	20	114.2	111.5	4.33	4.03	2:00
11	12	1	200	111.5	109.3	4.03	3.83	2:02
12	12	1	2000	109.3	107.6	3.83	3.81	4:38
13	12	2	20	107.6	104.5	3.81	3.53	1:34
14	12	2	200	104.5	102.7	3.53	3.32	1:54
15	12	2	2000	102.7	100.9	3.32	3.30	4:20
16	12	3	20	100.9	978	3.30	2.99	1:08
17	12	3	200	978	960	2.99	2.76	1:27
18	12	3	2000	960	943	2.76	2.73	3:19

3. RESULT AND DESCUSSION

Table.6 Response table

No.	Ip (A)	V (v)	Ton (μs)	MRR (mm^3/min)	TWR(gm/min)
1	6	1	20	0.00065	0.00004
2	6	1	200	0.00119	0.00008
3	6	1	2000	0.00009	0
4	6	2	20	0.00102	0.00007
5	6	2	200	0.00051	0.00012
6	6	2	2000	0.00012	0.00001
7	6	3	20	0.00126	0.00013
8	6	3	200	0.05042	0.0002
9	6	3	2000	0.00014	0.00002
10	12	1	20	0.00192	0.0015
11	12	1	200	0.00120	0.00099
12	12	1	2000	0.00050	0.00005
13	12	2	20	0.00296	0.00209
14	12	2	200	0.00150	0.00136
15	12	2	2000	0.00529	0.00005
16	12	3	20	0.00368	0.00287
17	12	3	200	0.00181	0.00181
18	12	3	2000	0.00068	0.00009

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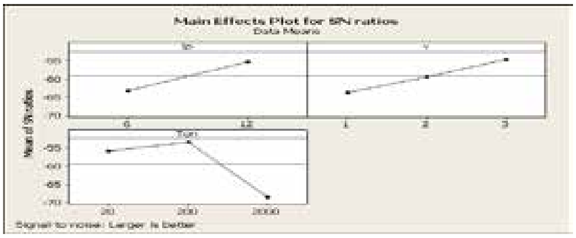

3.1 MRR

Figure. 5 Main effect plots for S/N ratios (MRR)

Table.7 Response for S/N Rations Larger is better (MRR)

Level	V	Ip	Ton
1	-63.65	-63.14	-55.86
2	-59.45	-55.36	-53.34
3	-54.65		-68.55
Delta	9.00	7.78	15.21
Rank	2	3	1

3.2 TWR

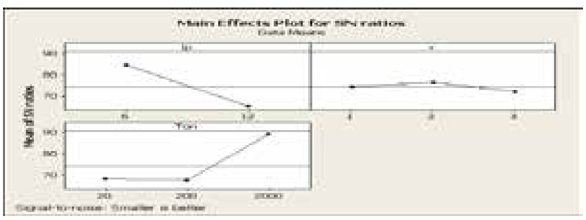

Figure.6 Main effect plot for SN ratios (TWR)

Table.8 Response Table for Signal to Noise Ratios Smaller is better (TWR)

Level	V	Ip	Ton
1	74.50	84.64	68.28
2	76.41	65.13	67.77
3	72.05		89.39
Delta	4.36	19.51	21.62
Rank	3	2	1

4. Conclusion

In the present study on the effect of machining responses are MRR and TWR of the EN 31 steel component using the Rectangular-Shaped cu tool with Jet flushing system tool have been investigated for EDM process. The experiments were conducted under various parameters setting of Discharge Current (Ip), Pulse On-Time (Ton), and Voltage (v). L-18 OA based on Taguchi design was performed for Minitab software was used for analysis the result and theses responses were partially validated experimentally.

(1). Finding the result of MRR discharge current is most influencing factor and then pulse duration time and the last is diameter of the tool. MRR increased with the discharge current (Ip). As the pulse duration extended, the MRR decreases monotonically

(2). In the case of Tool wear rate the most important factor is discharge current then pulse on time and after that diameter of tool.

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