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Experimental Investigation and Optimization of Die sinker EDM Process Parameters on Inconel-625 alloy

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Abstract

Inconel 625 super alloy used in many industries application like marine, aerospace, gas turbines blades, nuclear plant reactors, tooling, etc. Due to its superior mechanical characteristics, great strength at high temperatures, and difficulty in traditional machining. The objective of the current work is to investigate the Die Sinker EDM Process Parameters on Inconel 625 material with copper and graphite electrodes. For the purpose of process optimization of material removal rate, Taguchi L9 orthogonal array was employed as a design of experiment technique for machining, with the input process parameters being Current, Time ON, and Flushing Pressure (MRR). In order to determine the level of significance of machining

Keywords: Inconel 625 , Design of Experiments –Taguchi L9 OA, Material Removal rate, S/N ratio-Larger the better, Anova-Significant factor

Introduction

In industries, difficult and sophisticated materials are machined using electrical discharge machining (EDM). Spark discharges between the electrode tool and the work piece remove material during the EDM process. By melting and vaporising, the spark discharges that occur every second create a small crater, replicating the shape of the tool into the work piece. The "chips" that are the discharges are removed by a dielectric fluid. The work piece may replicate a wide variety of complex forms

Because of its excellent mechanical qualities, Inconel alloy are employed in a variety of sectors, including nuclear power plants, medical equipment, and aerospace. An alternate approach for shaping Inconel alloys according to the tool design is electrical discharge machining (EDM). As a result, EDM can efficiently machine a variety of objects with hardness characteristics. In the current study, inconel alloy 625 is being machined with the help of current, time-on, and flushing pressure process parameters. Experiments on taguchi L9 orthogonal arrays with three levels each were planned to determine the material removal rate response by signal to noise ratio and the significance of each parameter's performance by ANOVA.

Experimental Details

Work Piece Material

Samples are of Inconel 625 steel with dimension size of 180 mm x 150 mm x 10 mm thick and the properties with Composition in percentage by weight are given in table 1.

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With copper electrode and graphite electrode of 10mm diameter for machining
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Table 1. Composition of Inconel 625

Elements	Ni	Ti	Al	Cr	Mo	Mn	C
Composition	Balance	0.25	0.17	20	8.8	0.14	0.05

Table 2. Selected process parameters for machining conditions of Inconel 625

Parameters	Level 1	Level 2	Level 3
Current	8	10	12
Pulse –On	40	50	60
Flushing Pressure	0.5	0.75	1.0

The current, Time ON time and Flushing Pressure the input machining conditions of the EDM for machining INCONEL 625 the outcome response of machining effectiveness is material removal rate. Design of Experiments was based on the factors and levels using taguchi L9 Orthogonal array with input parameters and their levels shown in Table 2 .Table 3 shown the Experiments were carried out according to the taguchi L9 Orthogonal array.

Table 3. Shows the L 9 Orthogonal array experimental for EDM of Inconel 625

Expt. No	Current	Time ON	Flushing Pressure
1	8	40	0.5
2	8	50	0.75
3	8	60	1
4	10	40	0.75
5	10	50	1
6	10	60	0.5
7	12	40	1
8	12	50	0.5
9	12	60	0.75

Results & Discussions

Table 4. Experimental results of Inconel 625 by EDM with copper and graphite electrode

Expt. No	Current	Time ON	Flushing Pressure	MRR with Copper Electrode (mm/min)	MRR with Graphite Electrode (mm/min)
1	8	40	0.5	0.332	0.186
2	8	50	0.75	0.359	0.164
3	8	60	1	0.236	0.281
4	10	40	0.75	0.249	0.289
5	10	50	1	0.379	0.124
6	10	60	0.5	0.358	0.139

7	12	40	1	0.368	0.179
8	12	50	0.5	0.397	0.199
9	12	60	0.75	0.398	0.277

Higher Material Removal Rate (MRR) is calculated by dividing the difference between the weight of work piece before (wb) and after (wa) machining, against the machining time (tn). With copper and graphite electrodes on machining of Inconel 625 as Table 4. shows

$$MRR = \frac{\text{Before and after machining weight of work piece}}{\text{Machining Time}}$$

Signal to noise Ratio of MRR with copper electrode on Inconel 625

Table 5. Response table for S/N ratios of MRR with copper electrode on Inconel 625

Level	Current	Time ON	Flushing Pressure
1	-10.339	-10.112	-8.841
2	-9.809	-8.450	-9.659
3	-8.237	-9.822	-9.884
Delta	2.103	1.662	1.043
Rank	1	2	3

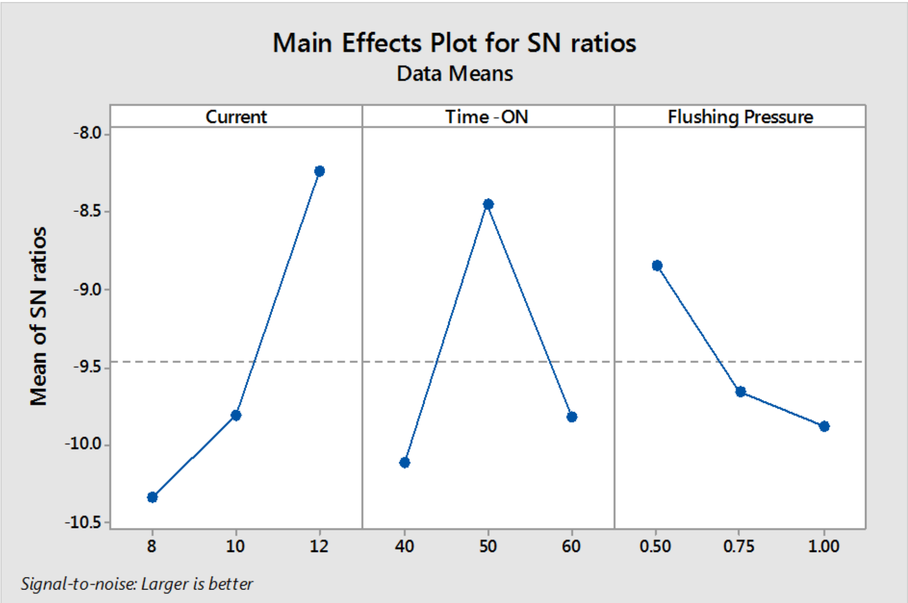

Fig.1. Graph S/N Ratios of MRR with copper electrode machining on Inconel625

From Table.5. shows the S/N Ratios of MRR with copper electrode machining on Inconel 625 w.r.t input parameters of Current, Time ON, and Flushing Pressure and the optimum combination is

A3B2C1 from Fig.1 for Material removal rate for which higher the better is consider and the optimum combination matches with L-9 Orthogonal Array of Experiment no.8

ANOVA for of MRR with copper electrode by EDM on Inconel 625

Table 6. ANOVA of MRR with copper electrode

Source	DF	Adj SS	Adj MS	% Contribution
Current	2	0.0121	0.005028	41.954
Time ON	2	0.0065	0.003161	22.696
Flushing Pressure	2	0.0090	0.000995	31.285
Error	2	0.0010	0.005184	3.608
Total	8	0.0287		99.543

From Table 6. the ANOVA for of MRR with copper electrode by EDM on Inconel 625 in which the most contribution percentage factor is current 41.95%, which shows the highest value in machining process followed by less Time ON 22.69% and Flushing Pressure 31.280%.,and error contribution 3.6%.

Signal to noise Ratio of MRR with Graphite electrode on Inconel 625

Table 7. S/N Ratios of MRR with graphite electrode on Inconel 625

Level	Current	Time ON	Flushing Pressure
1	-13.78	-13.44	-15.26
2	-15.35	-15.95	**-12.55**
3	**-13.37**	**-13.11**	-14.70
Delta	1.98	2.85	2.71
Rank	3	1	2

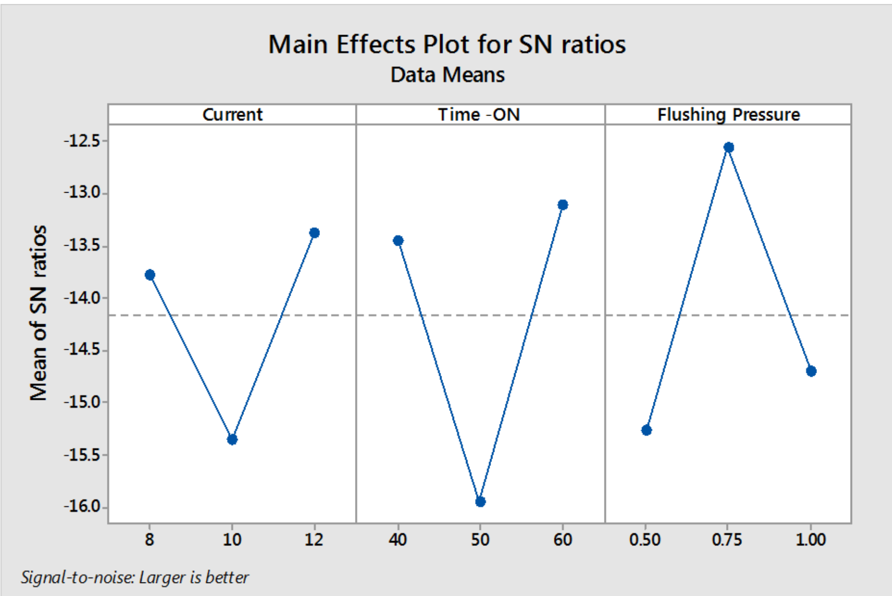

Fig.2. Graph S/N ratios of MRR with graphite electrode machining on Inconel 625

From Table 7. shows the S/N Ratios of MRR with graphite electrode machining on Inconel 625 w.r.t input parameters of Current, Time ON, and Flushing Pressure and the optimum combination is A3B3C2 from graph Fig 2.for Material removal rate for which higher the better is consider .

ANOVA for of MRR with Graphite electrode by EDM on Inconel625

Table 8. ANOVA of MRR with Graphite electrode

Source	DF	Adj SS	Adj MS	% Contribution
Current	2	0.0194	0.000968	53.108
Time ON	2	0.0082	0.004102	22.505
Flushing Pressure	2	0.0075	0.003742	20.530
Error	2	0.0014	0.007029	3.856
Total	8	0.0365		100.000

From Table 8. the ANOVA for of MRR with Graphite electrode by EDM on Inconel 625 in which the most contribution percentage factor is current 53.11%,which shows the highest value in machining process followed by less Time ON 22.51% and Flushing Pressure 20.54%.,and error contribution 3.85%.

Conclusions

In this study Material removal rate is the most important performance measure using taguchi L-9 design of experiments. In order to improve productivity in EDM machining of Inconel 625, the optimum level of copper and graphite are calculated as follows

- For Material removal rate of Inconel 625 with copper and graphite electrode is showing maximum removal rate.
    - The optimum combination is A3B2C1 i.e. Current 12 Amps, Time ON 50 µs, Flushing Pressure 0.5 psi is 0.199 mm/min for Copper Electrode and
    - The optimum combination is A3B3C2 i.e. Current 12 Amps, Time ON 60 µs, Flushing Pressure 0.75 psi is 0.277 mm/min for Graphite Electrode which is both matching within the taguchi L9 Orthogonal Array of Design of Experiment
- From ANOVA current is the most significant factor which is contributing in MRR w.r.t electrodes of copper 42.1% and graphite 54.1 % and error estimation is 3.85% for graphite and 3.6 % for copper electrode

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