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Research paper

Experimental Analysis of Electric Discharge Machining Over Inconel 825 Using Copper Electrode and Al_2O_3 Coated Copper Electrode

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Abstract

In this project work, Electric Discharge Machining (EDM) of Inconel 825 is done with a copper electrode and Al_2O_3 coated copper electrode. The objective of this paper is to reduce the tool wear by employing Al_2O_3 coated copper electrode. And also the optimum combination of machining parameters had been arrived using grey relational analysis. It is concluded that the voltage of 25 v, a peak current of 15 A, pulse on-time of 30 µs, pulse off-time of 9 µs provides optimum solutions. The Inconel 825 is one of the hardest materials and finds wide applications in high-tech industries due to its sole advantages.

Keywords: *EDM; Inconel-825; Grey Relational Analysis.*

1. Introduction

EDM is one of the most excellent non-contacts machining process purely applied for machining electrically conductive materials of any hardness, to obtain accurate shapes with accuracy [1]. It is independent of the unique properties of the processed material, which removes the material from the workpiece by using electrical energy in the form sparks in short span of time [2]. The nature of the plasma channel between electrode and workpiece strongly impacts the material removal in EDM process [3]. Manohar et al. performed EDM of Inconel 718 with 12 mm copper electrode by changing the bottom profile of the electrode. Ahmad et al investigated the Inconel 718 material with copper as a tool under at high peak current and pulse on-time for MRR, EWR, SR. In this work, the high peak (40 A) is a most contributing parameter for achieving higher MRR.

Rajyalakshmi et al. machined Inconel 825 in WEDM using neural network algorithm. Suneel Kumar et al. performed EDM of Inconel 825 for increasing the material removal rate using multi-objective optimizations techniques. Payal et al. modelled EDM process variables in ANN while machining Inconel 825. Anand et al. performed EDM using grey relational analysis.

Geethapriyan et al. explained use of coated electrode for the electrochemical machining process. Beri et al. coined EDM of Inconel 718 using grey relational analysis with a different electrode. Aveek et al. experimentally studied electric discharge machining of Inconel 825 for various machining characteristics like MRR, SR and so on with the grey relational analysis.

2. Experimental Setup and Procedure

The Inconel 825 has a thickness of 5 mm is used as workpiece and copper electrode and Al_2O_3 coated copper electrode has diameter 8 mm is act as electrodes. The machining parameters in EDM machine are discovered in table 1 which is based on machining characteristics, like material removal rate (MRR) and tool wear rate (TWR). The experiments were planned using Taguchi L9 orthogonal array (presented in Table 2). The entire experiments are conducted on the particular electric discharge machine which is photographed in figure 1. The formulae used for calculating the wear rate is written in equation 1

$$\text{Removal Rate} = \text{Mass} / (\text{Time*Density})\ mm^3/min \quad (1)$$

Mass = (Weight of electrodes before machining – Weight of electrodes after machining) in grams
Time = Machining time in minutes

Fig. 1: Electric Discharge Machining

Table 1: Machining Parameter

Levels	Current (I)	Voltage (V)	Pulse on-time (Ton)	Pulse off-time (Toff)
1	5	25	10	3
2	10	50	20	6
3	15	120	30	9

The machining time is kept constant as 10 minutes for all experiments. Experiment is conducted each set of machining parameters. After machining MRR and TWR are calculated is pointed in table 3. The grey relational analysis optimization technique is employed. Using grey relational analysis optimum value of MRR and TWR arrived with a set of machining parameters. Particularly for this setting, the Al_2O_3 coated copper electrode is employed to categorize the effect of MRR and TWR.

3. Grey Relational Analysis

The grey relational optimization technique is used to acquire the best experimental run because of its sole benefits like simple but powerful, cost-effective, least time consuming and so on. The step by step grey relational analysis is highlighted in figure 2.

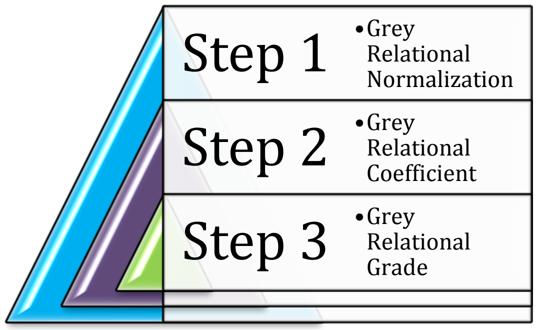

Fig. 2: Grey Relational Analysis

In the first step of grey relational analysis, MRR and TWR values are normalized using equation 2 and equation 3. By normalizing, MRR and TWR values have come to the comparable range. In the second step, the normalized values are taken for calculations of grey relational coefficient using equation 4. Next , th,e grey relational grade is calculated by taking an average of all values of grey relational co-efficient and it is noted in equation 5. Finally, the rank is found in the grey relational grade.

$$x_{ij} = \frac{y_{ij} - \min_{ij} y_{ij}}{\max_{ij} y_{ij} - \min_{ij} y_{ij}} \quad (2)$$

Where i=1to13, j=1to5. It is used for Lower is the Better characteristics.

$$x_{ij} = \frac{\max_{ij} y_{ij} - y_{ij}}{\max_{ij} y_{ij} - \min_{ij} y_{ij}} \quad (3)$$

$$\xi_{ij} = \frac{\Delta_{min} - k\Delta_{max}}{\Delta x_{ij} - k\Delta_{max}} \quad (4)$$

Distinguishing coefficient (k) is normally in between 0 to 1. We have taken as k =0.5. where $\Delta_{min} = 0$, $\Delta_{max} = 1$, & $\Delta x_{ij} = (\text{maximum } x_{ij} - x_{ij})$.

$$\gamma_i = \frac{1}{n}\sum_{j=1}^{n} \xi_{ij} \quad (5)$$

Table 2:. Taguchi L9 Orthogonal Array

Run	Current (I)	Voltage (V)	Pulse on-time (Ton)	Pulse off-time (Toff)
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

Table 3: Experimental Observations

Run	V	Ip	Ton	Toff	MRR	TWR
1	25	5	10	3	0.082180	0.011138
2	25	10	20	6	0.159750	0.002910
3	25	15	30	9	0.246071	0.001799
4	50	5	20	6	0.095610	0.000770
5	50	10	30	9	0.269774	0.012886
6	50	15	10	3	0.133880	0.032750
7	120	5	30	9	0.107870	0.088910
8	120	10	10	3	0.001300	0.012990
9	120	15	20	6	0.2113302	0.018107

The optimal MRR and TWR are noted for the experimental run 3 using grey relational analysis. The corresponding setting has a voltage of 25 V, a current of 15 A, pulse on-time of 30 µs and pulse off-time of 9 µs. For this setting, an experiment is conducted using Al_2O_3 coated copper electrode. The Al_2O_3 coated copper electrode MRR and TWR values are indicated in table 4.

Table 4: MRR & TWR on Al_2O_3 Coated Copper Electrode

Tool Material	V	Ip	Ton	Toff	MRR	TWR
Al_2O_3 coated copper	25	15	30	9	0.12007	0.00029

4. Conclusion

An experimental investigation in EDM of Inconel 825 with the copper electrode and also with Al_2O_3 coated copper electrode is performed to discuss the impact of Al_2O_3 coating in terms of MRR and TWR. Based on the experimental result and grey relational optimization the following conclusion is drawn.

When machining with the copper electrode, optimal combination of process parameters for finding using grey relational analysis is voltage: 25, current: 15 A, pulse on time: 30µs and pulse off time: 9 µs.

The copper electrode has yields an MRR 0.246071 mm^3/min and TWR 0.001799 mm^3/min.

The Al_2O_3 coated copper electrode has yields an MRR 0.12007 mm^3/min and TWR 0.00029 mm^3/min.

It is keenly seen with Al_2O_3 coated copper electrode in EDM of Inconel 825, there will be 83.88% saving in TWR but MRR is reduced to 51.20%.

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