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Electrical Discharge Machining studies on Monel- Super Alloy

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Abstract

In this work, the machinability effect of monel alloy is examined by varying the parameters of Electrical Discharge Machine (EDM). EDM operation is governed by Pulse ON time, pulse OFF time, discharge current and gap voltage and they are taken as independent parameters. Material Removal Rate (MRR) and Surface Profile (Ra) are taken as the dependent parameters. To predict the optimal condition, the experiments are conducted by using Taguchi's L27 orthogonal array. The influences of each independent parameter on the dependent parameters are analysed using multi functional grey relational analysis with the intension of increasing MRR with acceptable level of Ra. Through response table, optimized condition has been predicted. From ANOVA, it is identified that discharge current has a significant effect on MRR and Ra with a contribution of 71% and 81%, respectively. The experiment has been conducted to validate the optimal condition and it is found to be 99.1% acceptable level.

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Keywords: Electrical Discharge Machine; Monel; optimization; GRA; ANOVA; MRR; Ra

1. Introduction

EDM is a thermoelectric process in which heat energy of a spark is capable of melting and vapourizing material from localized area on the electrodes, i.e tool and work-piece. To minimize the tool wear rate and to improve the machining process, selection of parameter is a significantly complicated process. Shashikant et al [1] predicted the optimized value by considering the four input parameters through a series of experiments on EN19 and EN41 in EDM to get the maximum valve of MRR. Apurba kumar et al. [2] reported the effects of various input process parameters like Pulse ON time, Pulse OFF time, Discharge Current and Voltage over the surface roughness on EN41 material. Jahan et al. [3] performed the experiments with different electrode materials like Tungsten, Copper Tungsten and Silver Tungsten electrodes on WC composites on Ra. Kuppani et al. [4] conducted experiments in Inconel 718 to study the machining characteristics by using EDM process. Kanagarajan, et al. [5] the influence of

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operating parameters of EDM like pulse current, pulse on time, electrode rotation and flushing pressure on tungsten carbide and cobalt composites to obtain maximum value of MRR and minimum Ra. Singh and Kumar [6] performed experimental observations to optimize the EDM parameters in order to get an acceptable level of surface finish on titanium alloys (Ti- 6AL- 4V).

Kumaran and Uthayakumar [7] have reported that power consumption is one of the important parameters which directly increases the production cost. According to Jeyapaul R, Shahabudeen [8], Grey Relational Analysis (GRA) is a suitable multi response and single response optimization tool for predicting the optimal condition. Suresh kumar et al., [9] have focused that GRA is a successful tool for optimization problems. Pawade and Joshi [10] have used GRA for turning of Inconel 718 in order to optimize its parameters. Alaattin and Ferhat [11] optimized the machining parameters by GRA with different response characteristics viz. Tool wear, machining force, surface roughness and specific cutting force. Suresh Kumar et al., [12] studied the influence of various process parameters of EDM through GRA and the machining effect on the surface profile was also reported.

There are various process parameters in EDM and they govern the machining condition. Through literature survey, it is identified that the machining effect of EDM will linearly depend on the machining parameters and also on the work samples. In this work, monel- a nickel based super alloy, which is hard to machine due to its work hardening effect by conventional machine process, is taken as the sample and the machining effects with varied input parameters like pulse on time, pulse off time, discharge current and gap voltage in EDM are discussed. The effects of these parameters on MRR and Ra are evaluated by using Grey Relational Analysis (GRA) and regression equations.

Nomenclature

T_{on}	Pulse on time
T_{off}	Pulse off time
I_p	Pulse current
G_v	Gap voltage
MRR	Material Removal Rate
R_a	Surface profile
R^2	R-square
Adj(R^2)	Adjacent R-square

2. Experimental Setup

The experiments are performed using Die sinking EDM machine of model EDM-SMART ZNC which has 3-phase servo stabilizer. Monel metal with a rectangular cross section of 30mm X 30mm X 4mm is taken as the sample. Commercially available EDM oil is used as the dielectric medium and a cylindrical copper electrode of diameter 20 mm is used. To measure MRR, the high precision Shimatzu weighing balance of model AUX120 is used. The surface profile is measured using surface roughness tester of Mitutoyo model No. SJ301. Power harmonic analyzer is used to measure the electric power consumption. Table 1 shows the composition of monel material and the experimental arrangements are shown in Figure 1. The independent machining parameters and their levels are shown in Table.2. The parameters are optimized using GRA. The equations (1&2), which are given below, are used for calculating S/N ratio to obtain the maximum MRR and to get the acceptable level of Ra .

Larger the better : $$\frac{S}{N_{LB}} = -10\log_{10}\left[\frac{1}{n}\sum_{i=1}^{n}\frac{1}{y_{ij}^2}\right] \quad (1)$$

Smaller the better: $$\frac{S}{N_{SB}} = -10\log_{10}\left[\frac{1}{n}\left(\sum_{i=1}^{n} y_{ij}^2\right)\right] \quad (2)$$

Where y_{ij} is the i^{th} observation on the j^{th} experiment and n is the total number of experiment performed.

Table :1 Chemical composition of Monel –copper based alloy

Elements	Ni	Fe	Cu	Mn
Composition %	64.49	1.56	32.27	0.76