Effect of Polarity and Machining Characteristics of Nimonic 80A by Taguchi method

Bhavani Chowdary Eedara[1], Ravi Varma Penmetsa[2], Ch .Ramabhadri Raju[3], S. Madhavarao[4]

Sagi Rama Krishnam Raju Engineering College,
Bhimavaram, India -534204

***ABSTRACT*: In this current study, Machining characteristics of Nimonic 80A are analyzed. The effect is calculated on material removal rate (MRR) and Tool Wear Rate (TWR) by using the input parameters like peak current, pulse on time, pulse off time and flushing pressure on the EDM setup. The present work is done by analyzing the Taguchi method, Based on the polarity values the experimental values are studied.**

***Keywords*: Nimonic 80A; Metal Removal Rate (MRR); Tool Wear Rate (TWR); Electro Discharge Machining (EDM); Taguchi.**

1. INTRODUCTION

EDM is a non-conventional machining technique uniquely used for cutting metals which are not possible to cut with traditional methods. EDM only works with materials which are electrically conductive, cutting tools used for EDM are steel, titanium carbide, etc.

Nimonic 80A alloy is a Nickel-Chromium alloy that is strengthened by the additions of titanium and aluminum it has high tensile and creep-rupture properties at temperatures up to 815^0C (1500^0F)

Mechanical Properties

PROPERTIES	METRIC	IMPERIAL
Tensile strength(annealed)	1250 Mpa	181 ksi
Yield strength(annealed)	750 Mpa	113 ksi
Elongation at break	30 %	30 %

2. EXPERIMENTATION

2.1 Equipment and Material selection

The experiments are carried out on die-sinking EDM (CREATOR CR-6C) setup EDM oil grade 2 is used as a dielectric fluid. Positive polarity is maintained throughout the experiment. The work piece used is Nimonic 80A super alloy having a chemical composition The dimensions considered are flat plate of 30mm X 15 mm with a thickness of 3 mm. Copper is employed as the tool material in the current study. Copper(tool material) dimensions are 12mm diameter and 120 m length. Total number of pieces used in the experiment are 25 electrodes

Table 1 Chemical composition (wt %) of Nimonic 80A alloy

Constituents	Ni	Cr	Fe	Co	Ti	Al	Others
Weight %	69	18-21	3	2	1.8-2.7	1.0-1.8	Remainder

2.2 Selection of machining parameters

Parameters used in the machining are the most re-nowed parameters like Peak Current(C),Pulse on-time(T_{on}),pulse off – time (T_{off}) ,Flushing pressure[1] by considering this parameters we are having output reactions observed are Metal Removal Rate(MRR) ,Tool Wear Rate (TWR) .

Table 2 Process **Parameters levels considered**

Process Parameters	C in amperes	T_{on} in µs	T_{off} in µs	FP (kg/cm^2)
Level 1	4	18	12	0.2
Level 2	8	36	24	0.4
Level 3	12	54	36	0.6
Level 4	16	72	48	0.8
Level 5	20	90	64	1.0

2.3 Design of Experiments

The experimental design of process parameters is performed using MINITAB software. A constant machining time of 10 minutes is performed for all the experiments. TAGUCHI technique is employed to reduce the number of experiments from a full factorial design to an L25 orthogonal array.

2.4 Measurement of Responses

MRR and TWR are determined by weight loss criteria with the help of digital weighing balance in fig 1 having an accuracy of 0.0001 grams The weight difference before and after the experimentation is calculated.

Fig 1 Digital weighing balance

3. OPTIMIZATION APPROACH

Product cost and machining time are dependent factors that enhance the profitability. Thus achieving optimal machining parameters to obtain product specifications is a challenging task .The affect of input parameters on each output responses during the machining of Nimonic 80A super alloy are discussed below

3.1 Material Removal Rate

Metal removal rate occurs in EDM process due to ionization of die-electric fluid present in between the electrode and the work piece.

MRR is observed as per the % contribution (% C) in the Table 3 as the C ,T_{on} , T_{off}, and FP [2]. C and T_{on} possessed equal effect on MRR on different Ni-Cr alloy , while in our investigation it is identified that C is more than twice of T_{on} effecting MRR

Table 3 ANOVA of MRR

SOURCE	Degrees of Freedom	Sum of Squares	Mean of Squares	F	P	% Contribution
CURRENT	4	464.958	91.240	15.75	0.001	45.9
PULSE ON-TIME	4	260.860	40.215	6.94	0.010	21.1
PULSE 0FF-TIME	4	249.330	37.332	6.45	0.013	23.4
FLUSHING PRESSURE	4	20.173	2.543	0.44	0.778	1.3
ERROR	8	36.329	5.791			8.3
TOTAL	24	931.650				100

3.2 Tool Wear Rate

One way of reducing the machining cost is to minimize the TWR and hence the desired characteristics of ANOVA analysis is smaller the better ANOVA for TWR is in Table 4 . C is highly influencing the TWR with the percentage (%) contribution of 43.1. The increase in TWR with C followed by T_{on} are noted with investigation .However, Flushing Pressure is negligible effect on TWR

Table 4 ANOVA FOR TWR

SOURCE	Degrees of Freedom	Sum of Squares	Mean of Squares	F	P	% contribution
CURRENT	4	0.80610	0.020152	6.15	0.0015	43.1
PULSE ON-TIME	4	0.043278	0.010819	3.30	0.071	29.3
PULSE OFF-TIME	4	0.018095	0.004524	1.38	0.323	9.6
FLUSHING PRESSURE	4	0.003178	0.000794	0.24	0.906	2.8
ERROR	8	0.026214	0.003277			15.2
TOTAL	24	0.171374				100

4. RESULTS AND DISCUSSION

MRR = - 4.27 - 0.120 C + 0.137 Ton + 0.114 Toff + 8.8 FP - 0.0055 C*C - 0.00179 Ton*Ton - 0.00090 Toff*Toff - 5.40 FP*FP + 0.0171 C*Ton+ 0.0021 C*Toff - 0.260 C*FP - 0.00218 Ton*Toff + 0.038 Ton*FP - 0.061 Toff*FP

TWR = - 0.399 + 0.0050 C - 0.0193 Ton + 0.0349 Toff + 1.92 FP - 0.00047 C*C - 0.000162 Ton*Ton - 0.000386 Toff*Toff - 1.43 FP*FP +0.000262 C*Ton+ 0.000087 C*Toff - 0.00591 C*FP + 0.000394 Ton*Toff +0.0301 Ton*FP - 0.0413 Toff*FP

MRR and TWR are calculated by using the values from the experimental process

Validation runs are performed for the optimal conditions as many of the optimal conditions lie outside the L 25 orthogonal array and are listed in the table 5 for comparison with predicted[3] optimum response values

Table 5 Validation of Performance Results

PARAMETER	OPTIMUM CONDITION	PREDICTED OPTIMUM VALUE	EXPERIMENTAL VALUE
MRR	Current-20 Pulse ON time-90 Pulse OFF time-12 Flushing Pressure -0.2	20.1	19.8
TWR	Current-4 Pulse ON time-18 Pulse OFF time -64 Flushing Pressure-0.2	0.262	0.266

The predicted values for optimum conditions are attained for the equations 1-2 (MRR,TWR) obtained from multiple regression analysis conducted for experimental values .the average error obtained between the experimental and predicted runs is 4.58% i.e the accuracy developed models is as high as 95.42%

5. CONCLUSIONS

The present study exploits the influence of various Die sinking EDM process parameters on machinability of Nimonic 80A super alloy by Taguchi technique.

- Current is the most prominent factor affecting the responses followed by Pulse on time.
- MRR,TWR increases with Current and Pulse on time

- As Pulse off time increases MRR and TWR decreases
- Flushing pressure has negligible influence on responses

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