OPTIMIZATION OF MATERIAL REMOVAL RATE IN WIRE EDM BY DOE APPROACH FOR SUPER ALLOY

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Abstract

IN current research article, the effect of wire electrical discharge (WEDM) machining parameters such as current intensity, pulse on time, pulse off time and wire feed on material removal arte (MRR) in Inconel 625 super alloy were studied. The experiments are carried out as per design of experiments approach using L_9 (3*4) orthogonal array. The results are analyzed by analysis of variance and response graphs. This experimentation study it is found that different combination WEDM process parameters are required to achieve higher material removal rate. Pulse on time and current are found the most effective parameters. SEM analysis is also done for material characterization.

Key words: WEDM; super ally: material removal rate; Taguchi, SEM

I. INTRODUCTION

The advanced materials have attractive properties i.e., high strength, high bending stiffness, good damping capacity, low thermal expansion, better fatigue characteristics which make them potential material for modern day industrial application. Present manufacturing industries are facing challenges from these advanced materials viz. super alloys, ceramics, and composites, that are hard and difficult to machine, requiring high precision, surface quality which increases machining cost **[1].** WEDM was first introduced to the manufacturing industry in the late 1960s. In WEDM, material is eroded from the work material by a series of discrete sparks occurring between the work piece and the wire separated by a stream of dielectric fluid, which is continuously fed to the machining zone **[2].** The WEDM process makes use of electrical energy generating a channel of plasma between the cathode and anode **[3],** and turns it into thermal energy at a temperature in the range of 8000–12,000 ºC **[4].** When the pulsating direct current power supply occurring between 20,000 and 30,000 Hz **[5]** is turned off, the plasma channel breaks down. This causes a sudden reduction in the temperature allowing the circulating dielectric fluid to implore the plasma channel and flush the molten particles from the pole surfaces in the form of microscopic debris.

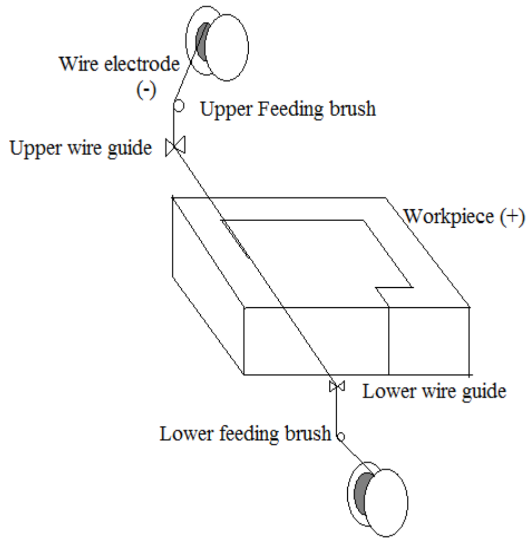

Fig: 1 WEDM machining process.

Lok et al. **[6]** presented the finding of processing two advanced materials Sialon and Al2O3-TiC by using WEDM. The author has taken MRR and surface finish as output parameters. The surface damage was evaluated by flexural strength data. The variability of flexural strength data was analyzed by weibull stastical method. The mean flexural strength drops from 32% to 67% due to thermal spalling erosion mechanism of wire-cut EDM process. Yan et al**.** **[7]** machined aluminum matrix composites (Al2O3p/6061 Al) using WEDM. The effect of pulse on time, cutting speed, width of slit, surface roughness was studied. The wire easily got broken while machining Al2O3p/6061 Al. It was observed that that the cutting speed, surface roughness and width of the slit significantly depend upon volume fraction of Al2O3 particles. Less volume percentage of reinforcement increases the surface finish, improves width of slit.

II. EXPERIMENT DETAILS

A. Second level Subheading

Machining of Inconel 625 super alloy are performed on electronica sprincut 4 axis CNC machine. A zinc coated brass wire of 0.25 mm diameter is used as an tool electrode. Deionized water is used as a dielectric fluid. Size of work piece is 150*50 mm and 2 mm is the thickness. Different machining parameters such as current, pulse on time, pulse off time and feed rate are varied at three levels. The machining parameters at different levels are selected based on trials runs carried out and mean of three expedients is considered is final MRR[8] .

Table 1 Control factor and their levels.

Symbol	Control factor	Unit	Level1	Level2	Level3
A	Current Intensity	A	10	12	14
B	Pulse on time	µs	105	115	125
C	Pulse off time	µs	48	54	60
D	Wire feed	m/min.	4	6	8

The results are analyzed by response graphs. The performance of WEDM process is evaluated using output parameters material removal rate.

The MRR is calculated using the formula:

$$MRR = \frac{(W_a - W_b)*1000}{\rho * t} \text{ mm}^3\text{/min. [1]}$$

Where W_a and W_b are the weight of work piece before and after machining respectively in grams is the density of material i.e.8.44g/cc,t is the machining time in minute.

Table 2 Measured responses corresponding to orthogonal array L9

S.no	Current	Pulse on time	Pulse off time	Wire feed	MRR	S/N ratio
1	10	105	48	4	4.34	
2	10	115	54	6	5.87	
3	10	125	60	8	6.45	
4	12	105	54	8	4.93	
5	12	115	60	4	6.09	
6	12	125	48	6	7.54	
7	14	105	60	6	7.1	
8	14	115	48	8	6.86	
9	14	125	54	4	7.96	

III. RESULT AND DISCUSSION

Effect on MRR:

In the WEDM, higher material removal rate is the indication of better performance. For optimization MRR is taken higher is better. The S/N ratio shown is fig. 2 to show the effect of machining parameters on MRR.

Table 3 shows the Response Table for Signal to Noise Ratios. By the response table it is clear the pulse on time is the most important factor for machining by WEDM, followed by current, wire feed and pulse off time is the less effective parameter for WEDM

Table 3 Response Table for Signal to Noise Ratios

Level	Current	Pulse on time	Pulse off time	Wire feed
1	14.77	14.54	15.67	15.49
2	15.70	15.93	15.75	16.65
3	17.26	17.25	16.30	15.59
Delta	2.49	2.71	0.62	1.16
Rank	2	1	4	3

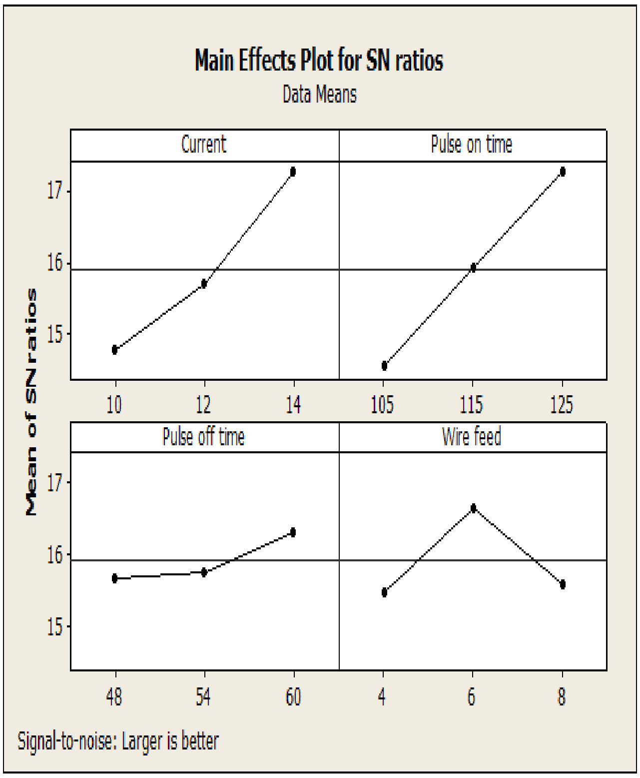

Fig: 2 S/N ratio plots show that MRR is increase by increase of current and pulse on time.

SEM analysis:

Figure 9 shows the SEM of the machining groove after WEDM and indicates that the crack on the groove surface caused by the machining groove at 12μs of pulse-on time is more obvious than it is at 2μs. Scanning Electron Microscopy (SEM) views of the WEDMed surfaces were taken in order to compare the effects of different wire typeson machining of Inconel 625 by analyzing surface integrity and characteristics. It is observed that formation of micro cracks, and shallow and even craters are obtained.

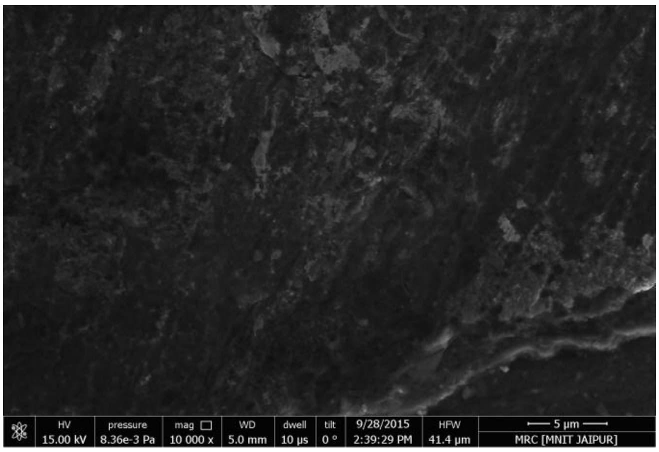

Fig: 3a

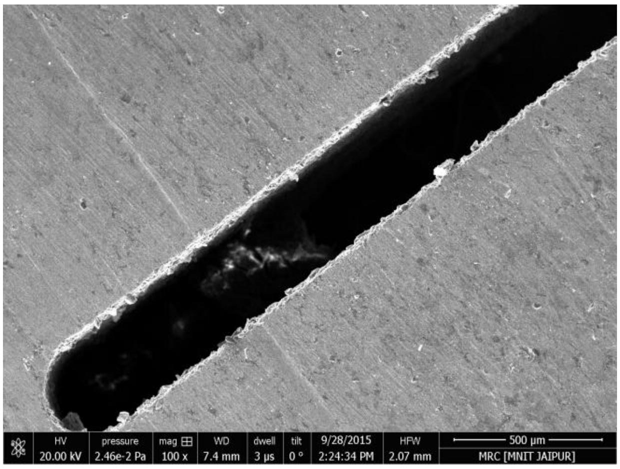

Fig: 3a, 3b shows. Microstructure of the machined sample at experiment no. 7, Table 3 Ton: 105**μs**, Toff: 60 **μs**, IP14A, WF: 6m/min. b. Microstructure of machine slit

IV. CONCLUSION

This study discusses the influences of WEDM parameters on machining Inconel 625. The conclusions are as follows:

- Increasing pulse-on time and current influence material removal rate the most. Increasing both also increases energy supply. Material remove rate rises accordingly.
- Maximum MRR obtained at current=14A, pulse on time=125 μs, pulse off time=60 μs, wire feed =6 m/min for machining of Inconel 625.
- WEDM obtains a particular geometry shape of Inconel 625 material.

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