International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 12 | Dec 2020 www.irjet.net p-ISSN: 2395-0072

Victrol4003 Mixed Wire Electric Discharge Machining (Wedm) of Optimization for Inconel Alloy 800HT using Taguchi-Grey Relation Analysis

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Abtract - *In this investigation primary spotlight is on the limited estimation of the reaction factors, for example, surface unpleasantness and kerf width by setting measure boundaries of wire electric release machining at the ideal level. Single objective optimization is done by using Taguchi L_9 orthogonal array and for multi-objective optimization grey relational analysis is used. The main focus is on optimization of process parameters of EDM and its modified versions like WEDM, Micro-EDM and VWEDM using Taguchi method and Grey relational analysis method. Victrol4003 mixed with demonized water of wire electric discharge machining for optimization of inconel alloy 800ht. the victrol4003 is a lubricant as additive and water soluble emulsifiers, of hard as well as ductile metal working process are used. The major application aerospace industry, automobile sector and sheet metal working industries. There are various response parameter effect surface roughness, kerf width and material removal rate and improved. From analysis show that for single objective optimization by using taguchi method gives in decrease surface roughness, kerf width individually value is 5 and 10 respectively. In the case of grey relational analysis decrease of surface roughness, kerf width simultaneously at the optimal condition as compared to the initial condition value is 0.1448 to 1*

Key Words: wedm; victrol4003, Inconel alloy 800ht, surface roughness, kerf width, taguchi-grey relational analysis.

1. INTRODUCTION

Wire electric release machining is one of the nonconventional sorts of the machining cycle and it is an adjusted variant of electric release machining. The anode utilized in the wire electric release machining is as wire and its width is fluctuated from the 0.18 to 0.30 mm. The material utilized for wire are Brass, bras zinc coated wire. The wire is consistently taken care of from a spool and it is guided by lower further more, upper spout in wire electric release machine. The potential contrast is to be applied between the wire terminal and workpiece in light of that cathode is going about as a cathode and workpiece is go about as anode and keep up a little hole between them. The dielectric liquid, for example, de-ionized water is like wise present between the wire terminal furthermore, workpiece. The electron moves from the cathode and its strike on to the particle of de-ionized water and delivers all the more no of electrons this electrons again strike on to the following particle of de-ionized water this cycle is going on consistently and at the same time sure particles move towards the cathode. In this manner an enormous number of electrons are moved towards the anode (workpiece) due to that active energy of electrons is changed over into warm energy and sparkle is produced. This flash energy builds the temperature of the workpiece is about 10,000°C because of this explanation softening and vanishing of workpiece material is occurred. This is steel alloy of inconel alloy 800ht also used for aerospace industry, automobile sector manufacturing shaft, gear, crankshaft, bolt, steel coupling etc. Several researchers tried to improve response variables such Material removal rate, Surface roughness, kerf width. B.V. Dharmendra et al. [1] investigated machining equipment and tooling to minimize chatter due to work-hardening of the INCONEL materials ahead of cutting. Optimum EDM parameters are to be identified to produce quality products of INCONEL800.Modified Taguchi approach is adopted in the multi-objective optimization to identify the optimum peak current, pulse-on-time and pulse-off-time in the nano powder mixed (EDM) of INCONEL800 with copper electrode for high material removal rate (MRR). Sharanjit Singh et al. [2] presented electrical discharge machining (EDM) is a well-established non-conventional machining process, used for manufacturing geometrically complex or hard and electrically conductive material parts that are extremely difficult-to-cut by other conventional machining processes. Presence of metal partials in dielectric fluid diverts its properties, which reduces the insulating strength of the dielectric fluid and increases the spark gap between the tool and work piece. Klocke et al. [3] evaluated high precision titanium parts for space applications, Wire EDM is without any appreciable alternative when it comes to filigree structures with high aspect ratio, as it allows machining independently of mechanical material properties like hardness or high temperature strength. Ashish Goyal et al. [4] studied the effect of process parameters on material removal rate (MRR) and surface roughness (Ra) in wire electric discharge machining of

Inconel 625. Machining was done by using a normal zinc coated wire and cryogenic treated zinc coated wire. The experiments were performed by considering different process parameters viz. tool electrode, current intensity, pulse on time, pulse off time, wire feed and wire tension. The thickness of work material and dia. of wire are kept constant. Taguchi L18 (21 * 35) orthogonal array of experimental design is used to perform the experiments. Somvir Singh Nain et al. [5] highlighted the behaviour of Udimet-L605 after wire electric discharge machining and evaluating the WEDM process using sophisticated machine learning approaches. The experimental work is depicted on the basis of Taguchi orthogonal L27 array, considering six input variables. Bijaya Bijeta Nayak et al. [6] investigated experimentally and optimized of various process parameters during taper cutting of deep cryo-treated Inconel 718 in wire electrical discharge machining process. Taguchi's design of experiment is used to gather information regarding the process. The conclusion of the experimentation is that modified error associated with MRR, SF and Kerf Width 3.45%, 2.25% and 4.2% respectively.

2. METHODOLOGY

2.1 Taguchi Method:

The Taguchi Method classified into two major parts.
A] Orthogonal array
B] Signal to noise ratio

A] Orthogonal array: Orthogonal array helps in decrease total number of experiments to be conducted. Selection of orthogonal array it totally depends on the degree of freedom of process. Orthogonal array ≥ degree of freedom of process.

Degree of freedom of factor =Number of level -1

Degree of freedom of process =∑ Degree of freedom of factors

Taguchi represents an orthogonal array as:-

$L^N (S^K)$

Where,

S = The number of levels for each factor.

k = The maximum number of factors whose effects can be estimated without any interaction.

N = The total number of trials during experimentation.

B] Signal to noise ratio: Signal it is initial condition represents desirable quantity and noise its undesirable quantity, higher value of signal to noise ratio is selected because it contain lower noise value. There are classified into two way is as follows:-

1. Lower the better

2. Medium the best

3. Higher the best

The signal to noise ratio can be calculate is as follows : S/N ratio = -10 log(L_{ij})

Where, Lij-Loss function

2.2 Grey relational analysis:

The grey relational analysis method to gives a response variable parameter multi objective optimization to used. Taguchi method to used single optimization method. Step by step explained grey relational analysis method is as follows.

Step 1. Normalization of collected data:
1.Smaller , SR better, $Xi(k)= \frac{Maxi(k)-Xi(k)}{Maxi(k)-Minxi(k)}$
2.Larger,MRRthebetter,$Xi(k)=Xi(k)- MinXi(k)/Maxxi(k)-Minxi(k)$
Step 2. Calculation of deviation:$Xi(k)= |Xi0-Xi(K)|$ where, Xi(k)=1 , Normal value
Step 3. Find the grey relational coefficient (GRC):The grey relation coefficient (K) for K^{th} the characteristics of performances I^{th} experiment to be express as follows.
$Xi^K=Ximax+Ximin/Xi0(K)+Ximax$
Where, Ximax=1, Ximin=0 , K= 0.5
GRG:Yi=1/6*(All addition Reading GRC)*0.5

3. EXPERIMENTAL SETUP

3.1 Material selection and Victrol4003

The material inconel alloy 800ht suitable for additivies ,emulsifires soluable water used. Victrol4003 mixed with deionized water for decrease surface roughness, kerf width and increase material removal rate. Optimization material to increase the lifespan and to protect corrosion resistance material.

Applications of Material and Victrol4003:

Inconel alloy 800HT: alloys are used for radiant tubes, muffles, retorts, and assorted furnace fixtures, aerospace industry, automobile industry.

Victriol4003 (lubricant): Grinding process, metal cutting process, CNS Machine, Wire Cut EDM.

As show below table 3.1 and 3.2 this experimental work was performed at Government college Engineering Karad. The Experiment work is carried out "ECOCUT CNC Wire-cut EDM" Machine (supplied by Electronica India Pvt Ltd.). A schematic diagram of WEDM system. Fig.1, Fig.2 and Fig.3 The material select rectangular section of size 150x40x20 Inconel alloy 800HT and

Victrol4003 coolant, major application aerospace, automobile industry.Fig.2

Table3.1 Chemical composition Inconel Alloy 800HT:

Elements	**Cr%**	**Ir%**	**Ni%**	**Al%**	**Ti%**
contents	**20**	**40**	**30**	**0.60**	**1.25**

Table3.2 Victrol 4003 coolant:

Elements	**Fe**	**Al**	**Cu**	**Ti**	**Mg**

Water concentration:

Sr. No.	Deionized Water	Victrol 4003 Lubricant
1.	20 Lit.	500ml
2.	40 Lit.	1000ml
3.	60 Lit.	1500ml
4.	80 Lit.	2000ml
5.	100 Lit.	2500ml
6.	120 Lit.	3000ml
7.	140 Lit.	3500ml

Fig.1 Experimental Setup WEDM

Fig.2Mitutoyo Surface Roughness TesterSJ2

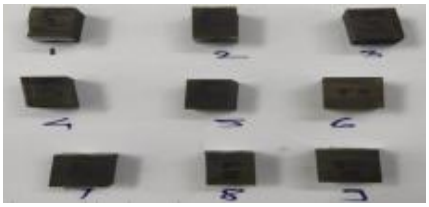

Fig.3 Machined specimen

The Brass zinc Coated Wire of 0.25 to 030 dia. is used an electrode. Deionized water mixed with Victrol4003 Lubricant as used dielectric fluid. The specimen is cut according to the Taguchi Design of experiment. During the measurement parameters of Surface roughness and Material removal rate. Victrol4003 Lubricant Metal cutting Fig. given below.

Fig.4 Victrol4003 cutting Metal

Table 3.3 Machining parameter and Level

Sr. No.	Process Parameter	Unit	Level 1	Level 2	Level 3
1.	Pulse On Time	µs	110	120	125
2.	Pulse Off Time	µs	40	45	55
3.	Servo Voltage	V	10	20	30
4.	Wire Feed	m/min	4	6	10

Table 3.4 Experimental Design using L_9 orthogonal array matrix.

Sr.No.	Pulse On Time µs	Pulse Off time µs	Wire Feed m/min	Servo Voltage V
1	110	40	4	10
2	110	40	6	20
3	110	40	10	30
4	120	45	10	20
5	120	45	4	30

6	120	45	6	10
7	125	55	6	30
8	125	55	4	10
9	125	55	10	20

4. Results and discussion

The experimental results for surface roughness and material removal rate as table 4. For further analysis of results regression analysis and signal to noise ratio is find out. In wire EDM response variable such as surface roughness and material removal rate are require to be minimum, because of that signal noise ratio of lower the better condition.

Pulse On Time	Pulse Off Time	Servo Voltage	Wire Feed	Surface Roughness (µm)	Material Removal rate
115	40	10	4	1.676	1.25
115	50	20	6	1.490	1.75
115	55	30	10	1.58	2.45
120	40	20	10	1.745	2.75
120	50	30	4	1.601	2.86
120	55	10	6	2.134	2.95
125	40	30	6	2.085	3.25
125	50	10	10	3.754	3.4
125	55	20	4	2.4543	3.45

4.1 Effect of process parameter on the surface roughness of Inconel Alloy 800HT :

The minimum value surface roughness is obtained and maximum material removal rate is obtained .when first level pulse on time, pulse off time, servo voltage is third level and wire feed second level. It is clear that pulse on time, pulse off time and servo voltage are main influencing parameter surface roughness and material removal rate and other parameter. Contribution Mean value and signal noise ratio show in Graphs 4.1Table

Pulse On Time	Pulse Off Time	Servo Voltage	SR	Signal to Noise ratio
115	40	10	1.6763	4.74740569
115	50	20	1.4903	1.39673125
115	55	30	1.585	-0.2334616
120	40	20	1.7453	0.05295644
120	50	30	1.6013	4.35595801
120	55	10	2.134	3.45054641
125	40	30	2.085	3.2886652
125	50	10	3.754	3.84624085
125	55	20	2.4543	9.40417886

Table 4.2 Signal to noise response table for surface roughness

Level	Pulse On Time	Pulse Off Time	Servo Voltage
1	1.970	2.696	**4.015**
2	2.620	3.200	3.618
3	**5.513**	**4.207**	2.470
Delta	3.543	1.511	1.544
Rank	1	3	2

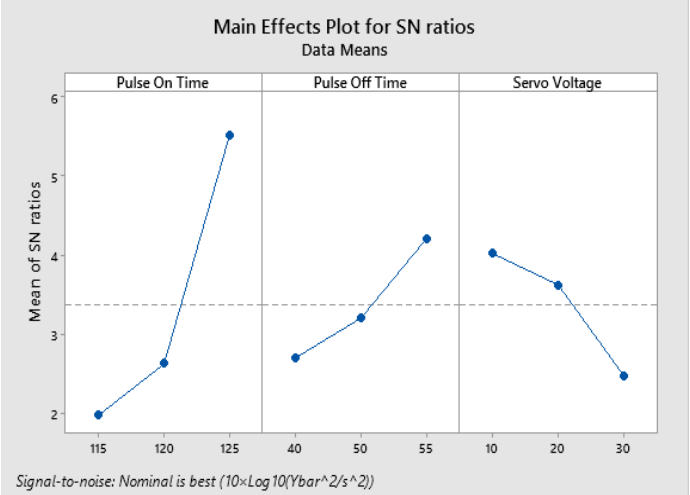

Fig.4.1Plot for signal to noise ratio for surface roughness

Fig. 4.2 plot for mean value for surface roughness

4.2 Effect of process parameter on the Material removal rate of Inconel Alloy 800HT.

Maximum material removal rate and minimum surface roughness is obtained first level Pulse on time , Pulse off Time ,second level servo voltage , wire feed first level. The various influencing parameter of wire feed, servo voltage to material removal rate analysis shows given below. Fig.4.2.1, Fig.4.2.2 and Table4.21

Table 4.21 Experimental results for material removal rate and corresponding signal to noise ratio

Pulse On Time	Pulse Off Time	Servo Voltage	MRR	Signal to Noise ratio
115	40	10	1.25	2.606233
115	50	20	1.75	2.207959
115	55	30	2.45	1.334144
120	40	20	2.75	1.893141
120	50	30	2.86	12.57803
120	55	10	2.95	6.340166
125	40	30	3.25	7.525882
125	50	10	3.4	3.14093
125	55	20	3.45	19.62557

Table 4.22 signal to noise response table for material removal rate

Level	Pulse On Time	Pulse Off Time	Servo Voltage
1	2.049	4.008	4.029
2	6.937	5.976	**7.909**
3	**10.097**	**9.100**	7.146
Delta	8.048	5.092	3.880
Rank	1	2	3

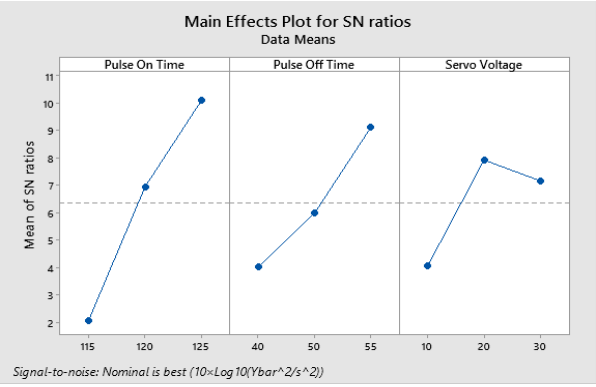

Fig.4.2.1 Plot of signal to noise ratio for material removal rate

Fig.4.2.2 Plot of Mean value for material removal rate

4.3 Grey relational analysis:

The grey relational analysis method calculate is as follow, table 4.31

Sr. No.	Experimental Data		Calculate Data			
	SR	MRR	SR	MRR		
1	1.676	1.2546	0.0812	0.01908		
2	1.490	1.2023	0	0		
3	1.58	2.4549	0.04063	0.4571		
4	1.745	2.7502	0.1126	0.5649		
5	1.601	2.8606	0.04912	0.6052		
6			2.134	2.9544	0.28509	0.6394
7			2.085	3.9421	0.2632	1
8			3.754	3.4561	1	0.8226
9			2.4543	3.4582	0.4264	0.8233

The Deviation sequence, Grey relational coefficient and Grey relational grade calculate is follow table 4.32

Weightage response parameter is

W1=0.5 W2=0.5

Deviation Sequence		Grey relational Coefficient		Grey relational Grade w1=0.5
SR	MRR	SR	MRR	W1 W2=0.5
0.9888	0.98092	0.3524	0.3376	0.0575
1	1	0.3333	0.3333	0.0555
0.9593	0.5429	0.3426	0.4794	0.0745
0.8874	0.4351	0.3606	0.5347	0.0685
0.95088	0.3948	0.3427	0.5587	0.07458
0.7149	0.3606	0.4115	0.5809	0.0827
0.7368	0	0.4042	1	0.1170
0	0.1774	**1**	0.7381	**0.1448**
0.5736	0.1767	0.4657	0.7388	0.10037

The Experimentation of eight is minimum surface roughness and maximum material removal rate value is 0.1448 to 1

5. Conclusions

This paper has presented an experimental investigation response parameter of wire cut edm machining on Inconel alloy 800HT using Taguchi Method and Grey relational analysis.

1) The experimentation will be single objective optimization of input parameter to get maximum MRR Value is 5 first and second 10, minimum surface roughness spark. The grey relational analysis value is 0.1448 to 1
2) The experimentation will be multi-objective optimization process parameter (pulse on time, pulse off time, wire feed rate, servo voltage) value of high MRR, lower surface roughness and lower spark gap simultaneously.

It is show that response variable of the wire cut EDM such as Material removal rate and surface roughness are improved by using Taguchi method and grey relational analysis method proposed in this study.

Acknowledgements

The author would like to acknowledgement Mechanical Engineering Department of Government College of Engineering, Karad for providing research facilities and funding under TECHNICAL EDUCATION QUALITY IMPROVEMENT PROGRAME [TEQIP-III] OF THE MHRD, Government of India.

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