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Optimisation of Process Parameter for Material Removal Rate of Wire Cut EDM using Taguchi Method

Shrey Kapoor[1], Mr. Sharad Shrivastava[2]
[1]M.Tech, Department of Production engineering, Rajasthan Institute of Engineering and Technology, Jaipur
[2]Assistant Professor, Department of Mechanical Engineering, Rajasthan Institute of Engineering and Technology, Jaipur

Abstract: Accompanying the development of production, aerospace and automotive industries, the demand for alloy materials having high hardness, toughness and impact strength are increasing. As these alloy materials are having high material properties for machining them to finish product, need high advantageous machines other than traditional machines. So to machine these materials non-traditional machine are used which are very advantageous. Wire Cut EDM (WEDM) machine is non-traditional machine which have application to cut electrical conduction material irrespective of their high physical and chemical properties.

The ultimate requirement in manufacturing is to have high material removal rate (MRR). The paper deals with the optimisation of process parameters of WEDM to machine M-35 HSS with 5% Cobalt material. The process parameter pulse on time (ton), pulse off time (toff) and wire feed (Wf) are optimised using Taguchi's method. The result shows optimised values of parameters for material to get high MRR.

Keywords: Wire Cut EDM (WEDM), material removal rate (MRR), M-35 HSS with 5% Cobalt material, Taguchi's method

I. INTRODUCTION

Electrical discharge machining (EDM) is a non-traditional, thermo electrical process, which erodes material from the work piece by a series of discrete sparks between the work and tool electrode immersed in a liquid dielectric medium. These electrical discharges melt and vaporize minute amounts of the work material, which are then ejected and flushed away by the dielectric.

A wire EDM generates spark discharges between a small wire electrode and a work piece with de-ionized water as the dielectric medium and erodes and work piece to produce complex two and three-dimensional shapes according to a numerically controlled (NC) path.

The main goals of WEDM manufacturers and users are to achieve a better stability and higher productivity of the WEDM process. As newer and more exotic materials are developed, and more complex shapes are presented, traditional machines continue to reach their limitation and to machine alloy material having WEDM machine plays a key role and its usage in manufacturing field accelerating.

Wire electrical discharge machining manufactures and users emphasize on achievement of higher machining productivity with a desired accuracy and precession. To machine tough physical property materials with optimal values we need to find better values of input parameters to achieve desire output.

II. EXPERIMENTAL SETUP

In wire electrical discharge machining (WEDM), a thin single-strand metal wire, usually brass, is fed through the work piece, submerged in a tank of dielectric fluid, typically deionised water. Wire-cut EDM is typically used to cut plates as thick as 300mm and to make punches, tools, and dies from hard metals that are difficult to machine with other methods.

The wire, which is constantly fed from a spool, is held between upper and lower diamond guides. The guides, usually CNC-controlled, move in the x–y plane. In this experimental setup we have used 0.25 mm brass coated wire. Demineralised water is used as dielectric fluid which cools and flushes out burrs produced at machining zone. Pulse on time and pulse off time is set on the control panel. Also cutting path program is feed in the CNC controller.

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Fig. 1. Electra Maxicut 734 WEDM setup

III. WORKPIECE MATERIAL

M-35 HSS with 5% Cobalt material is used as work material. It is having several advantages in making parting blades, tool bits etc.

Table I
Chemical Composition Of Work Piece

Chemical Composition (in %)											
	C	Si	Mn	P	S	Cr	Mo	V	W	Co	Ni
M-35	0.85	0.40	0.4	0.3	0.3	4.0	5.25	2.15	6.65	5	-

Fig. 2. M-35 HSS with 5% Cobalt

IV. METHODOLOGY

Process parameters are pulse on time, pulse off time and wire feed are taken in three levels and experimented as per the L9 orthogonal array which is created by MINITAB software. There are nine experimental inputs which are varied for each cut and other parameters are set constant. For each cut the material removed is calculated and Taguchi optimisation technique is applied to find optimised value for higher MRR.

Table II
Process Parameter And Their Levels

Parameter	Symbol	Unit	Level		
			Level 1	Level 2	Level 3
Pulse on time	Ton	µs	4	5	6
Pulse off time	Toff	µs	3	4	5
wire feed	Wf	m/min	3	4	5

Table III. Taguchi Orthogonal Array L9

Ton (µs)	Toff (µs)	Wf (m/min)
4	3	3
4	4	4
4	5	5
5	3	4
5	4	5
5	5	3
6	3	5
6	4	3
6	5	4

V. RESULT & DISCUSSION

A. Experiment for MRR

The process parameter varied for nine different set of values which gives respond parameter as MRR which show in following table.

TABLE IV. RESULT TABLE FOR MRR

Ton (µs)	Toff (µs)	Wf (m/min)	MRR (mm^3/min)
4	3	3	0.321
4	4	4	0.381
4	5	5	0.45
5	3	4	0.495
5	4	5	0.356
5	5	3	0.451
6	3	5	0.479
6	4	3	0.501
6	5	4	0.382

B. Analysis

Output values of MRR for selected process parameter is now analysed using Taguchi Method in Minitab software and signal to noise ratio and mean values are calculated. Signal to noise ratio calculated to eliminate loss factors.

TABLE V. Values Of S/N Ratio And Mean For Mrr

Ton	Toff	Wf	MRR		
			MRR*	S/N ratio	MEAN
4	3	3	0.321	-9.8699	0.321
4	4	4	0.381	-8.3815	0.381
4	5	5	0.45	-6.93575	0.45
5	3	4	0.495	-6.1079	0.495
5	4	5	0.356	-8.971	0.356
5	5	3	0.451	-6.91647	0.451
6	3	5	0.479	-6.39329	0.479
6	4	3	0.501	-6.00325	0.501
6	5	4	0.382	-8.35873	0.382

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C. Response Table

After getting values of S/N ratio and mean the optimised response table is outputted as per Taguchi method, which gives delta values of each parameter and rank as per their influencing the response parameter.

TABLE VI
Response Table For Signal To Noise Ratio

Level	Ton	Toff	Wf
1	-8.396	-7.457	-7.597
2	-7.332	-7.785	-7.616
3	-6.918	-7.404	-7.433
Delta	1.477	0.382	0.183
Rank	1	2	3

TABLE VII
Response Table For Mean

Level	Ton	Toff	Wf
1	0.384	0.4317	0.4243
2	0.434	0.4127	0.4193
3	0.454	0.4277	0.4283
Delta	0.07	0.019	0.009
Rank	1	2	3

D. Graphs for mean and S/N ratio

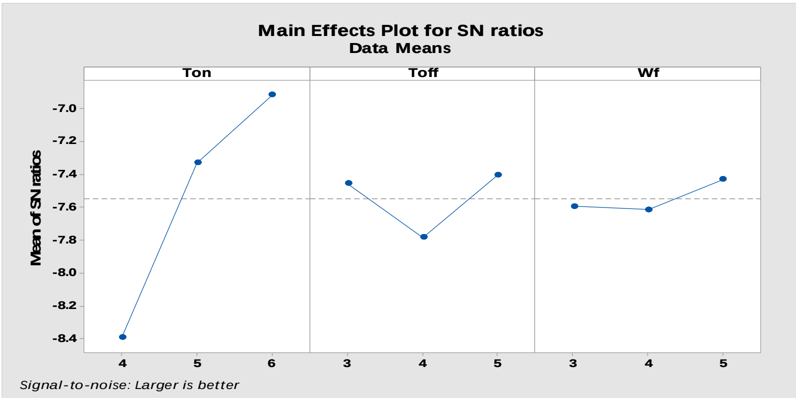

Fig.3. Main effect plot of S/N ratio for MRR

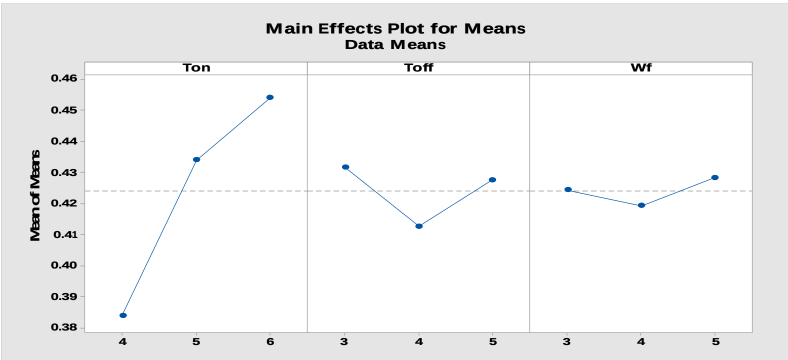

Fig.4. Main effect plot of mean For MRR

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E. Result

From the graphs of S/N ratio and mean we can come to a result that for machining M-35 HSS with 5% Cobalt material to get high MRR respond factor we need to set process parameter as given in following table.

TABLE VIII
optimal Parameter for High MRR

Pulse on time	6µs
Pulse off time	3µs
Wire feed	5m/min

VI. CONCLUSION

On the basis of experimental result, from S/N ratio, mean values and graph plots for both, we can come to a conclusion that to machine M-35 HSS with 5% cobalt material to get higher MRR respond factor the values for process parameters pulse on time is 6µs, pulse off time is 3µs and wire feed is 5m/min. Also we have ranks for factors with influences the respond factor MRR as per their ranks so in the response table we have pulse on time as rank 1, it means pulse on time highly influence MRR then we have pulse on time as rank 2 which shows it has intermediate impact on response factor and wire feed has rank 3 which denotes it has less influence on MRR.

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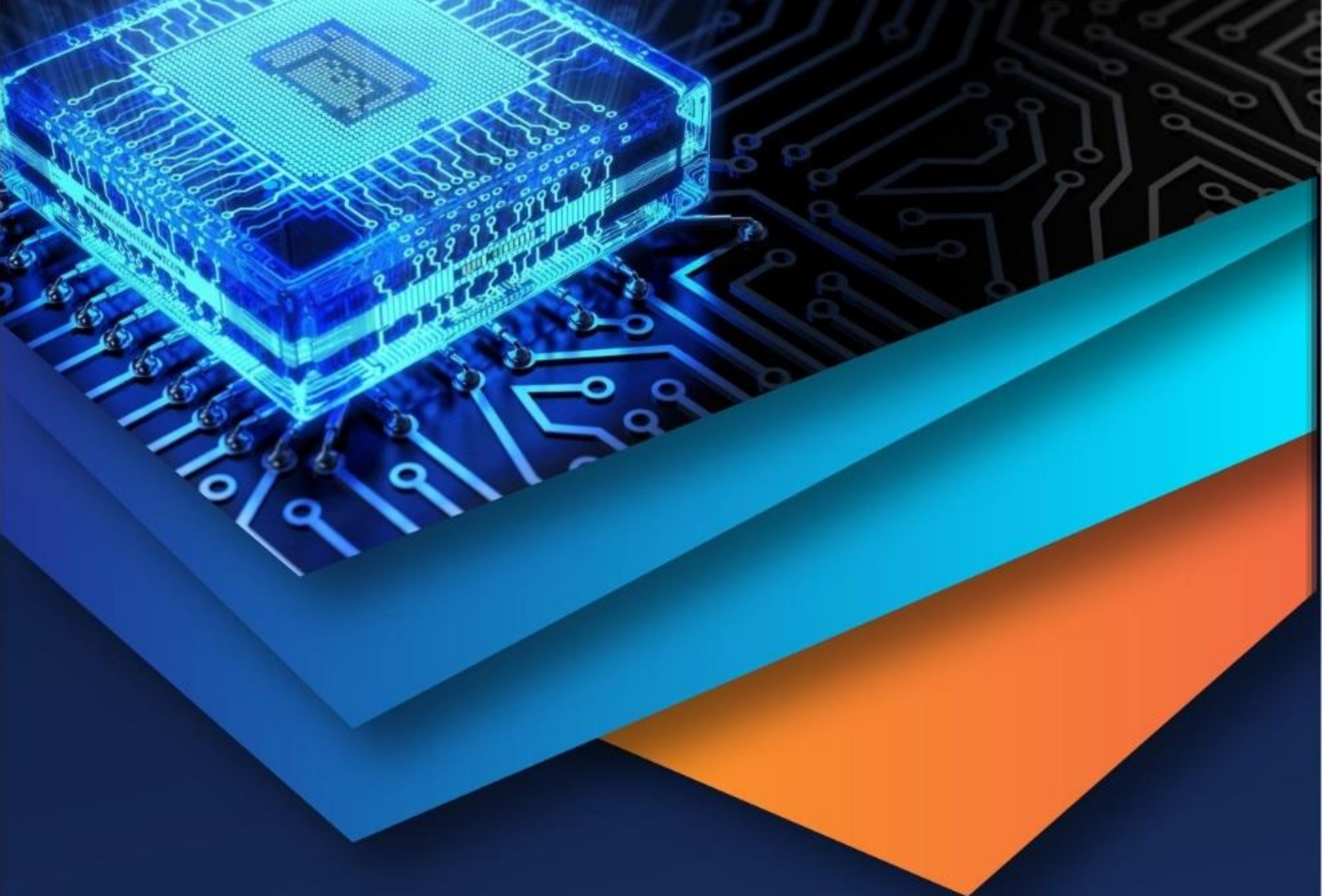

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