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Optimisation of Process Parameter of Wire EDM for Material Removal Rate Using Taguchi's Technique

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ABSTRACT :-In the present competitive world we needs to have perfection, fast processing, better efficiency, precision work. To obtain that we have developed several processes instruments, machines, techniques, mechanisms etc.. In the field of manufacturing there are many types of machines conventional or non-conventional. Now-a-days uses of non-conventional machines are increasing rapidly due to several advantages over conventional machines. Also we need the better quality and performance in work using these machines, to achieve that we need to be optimizing our work and parameters of machining.

Wire EDM machine is used to machining of hard material, complex shapes for conductive material. The objective of this paper is to evaluate the best Wire EDM process parameters like pulse on time (T_{on}), pulse off time (T_{off}), peak current (I_p), spark voltage (S_v) for T-42 HSS with 10% Cobalt material. The experiments are carried out on work piece by varying parameters in response material removal rate (MRR) is calculated. Using Taguchi's design of experiment orthogonal array of L_9 matrix is formed. There are three levels and four factors over which analysis is carried out. Out of this nine experimental reading optimised values are to be determined using Taguchi's analysis with the help of statistical software MINITAB 18.

KEYWORDS :- T-42 HSS with 10% Cobalt material, material removal rate (MRR), Taguchi's design of experiment, orthogonal array, MINITAB 18.

I. INTRODUCTION

The Wire cut EDM machine has a predominant role in field of manufacturing recently; since the process can machine complex and intricate shapes of components in all electrically conductive materials with better precision and accuracy. In the WEDM process there is no relative contact between the tool and work material, therefore the work material hardness is not a limiting factor for machining materials by this process. In this operation the material removal occurs from any electrically conductive material by the initiation of rapid and repetitive spark discharges between the gap of the work and tool electrode connected in an electrical circuit and the liquid dielectric medium is continuously supplied to deliver the eroded particles and to provide the cooling effect. A small diameter wire ranging from 0.05 to 0.25mm is applied as the tool electrode. The wire flows continuously and it is not reused due to the variation in dimensional accuracy. Deionised water is used as dielectric fluid; dielectric fluid is continuously flashing the spark gap. A collection tank is used to collect fluid and send to filtration tank. Brass, aluminum and zinc coated brass or copper wires are widely applied as the tool electrode. Nowadays WEDM is an important machine tool to produce complex and intricate shapes of components in areas such as tool and die making industries, automobile, aerospace, nuclear, computer, and electronics industries.[1]

II. BASIC PRINCIPLE OF WIRE CUT EDM

Wire cut EDM process is non-traditional type machining process in which the material is removed by thermo-electric spark erosion process. The spark is generated between the work piece and wire. The wire does not touch the work piece but certain gap is maintained between wire and work piece, the material removed is flushed out of the gap with the flowing dielectric fluid, which is made to flow through the gap constantly.

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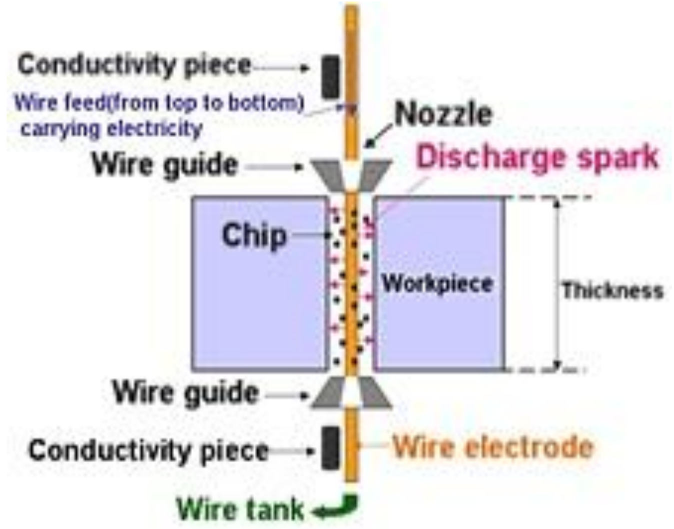

Figure 1. Mechanism of Wire cut EDM

An extremely high temperature generates in the region where discharge occurs causing melting and removal of work piece surface. In WEDM process a thin wire is used which is continuous feeding through the work piece. A small gap is between wire and work piece. There is no direct contact between wire and work piece. The conductive material of any hardness can be cut.[2]

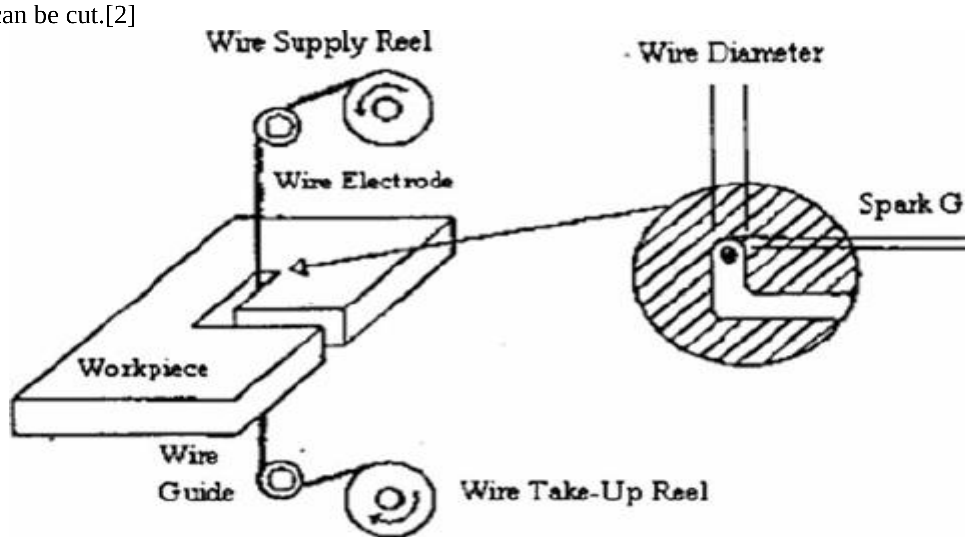

Figure 2. Wire cut EDM process

III. LITERATURE REVIEW

- Milon Selvam Dennison et. al. investigation on optimization of the process parameters of the wire cut EDM of mild steel and stainless steel. Material removal rate, surface roughness, were studied against the wire cut EDM process parameters, such as pulse on, voltage and wire feed rate. A regression model was obtained for material removal rate and surface roughness. To find the optimal value of material removal rate and surface roughness optimization of process parameters are carried out with Taguchi's robust design.[3]
- S. Sivanaga Malleswara Rao et. al. has investigates the effect of parameters such as discharge current, power, cutting speed, and spark gap on surface roughness for different thickness of high-speed steel plates in wire cut electric discharge machining. Experiments were performed at different levels of discharge current on different

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levels of plate thickness and experimental results of surface roughness, spark gap, and cutting speed were taken. Optimum process parameters were found for each thickness of plate experimentally and validated with the Artificial Neural Network (ANN) and Supporting Vector Machines (SVM) models.[4]

- Hulas Raj Tonday et. al. predicted the optimal values of MRR and surface roughness using L18 orthogonal arrays of Taguchi method. ANOVA technique is carried out to determine the significant cutting parameters of wire EDM, which influences the output factors. Also the Response Surface Methodology has been utilized for statistical evaluation and optimization MRR and surface roughness. It is acquired that cutting voltage is the most substantial input factor, which has the greatest impact on MRR as well as surface roughness in wire electrical discharge machining of Inconel 718 material. The application of his research work is helpful in in aerospace, tool and die, and automobile industries in machining of nickel alloys.[5]

- A.R.Sivaram et. al. investigate the effects of pulse on time, pulse off time and wire feed rate in EDM performance on material removal rate. Rough cutting operation in wire EDM is treated as a challenging one because improvement of more than one performance measures viz. Metal removal rate (MRR), surface finish & cutting Width (kerf) are sought to obtain precision work. In this paper, using Taguchi experimental design, significant machining parameters affecting the performance measures are identified as pulse on time, pulse off time and wire feed rate.[6]
- Barun Kumar et. al. has investigate and optimize the process parameters of Wire EDM by Grey relational method. For this, D2 steel work piece has been selected. D2 Die steel is an air hardening, high carbon, and High chromium tool steel. Input process parameters that are taken into consideration are Wire feed rate, Pulse on time, Pulse off time, Peak current, and Servo voltage. Output parameters are Material removal rate, Kerf width, Surface roughness. They used Taguchi methodology of L18 orthogonal array for design of experiment. They concluded that Pulse on time is the greatest effect on MRR and surface roughness compare to other parameters. Servo voltage has little effect on SR and kerf width but it has more effect over MRR.[7]

IV. EXPERIMENTAL SETUP

The experimental work is carried out on Wire cut EDM (ELEKTRA MAXICUT 734) machine as shown in the figure 3, of T-42 HSS with 10% Cobalt by varying machine parameters.

Figure 3. ELEKTRA MAXICUT 734 Wire cut EDM

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A. WORKPIECE MATERIAL

T-42 HSS with 10% Cobalt plate has been used as a work piece material for the present experiments. The material has several applications like turning and milling tools for roughing and finishing work, wood working tools, highly stressed cold work tools, tool bits. The work piece material is used of MIRANDA with dimension 3.18x19.05x152.04mm

Table 1. Chemical Composition of T-42 HSS with 10% Cobalt

Chemical Composition (in %)											
	C	**Si**	**Mn**	**P**	**S**	**Cr**	**Mo**	**V**	**W**	**Co**	**Ni**
T-42	1.4	0.4	0.4	0.35	0.35	4.5	3.5	3.25	9.5	10	0.4

B. SELECTION OF ORTHOGONAL ARRAY AND PARAMETER ASSIGNMENT

For the present work four process parameter are selected as pulse on time (T_{on}), pulse off time (T_{off}), peak current (I_p), spark voltage (S_v) each at three levels have been decided. To find he true behaviour of response factor these parameter are considered at three levels.

Table 2: Process Parameter and their Levels

Parameter	Symbol	Unit	Level		
			Level 1	level 2	Level 3
Pulse on time	Ton	µs	2	3	4
Pulse off time	Toff	µs	3	4	5
Servo voltage	Sv	V	60	65	70
Peak current	Ip	A	1	2	3

Table 3: Fixed Parameters

Parameter	Fixed value
Cutting tool	Brass coated wire
Diameter of wire	0.25mm
Dielectric fluid	Di-ionised water
Conductivity of dielectric	40mho
wire speed	5 m/min
Dielectric flow	40 lit/min
Wire tension	9.6N

In the present experiment there are three levels and four factors (process parameter). It mean the total number of experiments become 81 (3^4). The design of orthogonal array is formed for OA L_9 (3^4) using Mintab18 software. This software has directly given the best fit L_9 experiment is reduced to nine instead of eighty one. Table 4 shows the Taguchi orthogonal array L_9, using this values experimentation is performed.

Table 4: Taguchi Orthogonal Array L9

Ton	Toff	Sv	Ip
2	3	60	1
2	4	65	2
2	5	70	3
3	3	65	3
3	4	70	1
3	5	60	2
4	3	70	2
4	4	60	3
4	5	65	1

V. RESULT & DISCUSSIONS

A. Experiment for MRR

The experiment is carried out for MRR as response factor with respect to the parameters formed in Taguchi orthogonal array in Table 4. The results for MRR is determined are shown in the Table 5

Table 5: Result table for MRR

Ton	Toff	Sv	Ip	MRR
2	3	60	1	0.295
2	4	65	2	0.300
2	5	70	3	0.320
3	3	65	3	0.325
3	4	70	1	0.315
3	5	60	2	0.319
4	3	70	2	0.321
4	4	60	3	0.345
4	5	65	1	0.300

B. Analysis

For the response factor (MRR) determined in Table 5; Taguchi analysis is carried out and mean and signal to noise ratio is formed. The values of signal to noise ratio and mean for MRR is determine using Minitab 18 software. For material removal rate (MRR) whose larger-is-better for work optimisation work. The S/N ratio is calculated by the logarithmic transformation of loss function as in the Eq (1)

$$S/N\ ratio= -10 \log_{10} [\ 1/n\sum^{n}_{i=1} 1/y_i^2] \ ....Eq(1)$$

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Table 6: Value of S/N ratio and Mean for MRR

Ton	Toff	Sv	Ip	MRR		
				MRR*	S/N ratio	MEAN
2	3	60	1	0.295	-10.6036	0.295
2	4	65	2	0.30	-10.4576	0.3
2	5	70	3	0.32	-9.897	0.32
3	3	65	3	0.325	-9.76233	0.325
3	4	70	1	0.315	-10.0338	0.315
3	5	60	2	0.319	-9.92419	0.319
4	3	70	2	0.321	-9.8699	0.321
4	4	60	3	0.345	-9.24362	0.345
4	5	65	1	0.3	-10.4576	0.3

C. Response Tables

Table 7: Response Table for Signal to Noise Ratios

Level	Ton	Toff	Sv	Ip
1	-10.319	-10.079	-9.924	-10.365
2	-9.907	-9.912	-10.226	-10.084
3	-9.857	-10.093	-9.934	-9.634
Delta	0.462	0.181	0.302	0.731
Rank	2	4	3	1

Table 8: Response Table for Means

Level	Ton	Toff	Sv	Ip
1	0.3050	0.3137	0.3197	0.3033
2	0.3197	0.3200	0.3083	0.3133
3	0.3220	0.3130	0.3187	0.3300
Delta	0.0170	0.0070	0.0113	0.0267
Rank	2	4	3	1

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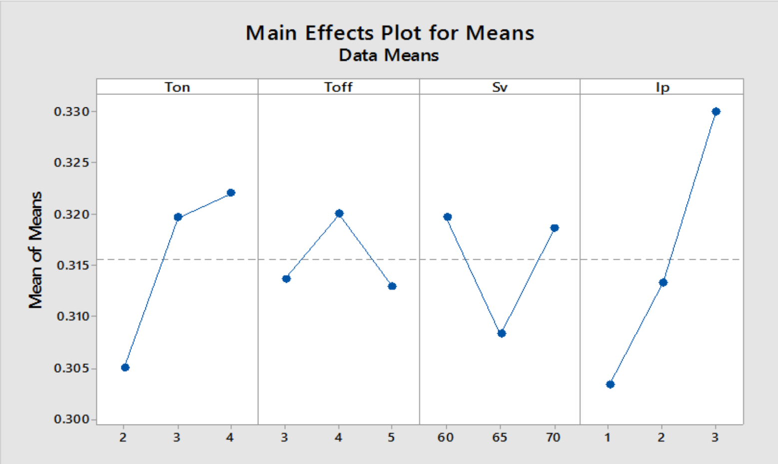

Figure 4. Main effect plot for mean for MRR

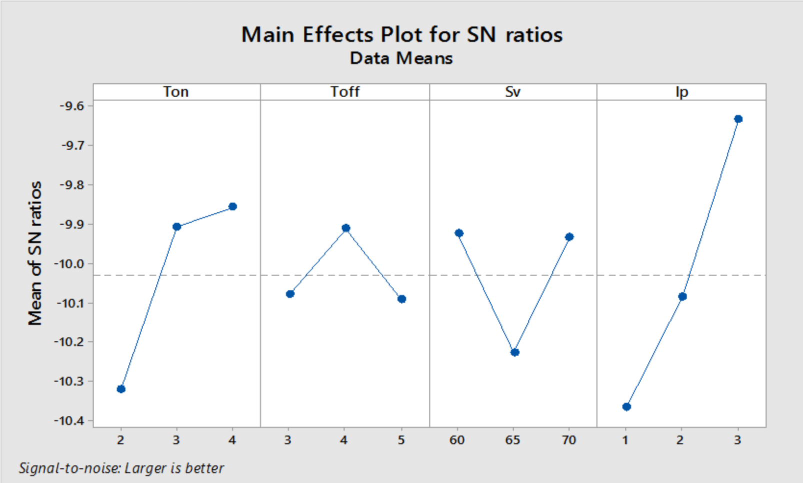

Figure 5. Main Effect plot for S/N ratio for MRR

D. RESULT

Figure 4 and 5 shows the graphs for mean and S/N ratio for MRR. As the graph denotes the larger-is-better for MRR, Table 9 shows the optimal parameter for material removal rate for T-42 HSS with 10% Cobalt material.

Table 9: Optimal parameter for MRR

Pulse on time	4µs
Pulse off time	4µs
Servo voltage	65V
Peak current	3A

VI. CONCLUSION

This research work has presented an investigation on the optimisation and the effect of response parameter on the MRR in Wire cut EDM for -42 HSS with 10% Cobalt material. With the use of Taguchi analysis we have determine the level of importance of machining parameters on the MRR. According to Taguchi analysis for MRR Peak current (I_p) is the most significant factor because it is having Rank 1 then having Rank 2 of Pulse on time (T_{on}) and Rank 3 for Servo voltage (S_v) and Rank 4 pulse off time (T_{off}) are less effective factors in the case of MRR. And predicted optimal setting is shown in Table 9.

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