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Experimental Investigation of Process Parameters Using Molybdenum Wire on Tungsten Carbide in Wire Cut EDM

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ABSTRACT

Wire Electric discharge machine is one of the most commonly used machine which is employed in machining of conductive metals of any hardness or that are difficult or impossible to cut with traditional methods. The objective of the present study is to study the effect of different process parameters viz. peak current, pulse on time, pulse off time and wire feed rate on the response variables such as kerf width using Tungsten carbide as a workpiece and molybdenum wire as electrode (0.18 mm diameter). Taguchi design methodology has been chosen for design of experiment and L9 orthogonal array has been selected for present study. The S/N ratio analysis is used for selecting the optimum parameter level combination for achieving the minimum kerf width in WEDM. Analysis of variance has been used to calculate percentage contribution of factors & to find the significant process parameters and their effect on the response variables.

Keywords-: ANOVA, Design of experiments, Kerf width, S/N Ratio, Taguchi method, Tungsten carbide, Wire electrical discharge Machining

I. INTRIDUCTION

Modernization of mechanical industry has lead to the increase in demand which specializes in cutting complex shapes and geometries of conductive metals of any hardness that are difficult or impossible to cut with traditional machining method. Wire cut electro discharge machining (WEDM), a form of EDM, is a non-traditional machining method which is employed in machining of conductive or hard metals. Non-traditional machining processes like Electro discharge machining (EDM) and wire electro discharge machining (WEDM) plays important role in precision manufacturing industries like automobile, aerospace and sheet metal industries. Especially for the manufacturing of punch, dies, jigs and fixtures. The non-contact machining technique has been continuously evolving from a mere tool and dies making process to a micro-scale application machining alternative attracting a significant amount of research interests.WEDM has been defined as the process of material removal of electrically conductive materials by the thermo-electric source of energy. It is the process of material removal by controlled erosion through a series of repetitive sparks between electrodes, i.e. work piece and tool. In wire EDM a very thin wire serves as the electrode. The wire is slowly fed through the material and the electrical discharges actually cut the work piece. Wire electrode usually made of thin copper, brass, molybdenum or tungsten of diameter 0.05-0.30 mm, which transforms electrical energy to thermal energy, is used for cutting materials. The wire is stored and wound on a wire drum. The wire is continuously fed from wire drum which moves though the work piece and is supported under tension between a pair of wire guides located at the opposite sides of the work piece. During the WEDM process, the material is eroded ahead of the wire and there is no direct contact between the work piece and the wire, eliminating the mechanical stresses during machining. Also the workpiece and the wire electrode (tool) are separated by a thin film of dielectric fluid that is continuously fed to the machining zone to flush away the eroded particles. Wire EDM is usually performed in a bath of water.The wire itself does not actually touch the metal to be cut; the electrical discharges actually remove small amounts of material and allow the wire to be moved through the work piece

II. EXPERIMENTAL WORK

This section describes the experimental setup, explains the method of conducting experiments, and design of experiment based on Taguchi method.

A. Experimental set up

The Wire electric discharge machining (WEDM) of Tungsten carbide has been carried out in an 'Ezeecut Plus' Wire Electric Discharge Machine. The present work will be conducted on a WEDM by using Tungsten carbide as a work piece material and Molybdenum wire (dia 0.18 mm) as a electrodes material to investigate the effect of input parameters peak current, pulse on time, pulse off time, wire feed rate on kerf width.

Figure 1 shows that arrangement of wire cut EDM machine the experimental data based on the DOE were collected to study the effect of various machining parameters of the EDM process.

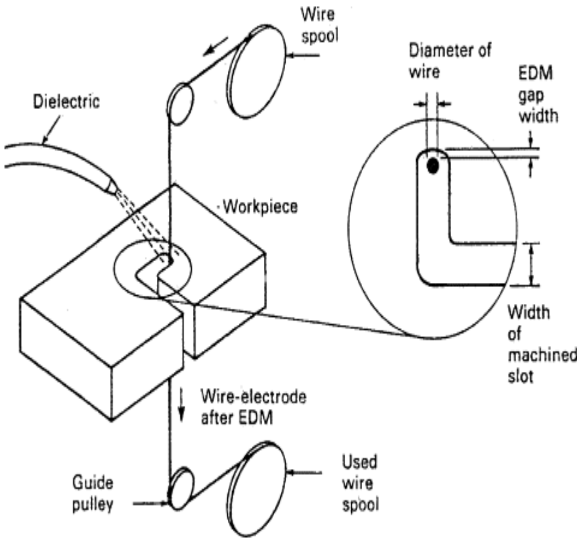

Fig. 1 Experimental setup

B. Experimental procedure

The experiments were conducted on Tungsten carbide (94%tungsten &6% cobalt) material as a work specimen. The work piece is in the form of plate having dimensions 76mm x 40 mm x 13mm. molybdenum wire (dia 0.18mm) is used as tool. and de-ionized water as a dielectric fluid.The kerf width of the workpieces were measured by a 'Trimos' Measuring instrument.

C. Design of experiments

Experiments were designed using Taguchi method which uses an OA to study the entire parametric space with alimited number of experiments. In present research four process parameter (factors) chosen such as Pulse on Time, Pulse off Time, Peak Current and Wire feed rate. All of them were set at three different levels. Optimization of process parameters is done to have great control over quality, productivity and cost aspects of the process. Analysis of variance (ANOVA) is used to study the effect of process parameters on the machining process. The approach is based on taguchi method, the signal-to-noise (S/N) ratio and the analysis of variance (ANOVA) are employed to study the performance characteristics

I. Level Values of Input Factors

Sr No	Factors	Level		
		1	2	3
A	Pulse on Time (Ton)	30	35	40
B	Pulse off Time (Toff)	6	7	8
C	Wire feed rate (F)	90	95	100
D	Peak current (Ip)	1	2	3

Results obtained from experiment of kerf width are then transformed into smaller the better characteristics of S/N ratio and S/N ratio values are calculated, which are shown in table II.

II. Experimental Results & calculations of kerf width Based on L9 Orthogonal Array.

Sr no	Ton	Toff	F	Ip	Kerf width value (mm/min)	S/N Ratio (db)
E1	30	6	90	1	0.074	22.6153
E2	30	7	95	2	0.054	25.3521
E3	30	8	100	3	0.0705	23.0362
E4	35	6	95	3	0.059	24.5829
E5	35	7	100	1	0.113	18.9384
E6	35	8	90	2	0.104	19.6593
E7	40	6	100	2	0.1005	19.9566
E8	40	7	90	3	0.0915	20.7715
E9	40	8	95	1	0.110	19.1721

D. SIGNAL TO NOISE RATIO

If the nominal value for a characteristic Y is the best for the user, then the designer should maximize the S/N ratio

$$n = 10 \log_{10} (\text{ybar}^2/s^2)$$

Where,

$$\text{ybar} = [\frac{1}{n}\sum_{i=1}^{n} y_i / n]$$

Where the objective optimal value is smaller, the Smaller-the-Better (SB) method applies, such as in surface roughness and kerf width.

$$n = -10\log [\frac{1}{n}\sum_{k=1}^{n} y_k^2]$$

Where the objective optimal value is larger, the Higher-the-Better (HB) method applies, such as in material removal rate.

$$n = -10\log [\frac{1}{n}\sum_{k=1}^{n} 1/y_k^2]$$

Regardless of the category of the performance characteristic, a larger S/N ratio corresponds to better performance characteristic. Therefore, the optimal level of the process parameters is the level with the highest S/N ratio.

E. Confirmation Experiment

The final step in Taguchi's design of experiment (DOE) process is the confirmation experiment. The purpose of the confirmation experiment is to validate the conclusions drawn during the analysis phase. The confirmation experiment is performed by conducting a test with specific combination of factors and levels previously evaluated. In this study, after determining the optimum levels, a new experiment is designed and conducted with optimum levels of the machining parameters. The final step is to predict and verify the improvement of the performance characteristics. The predicted S/N ratio using the optimal levels of the machining parameters can be calculated as in the following Eq.

$$\eta_{opt} = \eta_m + \sum_{j=1}^{k} (\eta_j - \eta_m)$$

Here, n*opt* is the predicted optimal S/N ratio, is *nm* the total mean of the S/N ratios, *nj* is the mean S/N ratio at the optimal levels and k is the Number of main design parameters that affect the quality characteristics.

III. ANALYSIS AND DISCUSSION:

I. Response Table for Signal to Noise Ratios for Kerf width.

Level	Pulse-on Time (T_{on})	Pulse-off Time (T_{off})	Wire feed rate (F)	Peak current (Ip)
1.	24.3647	23.0068	21.5230	20.7102
2.	21.5902	22.2623	23.7081	22.2429
3.	20.4271	21.1128	21.1507	23.4289
Delta	3.9376	1.894	2.5574	2.7187
Rank	1	4	3	2

II. Analysis Of Variance (ANOVA) for kerf width.

Sources	D.O.F	Sum of Squares	Mean square	% Contribution
T_{on}	2	24.7874	12.2754	46.4537
T_{off}	2	5.4631	2.7315	10.3369
F	2	11.4526	5.7263	21.6699
Ip	2	11.1471	5.5735	21.0918
Total	8	52.8502		

IV. Optimal parameters combination:

Verification of experiment is carried out optimal combination.From optimal parameter combination predicted values are calculated and the values are compared with experimental values got after verification experiment.

I. Optimal parameters combination

Factor	*Optimal combination*	*Predicted value*	*Experimental value*
Kerf width	*A, B1, C2, D3*	0.0614	0.0315

EFFECT OF INPUT FACTORS ON KERF WIDTH:

Following Fig shows the effect of each parameter on kerf width (KW), which is shown in Fig A to Fig D

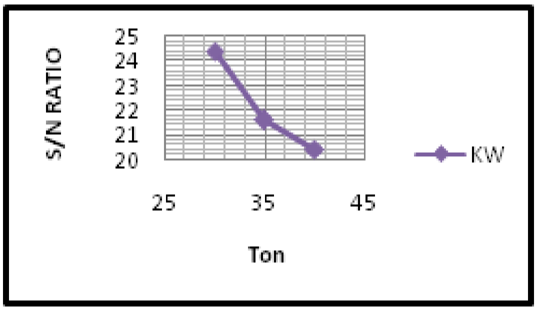

Fig A:S/N Ratio Vs Ton

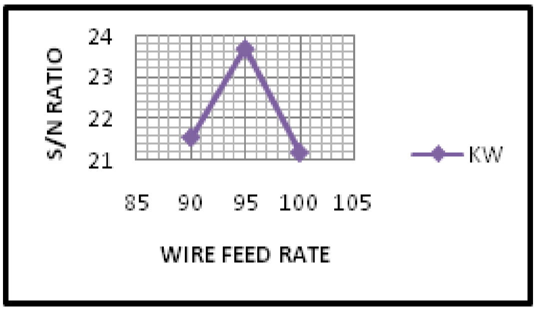

Fig C:S/N Ratio Vs wire feed rate

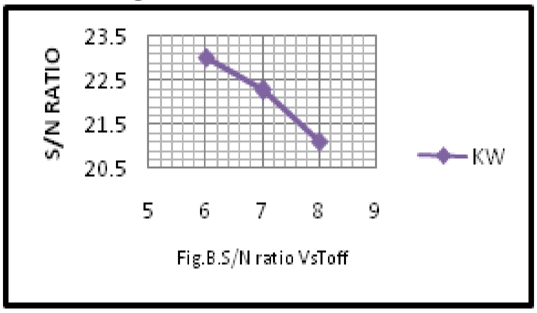

Fig B:S/N Ratio Vs Toff

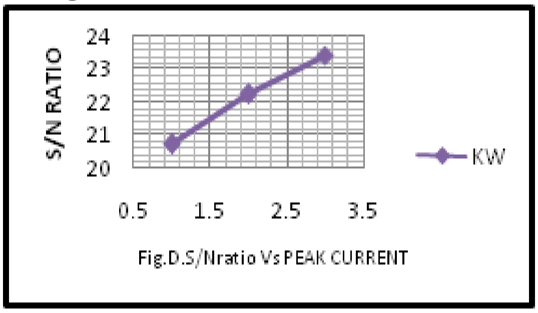

Fig D:S/N Ratio Vs Peak current

V. CONCLUSION

In machining of Tungsten carbide material by wire electric discharge machining, the Following conclusions may be drawn based on the experimental observations:-

In the investigation of effect of machining parameters on the kerf width in WEDM operations. S/N ratio value is used to select the optimal parameters combination for minimization of kerf width.The level of importance of the machining parameters on the kerf width is determined by using ANOVA.Based on ANOVA method, the highly effective parameters on, kerf width were found.

- Pulse-on time (T_{on}), Peak current (Ip) and wire feed rate are the most significant factors to the kerf width while the and pulse off time (Ton) are the less significant factors to the kerf width.
- Larger the machining time larger the kerf value.

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