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Engineering

AN EXPERIMENTAL INVESTIGATION OF WIRE- EDM FOR ALUMINUM 7075-T6

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ABSTRACT Wire electrical discharge machining (WEDM) is a specialized thermal machining process which is capable of accurately machining parts with varying hardness or complex shapes, which have sharp edges that are very difficult to be machined by the conventional machines. This practical technology of the WEDM process is based on the conventional EDM sparking factor utilizing the widely accepted non-contact technique of material removal. It can machine anything that is electrically conductive regardless of the hardness, from relatively common materials such as tool steel, aluminum, copper, and graphite, to exotic space-age alloys including has alloy, wasp alloy, Inconel, titanium, carbide, polycrystalline diamond compacts and conductive ceramics. Parts that have complex geometry and tolerances don't require you to rely on different skill levels or multiple equipment. Most work pieces come off the machine as a finished part, without the need for secondary operations

KEYWORDS : Zinc coated wire, Tungsten wires, MRR, DOE, Kerf Width, and SR

I. INTRODUCTION

The demands for alloy materials having high hardness, toughness and impact resistance are increasing today in the growth of mechanical industry.one of the important non-traditional machining processes is Wire Electro Discharge machining (WEDM), used for machining difficult to machine materials like composites and inter-metallic materials. WEDM process with a thin wire as an electrode transforms electrical energy to thermal energy for cutting materials. With this process alloy steel, conductive ceramics and aerospace materials can be machined irrespective to their hardness and toughness. Furthermore, WEDM is capable of producing a fine, precise, corrosion and wear resistant surface. Increased use of newer and harder materials like titanium, hardened steel, high strength temperature resistant alloys, fiber-reinforced composites and ceramics in aerospace, nuclear, missile, turbine, automobile, tool and die making industries, a different class of modern machining techniques such as Wire Electrical Discharge Machining (WEDM) have emerged. These techniques satisfy the present demands of the manufacturing industries such as better finish, low tolerance, higher production rate, miniaturization etc.

It can machine anything that is electrically conductive regardless of the hardness,from relatively common material. Parts that have complex geometry and tolerances don't require you torely on different skill level so multiple equipments. Most work pieces come off the machine as a finished part, without the need for secondary operations.

II. WORKING PRINCIPLE OF WIRE-EDM

A model of Wire EDM is shown in figure 1.In Wire EDM, the conductive materials are machined with a series of electrical discharges (sparks) that are produced between an accurately positioned moving wire (the electrode) and the workpiece. High frequency pulse so alternatingor direct current is discharged from the wire to the work piece with a very small spark gap through an insulated dielectric fluid (water).Wire EDM uses a travelling wire electrode that passes through the work piece. The wire is monitored precisely by a computer-numerically controlled (CNC) system. Many sparks can be observed tone time. This is because actual discharges can occur more than one hundred thousand times per second, with discharge sparks lasting in the range of 1/1,000,000 of a second or less. The volume of metal removed during this short period of spark discharge depends on the desired cutting speed and the surface finish required.

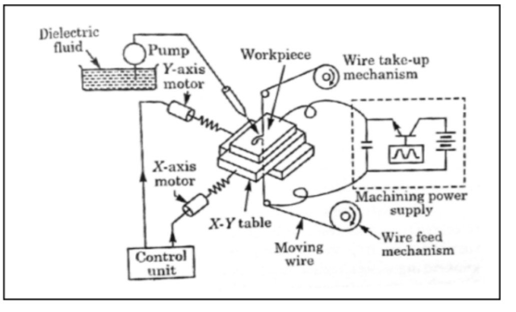


Fig. 1 WEDM Process

Fig.2: Wire EDM model

The most important performance measures in WEDM are metal removal rate, surface finish, and cutting width. They depend on machining parameters like discharge current, pulse duration, pulsefrequency, wirespeed, wire tension and dielectric flow rate. Among other performance measures, the kerf, which determines the dimensional accuracy of the finishing part, is of extreme importance. The internal corner radius to be produced in WEDM operations is also limited by the kerf. The gap between the wire and work piece usually ranges from 0.025 to 0.075 mm and is constantly maintained by a computer controlled positioning syste

III. OBJECTIVE

Encouraging for the use of aluminum Alloy-7075 instead of Aluminum alloy-6061 due to its less wear resistant Property. Finding out the best suitable wire material for machining Aluminum alloy-7075 depending upon requirements such as Surface Roughness, MRR which directly affects quality and machining time.

IV. LITERATURE REVIEW

Cyriac et. al. (2015), optimized the Wire-Cut EDM parameters of EN 24 steel by using Taguchi method.The process parameters selected for this experiment were pulse on time, pulse off time, current and speed. In this experiment the effect of above mentioned process parameters was observed on surface roughness. The design of experiment was based on Taguchi L16 orthogonal array. Analysis of variance (ANOVA) was used by the authors to find out the most significant parameter that affects the surface roughness. Further, the regression analysis was carried out to generate a mathematical model of surface roughness. From results, authors observed that current has major influence on surface roughness followed by pulse on time, pulse off time and cutting speed.

Pujari shrenivas rao, koona ramaji beela satyanarayana [2] studied the influence of Wire EDM parameter for Surface Roughness, MRR, and White layer machining of Aluminum Alloy. All the machining operation are conducted on ULTRA Cut 843/ ULTRA Cut f2 CNC wire EDM. Process Characterization is made by using ANOVA to identify the key input variables that affects SR and MRR. In which surface roughness measurements are done using a stylus-type profilometer. The cutting speed values which are displayed on the monitor of machine tool are taken for calculation of MRR using the equation MRR **= V_C *$_B$ * H MM^3/MIN**. In which they concluded that parameters pulse on time, peak current and spark gap voltage have shown significant effect on booth SR and MRR but different in optimum levels wire tension in SR and pulse off time and servo feed rate in MRR with a high regression coefficient value.

Rao and Sarcar [3] studied the influence of optimal parameters on cutting speed, surface roughness, spark gap, and material removal rate (MRR). He evaluated the optimal parameters such as discharge current, voltage at rated wire speed and tension for brass electrode of size 5-80mm. Mathematical relation was developed for cutting speed, spark gap and MRR. Effect of wire material on cutting Criteria was also evaluated for brass work piece with four wires of different copper percentages. This study is useful for evaluating cutting time for any size of job and to set parameters for required surface finish for high accuracy of cutting. Mathematical relations are helpful for estimating cutting time, custom machining, process planning and accuracy of cutting for any size of job within machine range. Results obtained are helpful for quantification of parameters for quality cuts. Also, results are useful in manufacturing wire EDM system for die and tool steel electrodes.

Nagaraja et. al. (2015), optimized the control parameters for metal matrix composite in Wire-Cut EDM. The bronze alumina (Al_2O_3) metal matrix composite was used as a work piece material. The cutting parameters considered in this experimental study were pulse on time, pulse off time and wire feed rate. Material removal rate and surface roughness were the performance parameters for this study. The experimental layout was based on Taguchi L9 orthogonal array. Further, the analysis of variance (ANOVA) was used to analyze the effect of each cutting parameter on surface roughness and material removal rate. Authors concluded that; wire feed rate was the most significant parameter for surface roughness. As the pulse on time increases the surface roughness also increases.

S.B. Prajapati, N.S.Patel, V D Asal [5] studied the effectto process parameter like Pulse ON time, Pulse OFF time, Voltage, Wire Feed and Wire Tension on MRR, SR, Kerf and Gap current. Output parameters of Wire EDM of AISIA2 Tool Steel are predicted by using Artificial Neural Network (ANN). ANN was founded a powerful tool for data prediction and it gives agreeable result when Experimental and Predicted Data were compared. Taguchi method is used for Design of Experiment. The control factors considered for the study are Pulse-on, Pulse-off, Bed speed and Current. Three levels for each control factor were used. Based on number of control factors and their levels, L27 orthogonal array (OA) was selected for data collection. From Comparison of Experimental result and ANN Predicted result it was found that they were very close and error was very less. The maximum error is 0.14.ANN is powerful technique for prediction of process parameters giving very accurate result.

Mathew et. al. (2014), found out the optimal process parameter setting of Wire-Cut EDM on SS 304. The material removal rate, surface roughness and dimensional deviation were the performance parameters for the optimization of pulse on time, pulse off time, servo voltage, wire feed, wire tension and dielectric pressure. The layout of experiment was based on Taguchi's L27 orthogonal array. Analysis of variance (ANOVA) was used to determine the optimum machining parameters for material removal rate, surface roughness and dimensional deviation. Authors concluded that all the parameters except wire feed and wire tension, significantly affects the material removal rate, surface roughness and dimensional deviation. The results showed that as the pulse on time increased, the MRR and SR also increased.

V. EXPERIMENTAL SET UP

Material to be used as work piece: - ALUMINUM 7075 T6. Electrode to be used: - Soft brass wire, ½ hard brass wire, ½hard zinc coated wire all of 0.25 mm diameter.

Full factorial method is used for DOE.A .Box-Behnken Design for 3 Level and 4 factors Design is used for selection the Total Number of Experiment Runs.

Table 1. Input parameters

Input Parameters	Output Parameters
Wire Tension (Kg)	Material Removal Rate (mm/min)
Wire Speed (m/min)	Surface Roughness (µm)
Pulse Width (µsec)	Kerf Width (mm)
Wire Material	

Table 2. Parameters Range

Factors	Level 1	Level 2	Level 3
Wire Speed m/min)	6	9	12
Wire Tension (Kg)	0.8	1.1	1.4
Pulse Width	0.8	1	1.2
Wire material	0	-1	1

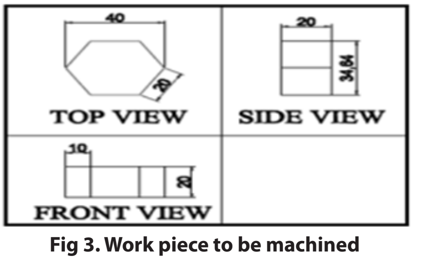


Fig 3. Work piece to be machined

Table 3. DOE

Sr no.	WS	WT	(A)	WM	MRR (mm^2/min)	SR (µm)	Kerf (mm)
1	6	0.8	1	0	69.2	3.25	0.35
2	12	0.8	1	0	78.5	3.3	0.345
3	6	1.4	1	0	100.4	3.1	0.35
4	12	1.4	1	0	68.1	3.3	0.375
5	9	1.1	0.8	-1	93.5	2.5	0.31
6	9	1.1	1.2	-1	75	3	0.315
7	9	1.1	0.8	1	74.6	2.9	0.33
8	9	1.1	1.2	1	98.1	3.35	0.345
9	6	1.1	1	-1	100.3	2.85	0.325
10	12	1.1	1	-1	67.4	3.15	0.35
11	6	1.1	1	1	94.2	3.1	0.355
12	12	1.1	1	1	98.6	2.95	0.337
13	9	0.8	0.8	0	74.6	2.8	0.34
14	9	1.4	0.8	0	73.8	2.8	0.335
15	9	0.8	1.2	0	35.9	3.2	0.365
16	9	1.4	1.2	0	69.2	3.4	0.325

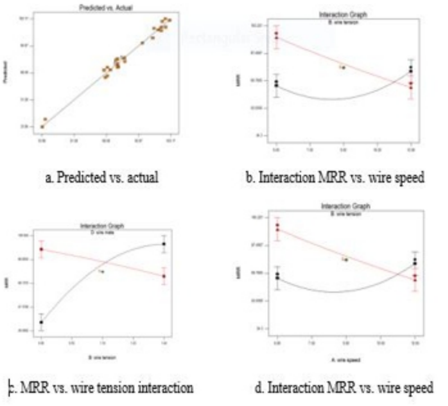
17	6	1.1	0.8	0	88	2.5	0.36
18	12	1.1	0.8	0	70.8	2.75	0.34
19	6	1.1	1.2	0	96.5	3	0.36
20	12	1.1	1.2	0	74.6	3.3	0.375
21	9	0.8	1	-1	34.3	2.9	0.346
22	9	1.4	1	-1	102.6	2.85	0.345
23	9	0.8	0.8	1	98.1	3.15	0.35
24	9	1.4	1	1	74.6	3.1	0.325
25	9	1.1	1.2	0	78.2	3	0.335
26	9	1.1	1	0	82.2	3	0.365
27	9	1.1	0.8	-1	78.2	3	0.34
28	9	1.1	1	0	58.2	3	0.355
29	9	1.1	1	-1	78.2	3	0.345

Where WS = Wire Speed, WT= Wire Tension, A = Pulse Width WM= Wire Material.

VI. Result

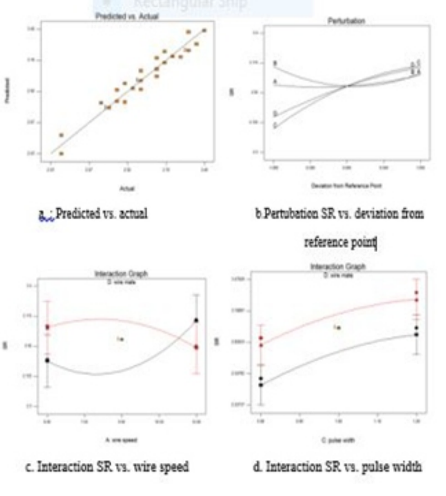
The below 6(a) to 6(c) graphs are generated using design expert software version 6 to show the different interaction between MRR, SR and Kerf width and also show predict vs actual graph

6(a). Interaction With MRR



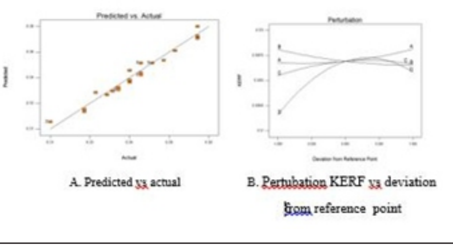
a. Predicted vs. actual
b. Interaction MRR vs. wire speed
c. MRR vs. wire tension interaction
d. Interaction MRR vs. wire speed

6(b). Interaction With SR



a. Predicted vs. actual
b. Pertubation SR vs. deviation from reference point
c. Interaction SR vs. wire speed
d. Interaction SR vs. pulse width

6(c) . Interaction With Kerf



A. Predicted vs actual
B. Pertubation KERF vs deviation from reference point

VII. Conclusion

Thus for above observations we can conclude that Wire (Half hard coated) is desirable for maximum MRR and SR, but for minimum Kerf Wire (Soft brass) is desirable.

Kerf width is largely affect by pulse width in all the three wires.

Soft brass wires doesn't break which helps for continuous cutting as breakage of wire may lead to wire marks, increase cutting time and also increase the surface roughness.

Surface Roughness are affected by the combination of wire tension and pulse width, with both having maximum values highest is the roughness and with both having minimum value minimum is the roughness

VIII. FUTURE SCOPE

For researchers there is wide scope for analyzing and developing new technology. Many different types of wire material can be used for machining on a particular material and optimum parameters can be obtained. Also many different work piece materials that can be used for research are Tool Steels, Titanium alloys, EN series, Inconel, Nickel alloys, Aluminum alloys etc.

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