Volume : 3 | Issue : 5 | May 2014 • ISSN No 2277 - 8160

Research Paper | Engineering

An Experimental Effect of Soft Brass Wire on MRR, Kerf Width and Surface Roughness of AISI D2 Tool Steel In WEDM

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ABSTRACT *The recent upgradation of newer and harder materials have made the machining task in WEDM quite challenging. Thus for the optimum use of all the resources it is essential to make the optimum use of parameters to get the best output to increase the productivity. Many different electrode materials are available now days for decreasing the machining time. This paper enlightens on analysis of effect of soft brass wire on D2 Tool Steel in WEDM and magnifies on maximum MRR, and minimum Kerf width and surface roughness.*

KEYWORDS : brass wires, coated wires, MRR, Surface roughness, DOE, Full factorial

INTRODUCTION

Wire electrical discharge machining (WEDM) is an indispensable machining technique for producing complicated cut-outs through difficult to machine metals without using high cost grinding or expensive formed tools. Wire-cutting EDM is commonly used when low residual stresses are desired, because it does not require high cutting forces for removal of material.

It can machine anything that is electrically conductive regardless of the hardness, from relatively common materials such as tool steel, aluminium, copper, and graphite, to exotic space-age alloys including hastalloy, waspalloy, 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.

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 work piece. High frequency pulses of alternating or 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.

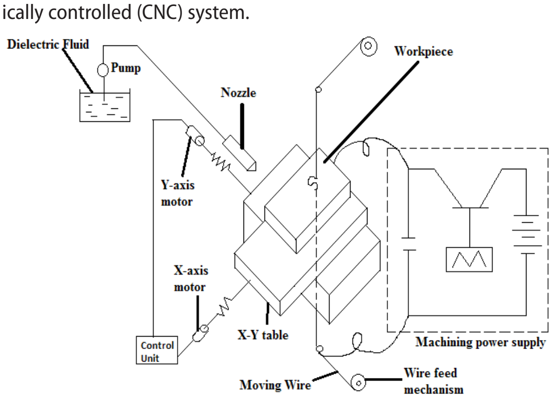

Fig. 1 Wire EDM model

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, pulse frequency, wire speed, 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 system.

LITERATURE REVIEW

S. B. Prajapati, N. S. Patel [1] evaluates the effect of pulse On-Off time, voltage, wire feed and wire tension on MRR, SR, kerf and gap current in Wire EDM. A series of experiments have been performed on AISI A2 tool steel in form of a square bar. Analysis of data optimization and performance is done by Response Surface Methodology (RSM).

Atul J. Patel, Prof. Satyam Patel [2] used Taguchi L9 orthogonal array to find out effects on AISI 304 Stainless Steel of thickness 10 mm in Wire EDM. Input parameters such as pulse On-Off time, wire tension and input power have been used to evaluate their influence on SR and MRR. Mathematical relations between input parameters and performance characteristics were established by the linear regression analysis method by using MINITAB software.

Rao and Sarcar [3] studied the influence of optimal parameters on cutting speed, SR, spark gap, and MRR. He evaluated the optimal parameters such as discharge current, voltage at rated wire speed and tension for brass electrode of size 5-80 mm. 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.

Nihat, Can, Gul [4] investigated on the effect and optimization of machining parameters on kerf and material removal rate (MRR) in WEDM operations. Experimental studies were conducted using different pulse duration, open circuit voltage, wire speed, and dielectric flushing pressure. The variation of kerf and MRR with machining parameters is mathematically modelled by using regression analysis method. Objective of minimum kerf together with maximum MRR was performed. The experimental studies were performed on a Sodick A320D/EX21 WEDM machine tool. CuZn37 Master Brass wire with 0.25mm diameter was used in the experiments. As work piece material, AISI 4140 steel (DIN 42CrMo4) with 200mm × 40mm × 10mm size was used.

S. B. Prajapati, N. S. Patel, V D Asal [5] studied the effect of process parameter like Pulse ON time, Pulse OFF time, Voltage, Wire Feed and Wire Tension on MRR, SR, Kerf and Gap current. 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.

Kuriakoseet. al. [6] carried out experiments with titanium and material removal rate (MRR) in wire electrical discharge machining (WEDM) operations. Based on ANOVA method, the highly effective parameters on both the Surface roughness and the MRR were found as open circuit voltage and pulse duration, whereas wire speed and dielectric flushing pressure were less effective factors. Optimization of the machining process first requires a mathematical model to be established to correlate the desired response and the process control parameters. Thereafter an optimization technique is applied to find optimal setting of the control parameters to derive the desired responses.

OBJECTIVE

Encouraging for the use of D2 Tool Steel instead of P20 Tool Steel due to its less wear resistant property.Finding out the effect of soft brass wire for machining D2 Tool Steel depending upon requirements such as SR, MRR which directly affects quality of machining and machining time.

EXPERIMENTAL SET-UP

Material to be used as work piece: - D2 Tool Steel.

Electrode used:- Soft brass wire of 0.25 mm diameter.

Variable input parameters: - Wire speed(m/min), wire tension(Kg), pulse width(μsec).

Hexagonal work piece has to be machined with each side of 20 mm where each side will be one run of DOE table.

Experiment has to be done on Charmilles Robofil CNC Wire – EDM.

Full factorial method is used for DOE.

A design in which every setting of every factor appears with every setting of every other factor is a full factorial design.

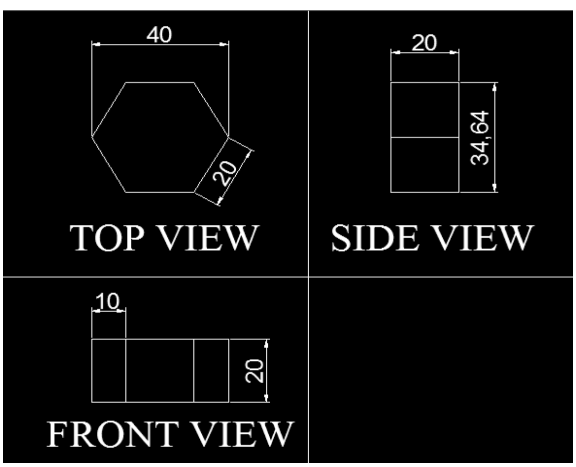

Fig. 2 Work piece design (All dimensions are in mm)

Factor	Level 1	Level 2	Level 3
Wire Speed (WS)	6	9	12
Wire Tension (WB)	0.8	1.1	1.4
Pulse Width (A)	0.4	0.8	1.2

Table 1 Factors with levels

From above experiment effect on output parameter: - MRR, SR and Kerf width are found.

Sr No.	WS	WB	A	SR	MRR	Kerf
1	9	0.8	0.4	1.8	27.3	0.28
2	9	1.4	1.2	3.2	89.7	0.3025
3	6	1.4	1.2	3.3	97.3	0.295
4	12	1.4	0.8	3	61.1	0.3
5	9	1.1	0.4	1.9	30.4	0.2825
6	6	0.8	0.4	1.7	25.6	0.29
7	12	0.8	1.2	3.4	93.8	0.325
8	9	1.1	0.8	2.5	67.4	0.3075
9	6	1.1	0.4	1.7	30.5	0.2675
10	6	1.1	0.8	2.9	69.6	0.26
11	6	1.4	0.8	3	67.1	0.27
12	6	1.1	1.2	3.1	93.3	0.325
13	12	1.1	0.8	2.8	70.2	0.27
14	12	1.1	0.4	2	32.4	0.2775
15	12	1.4	1.2	3.3	95.4	0.36
16	12	0.8	0.8	2.8	68.4	0.345
17	9	0.8	0.8	2.7	66.9	0.3525
18	9	1.4	0.8	2.7	70.2	0.3375
19	6	0.8	0.8	2.7	68.1	0.335
20	6	1.4	0.4	1.9	31.8	0.33
21	12	1.1	1.2	3.6	95.6	0.3275
22	12	1.4	0.4	1.9	27.7	0.3275
23	9	1.4	0.4	1.9	29.6	0.32
24	6	0.8	1.2	3.3	91.5	0.33
25	12	0.8	0.4	1.8	25.9	0.3125
26	9	0.8	1.2	3.4	87.9	0.34
27	9	1.1	1.2	3.4	93.5	0.3425

Table 2 Result table

Equations for output parameters from the results obtained :-

Equation for S.R

Surface Roughness (μm) = $0.70 - 0.140 A + 0.21 B + 4.05 C + 0.00988 A2 + 0.247 B2 - 1.11 C2 - 0.028 AB - 0.49 BC + 0.014 CA - 0.000 ABC$

Equation for M.R.R

MRR = $- 57.4 - 0.92 A + 71.2 B + 145 C + 0.120 A^2 - 25.0 B^2 - 41.3 C^2 - 1.44 AB - 1.4 BC + 0.24 CA + 0.07 ABC$

Equation for Kerf

Kerf Width = $0.244 + 0.0435 A - 0.343 B + 0.399 C - 0.00113 A2 + 0.267 B2 + 0.0278 C2 - 0.0204 AB - 0.389 BC - 0.0340 CA + 0.0330 ABC$

Where, A = Wire Speed
B = Wire Tension
C = Pulse Width

CONCLUSION

- Higher pulse width removes the material quickly with high cut speeds.
- Pulse width is the key factor as any changes in its value affects all the output factors.
- Surface Roughness is 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.
- Kerf width is largely affect by pulse width.
- With the increase in pulse width, soft brass wires doest break which helps for continuous cutting as breakage of wire may lead to wire marks, increase cutting time and also increase the surface roughness.

FUTURE SCOPE

For researchers there is wide scope for analysing 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, Aluminium alloys etc. Thus the best wire material with optimum parameters can be selected to obtain satisfying results for efficient and effective processing.

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