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A Review-An Experimental Effect of Electrode Material on MRR, Kerf width and Surface roughness of AISI D2 Tool Steel in WEDM

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

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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 reviews the various notable works in field of WEDM and magnifies on effect of electrode material of same diameter on MRR, Kerf width and surface roughness.*

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.

Many sparks can be observed at one 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.

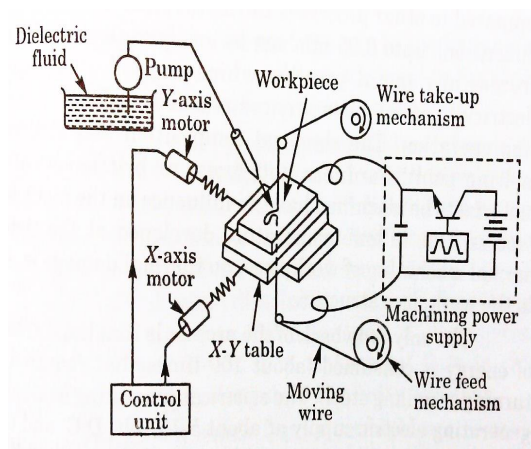

Fig. 1 Wire EDM model

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 parame-

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ters 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.

Aniza Alias, Bulan Abdullah, Norliana Mohd Abbas [6] aims to investigate the influence of feed rate on the performance of WEDM on Titanium Ti-Al-4V. Brass wire was employed as the electrode for the investigation. The best combination of machining parameter viz. machine feed rate (4 mm/min), wire speed (8 m/min), wire tension (1.4kg) and voltage (60V) were identified. The selection of parameters depends on the requirements based on a better surface roughness or a maximum material removal rate. Furthermore, this combination can contributes to increase production rates perceptibly by reducing machining time. The outcome of this study will help in improving the quality of products as well as minimizing the machining cost to realize the economic potential to the fullest.

Saurav Datta, Siba Sankar Mahapatra [7] experimented with six process parameters: discharge current, pulse duration, pulse frequency, wire speed, wire tension and dielectric flow rate; to be varied in three different levels. Data related to the process responses viz. material removal rate (MRR), roughness value of the worked surface and kerf have been measured for each of the experimental runs; which correspond to randomly chosen different combinations of factor setting. The work piece, a block of D2 tool steel with 200 mm × 25 mm ×10 mm size, has been cut 100 mm length with 10 mm depth along the longer length.

OBJECTIVE

Encouraging for the use of D2 Tool Steel instead of P20 Tool Steel due to its less wear resistant property. Finding out the best suitable wire material for machining D2 Tool Steel depending upon requirements such as SR, MRR which directly affects quality of machining and machining time. Also finding out optimum value and effect of input variable parameters such as wire tension, wire speed and injection pressure on Surface Roughness, Material Removal Rate and Kerf Width.

EXPERIMENTAL SET-UP

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

Electrode to be used :- Soft brass wire, ½ hard brass wire, ½ hard zinc coated wire all of 0.25 mm diameter./

Variable input parameters: - Wire speed, wire tension, injection pressure.

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. Three-level full factorial design is used. The three-level design is written as a 3^k factorial design. It means that k factors are considered, each at 3 levels. This is a design that consists of three factors, each at three levels. It can be expressed as a 3 x 3 x 3 = 27 designs for each wire.

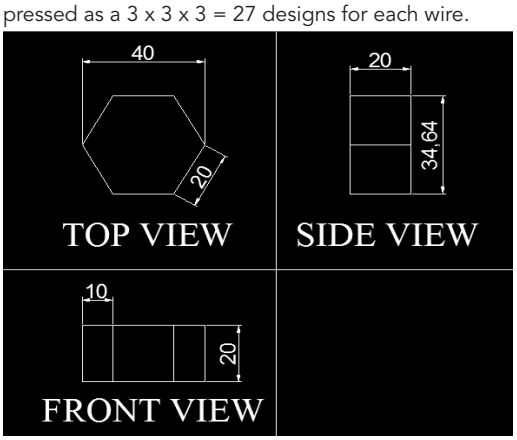

Fig. 2 Work piece design (All dimensions are in mm)

	Level 1	Level 2	Level 3
Wire Speed (WS)	5 m/min	10 m/min	15 m/min
Wire Tension (WB)	1 Kg	1.5 Kg	2 Kg
Injection Pressure (INJ)	1 Bar	2 Bar	4 Bar

Table 1 Factors with levels

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

CONCLUSION

From literature survey:-

1. For cutting rate and surface roughness, the pulse ON and pulse OFF time is most significant. The spark gape set voltage is significant for kerf.
2. Increase in Input power, value of surface roughness is increase. Increase in Pulse on time, value of material removal rate is increase.
3. Corresponding to minimum value of pulse off time the spark gap decreases with increase in dielectric pressure,

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whereas the spark gap increases with increase in dielectric pressure corresponding to maximum value of pulse off time.

4. As the machine feed rate increases, the kerf width decreases. Increasing machine feed rate, the MRR will increases simultaneously. Smoother surface can be obtained with low setting of machine feed rate.
5. It is found that SR tends to decrease significantly with decrease in IP and TON.

EXPECTED OUTCOME

The wire materials to be used include plain brass and coated wires. Thus it is likely that the coated wire will be more effective in terms of MRR and Surface roughness but with increased cost and high wear rate. Thus we may use ½ hard plain brass wire which performs reasonably well for the required application with optimized input parameters.

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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