Analysis and Study the Effects of various Control Factors of CNC-Wire Cut EDM for Al6063-T6 Using OFAT Approach

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Abstract - Wire electrical discharge machining (WEDM) is a non-conventional machining process which is widely used in machining of conductive materials. The applications of WEDM are in automobiles, aero-space, medical instruments, tool and die industries. in the present study analysis of effect of various control factors like Ton,Toff,Sv,Ip,Wf,Wt on checking the cutting rate of Al6063 is studied by using wire cut EDM and one factor time approach.AL6063 contain less carbon and higher toughness than the high carbon types that are more wear resistant. Shock resistant steels are used where heavy cutting or forming operations is required and chipping or breakage of high-carbon wear-resistant steels is a problem. The other big advantage of this study is to select the range of significant control factors for final experimentation.

Key words : Wire Electric discharge machining (WEDM) , OFAT (one factor time approach), Control Factors (like Pulse On-Time, pulse off time, Peak Current, servo voltage, wire feed and wire tension), Cutting rate (CR)

I. INTRODUCTION

Wire Electrical Discharge Machining (Wire-EDM) is an electro thermal production process in which a thin single strand metal wire in conjunction with de-ionized water (used to conduct electricity) allows the wire to cut through metal by the use of heat from electrical sparks. Due to the inherent properties of the process, wire EDM can easily machine complex parts and precision components out of hard conductive materials. Electrical discharge machining is frequently used to make dies and moulds conductive. The working principle of wedm is as shown in figure below.

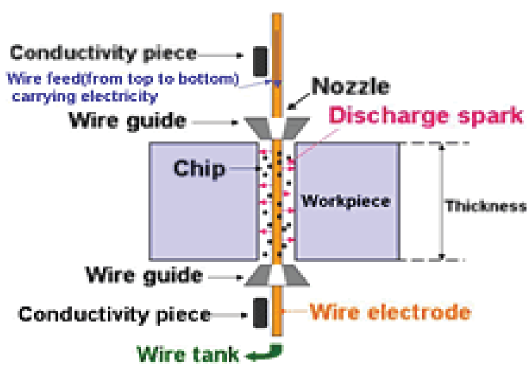

Fig 1.1: Mechanism of Material Removal In Wedm

Tosun et al. voltage, wire speed and dielectric fluid pressure was experimentally investigated in WEDM. Brass wire with 0.25 mm diameter and SAE 4140 steel with 10 mm thickness were used as tool and work-piece materials in the experiments, respectively. It is found experimentally that the increasing pulse duration, open circuit voltage and wire speed, increase the surface roughness whereas the increasing dielectric fluid pressure decreases the surface roughness. The variation of work-piece surface roughness with machining parameters is modelled by using a power function. The level of importance of the machining parameters on the work-piece surface roughness is determined by using analysis of variance (ANOVA).Yan and huang et al improved the machining accuracy by a closed-loop wire tension control system for a wire-EDM. PI controller and one-step-ahead adaptive controller are employed to investigate the dynamic performance of the closed-loop wire tension control system. In order to reduce the vibration of wire-tension during wire feeding, dynamic absorbers are added to the idle rollers of wire transportation mechanism. Experimental results indicate that the geometrical contour error of corner cutting is reduced with approximately 50% and the vertical straightness of a work-piece can be improved significantly. scott f. Miller et al Studied the WEDM of cross-section with minimum thickness and compliant mechanisms. Effects of EDM process parameters, particularly the spark cycle time and spark on-time on thin cross-section cutting of Nd–Fe–B magnetic material, carbon bipolar plate, and titanium are investigated. An envelope of feasible wire EDM process parameters is generated for the commercially pure titanium. The application of such envelope to select suitable EDM process parameters for micro feature generation is demonstrated. Scanning electron microscopy (SEM) analysis of EDM surface, subsurface, and debris are presented. Huang and Chang et al displayed the surface alloying behaviour of tempered martensitic stainless steel multi-cut with WEDM. Before machined with WEDM, the steel specimens were quenched at 1050□C and then tempered at 200□C, 400□C, and 600□C, respectively. The microstructure and surface morphology of the multi-cut surfaces were examined with scanning and transmission electron microscopes integrated with an energy-

dispersive X-ray spectrometer for chemical composition analysis. N.M. Abbas and bahari et al. studied that EDM process is based on thermoelectric energy between the work piece and an electrode. A pulse discharge occurs in a small gap between the work piece and the electrode and removes the unwanted material from the parent metal through melting and vaporizing. The electrode and the work piece must have electrical conductivity in order to generate the spark. mohammadi and karimi et at. The setting of machining parameters relies strongly on the experience of operators and machining parameter tables provided by machine tool builders. It is difficult to utilize the optimal functions of a machine owing to

there being too many adjustable machining parameters. H.Singh and Rohit Garg et al. found that the material removal rate (MRR) directly increases with increase in pulse on time and peak current while decreases with increase in pulse off time and servo voltage. They used ELECTRONICA SPRINTCUT WEDM as a machine tool and hot die steel (H-11) as work-piece. Jangra kamal et al presented the optimization of performance characteristics in WEDM using Taguchi Grey relational analysis. Process parameters were investigated using mixed L orthogonal array.GRA was applied to determine optimal L18 process parameters for optimization of multiple performance characteristics which were investigated during rough cutting operation in D-3 tool steel. U.Natarajan and yang et al. focuses RSM for the multiple response optimization in micro-end milling operation to achieve maximum metal removal rate (MRR) and minimum surface roughness. Aluminium block of 60×40×16 mm is used as the workpiece material and carbide end mill cutter of diameter 1 mm as the cutting

tool. N.Sharma and R. Sharma et al. optimized the process parameters for the cutting speed and dimensional deviation for high strength low alloy steel (HSLA) on WEDM. Response surface methodology was used for the modelling and multi-response optimization.

II. EXPERIMENTAL DETAIL

WEDM machine (S-35, Sparkonix) was used as the experimental machine in this study. A Brass Wire with a diameter of 0.025 mm was used as an electrode to erode a work piece of Al6063-T6 (flat plate). The gap between work piece and electrode was flooded with a moving dielectric fluid.

Fig 1.2: pictorial view of wedm machine

For WEDM, cutting rate is a desired characteristic and it should be as high as possible to give minimum machine cycle time leading to increased productivity. In the present study cutting rate and is mainly measures for an evaluation of job. The cutting which is directly displayed on the screen of the machine and is given units is in mm/min (Figure 1.4).

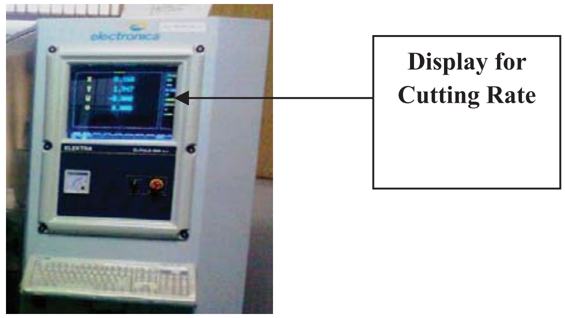

Figure 1.4: Set Up for Cutting Rate and Measurement

The purpose of the pilot experiments is to study the various changes of the WEDM control factors on performance measures such as Cutting Rate

The pilot experiments were performed on ELECTRONICA make SPRINTCUT 734 WEDM machine. Various input control factors varied during the experimentation are pulse on time, pulse off time, spark gap voltage, peak current, wire tension, wire feed. Apart from the parameters mentioned above following parameters were kept constant at a fixed value during the experimentation.

Work piece	**:**	**Al6063-T6**
Electrode (tool)	**:**	**0.25mmØ**
Work piece height	**:**	**12mm**
Cutting length	**:**	**78 mm**
Dielectric Conductivity	**:**	**20mho**
Dielectric temperature	**:**	**20-240C**

III. EXPERIMENTAL SET UP & METHODLOGY

The purpose of this study is analysing the effect of WEDM process parameters on response variable such as Cutting Rate. Also, it is intended to ascertain the ranges of different parameters required for the experimental design methodology used in this work. Investigation of the working range of the WEDM process parameters using one factor at a time approach (OFAT).i.e. fixing some parameters and vary individual parameters one by one with the response variable (cutting rate)

Effect of various control factors are analysed by performing various experiments with variation of input parameters.

First observation is made to check the Effect of Pulse on Time on Response Variable as:

IV. RESULT AND DISCUSSION

In the first set of experiment: - The pulse on time (Ton) is varied from 100 machine units to 131 machine units. The values of the other control factors are given as Toff = 31 unit; IP= 115 A SV =50V WT = 8 machine units; WF = 8 m/min; and SF = 2100 unit. The experimentally observed values of the response variables for different values of pulse on time are given in Table 1.1 The scatter plots of pulse on time versus response variables are shown in Figure 1.5.

Table 1.1 Experimental value of Ton vs CR

Range: (100-131)

Pulse on Time (µs)	Cutting Rate (mm/min)
100	0.73
104	1.03
116	2.05
120	2.09
128	2.3

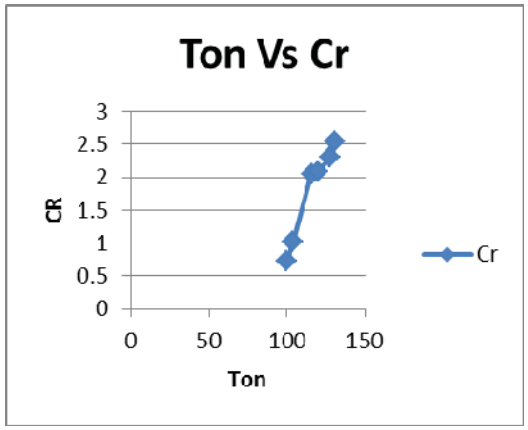

Figure 1.5: Effect of Pulse on Time on Cutting Rate.

The cutting rate increases with the increase in the pulse on time. This is due to the fact that with the increase in pulse on time the discharge energy increases, due to which CS increases also with the increase of Ton machining time increase. These findings are in agreement with some of researchers [Tarng, Y. S., Ma, S. C., Chung, L. K. (1995)].

In the second set of experiments: the pulse off time (Toff) is varied from 0 machine units to 60 machine units. The values of the other control factors are given as Ton = 116 unit; IP= 115 A SV =50V WT = 8 machine units; WF = 8 m/min; and SF = 2100 unit. The experimentally observed values of the response variables for different values of pulse off time are given in

Table 1.2 The scatter plots of pulse off time versus response variables are shown in Figure 1.6.

Table 1.2:Effect of Pulse OFF Time on CR

Range (0-60)

Pulse Off Time (µs)	Cutting Rate (mm/min)
10	2.45
15	2.33
31	2.12
40	1.44
46	0.87

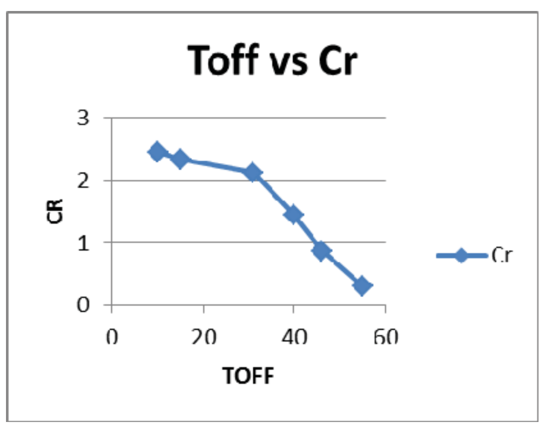

Figure 1.6: Effect of Pulse off Time on Cutting Rate.

With the increase in pulse off time, the cutting rate decreases. Due to decrease in spark energy. These findings are in agreement with some of researchers [Gwo-LianqChern and Ying-JengEngin in 2007].

In the third set of experiments: Effect of peak Current on Response Variable is calculated by considering following values:

The Peak Current is varied from 100 units to 200 units. The values of the other control factors are given as Ton=116 unit; Toff=31 unit, SV =50 V, WF=8 m/min, WT=8 machine unit and SF=2100 unit. The experimentally observed values of the response variables for different values of peak current are given in Table 1.3 The scatter plots of Peak Current versus response variables are shown in Figure 1.7

Table 1.4: Effect of Peak Current on CR

Range: (0-230)

Peak Current	Cutting Rate (mm/min)
100	0.63
110	1.13
120	2.52
140	2.96
180	3.2

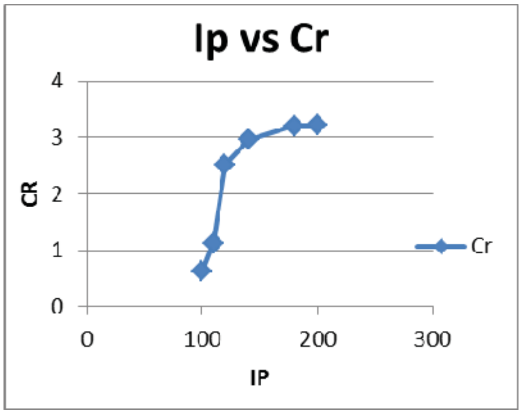

Figure 1.7: Effect of Peak current on Cutting Rate.

It has been observed that as the Peak current increases the value of cutting rate This is in line with one of the researcher [Gwo-LianqChern and Ying-JengEngin IN 2007].

In the fourth set of experiments: In the fourth set of experiments, the servo voltage is varied from 30 units to 85 units. The values of the other control factors are given as Ton = 116 unit; Toff = 31 A Ip = 115 A ;Wt = 8 machine unit ,Wf = 8 machine unit, SF = 2100 unit. The experimentally observed values of the response variables for different values of Servo voltage are given in Table 1.4 The scatter plots of pulse on time versus response variables are shown in Figure 1.8.

Table 1.5: Effect of Serco voltage on CR

Range: (0-99)

Servo voltage (SV)	Cutting Rate (mm/min)
30	2.18
35	2.12
50	2.04
60	1.58
70	1.39

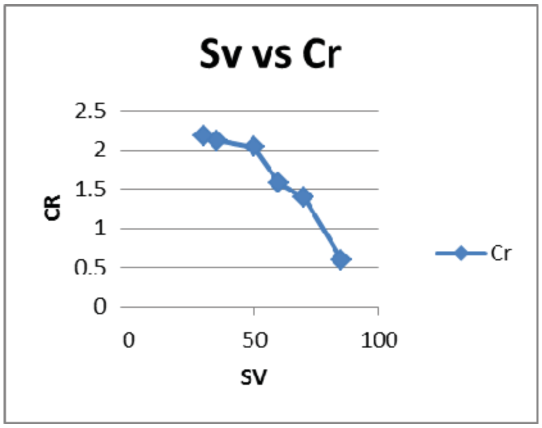

Figure 1.8: Effect of servo voltage on Cutting Rate.

It is observed that as the value of servo voltage increases, the value of cutting rate increases [Tarang et al (1994)].

In fifth set of experiments: The wire feed is varied from 7 units to 9 units. The values of the other control factors are given as Ton = 116 unit; Toff = 31,Ip= 115 A: SV =50V; WF= 8 machine unit and SF = 2100 unit. The experimentally observed values of the response variables for different values of Wire Feed are given in Table 1.6 The scatter plots of pulse on time versus response variables are shown in Figure 1.9.

Table 1.6 : Effect of wire feed on CR

Range: (0-15)

Wire Feed	Cutting Rate (mm/min)
7	2.15
7	2.15
8	2.15
8	2.15
9	2.15

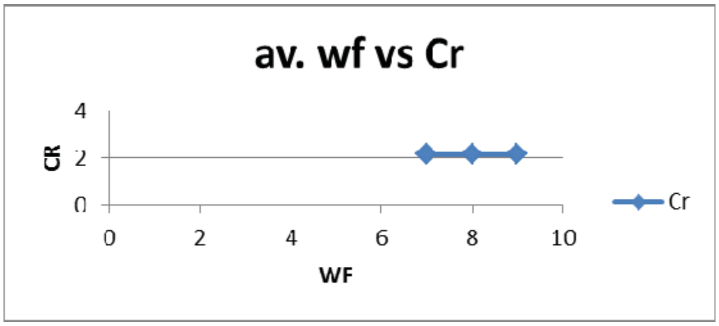

Figure 1.9: Effect of Wire Feed on Cutting Rate

The cutting rate remains practically constant with the increase in wire feed These finding are in line with a researcher [Hascalyk, A. and Caydas and U. (2004)]

In the sixth set of experiments:

the wire tension is varied from 7 units to 9 units. The values of the other control factors are given as Ton = 116 unit; Tofff = 31 ,Ip= 115 A: Sv =50V; Wf= 8 machine unit and Sf = 2100 unit. The experimentally observed values of the response variables for different values of Wire Tension are given in Table 1.7 The scatter plots of Wire Tension versus response variables are shown in Figure 1.11.

Table 1.7: Effect of wire tension on CR

Range: (0-15)

Wire tension	Cutting Rate (mm/min)
7	2.15
7	2.15
8	2.15
8	2.15
9	2.15

Figure 1.10: Effect of Wire tension on Cutting Rate

V. CONCLUSION

From the above study is concluded that :

a. Cutting Rate is increase with the increase in pulse on time upto a certain amount of range beyond this limit of pulse on time MRR start decrease.
b. CR is decreased with increase of pulse duration because discharge energy reduced which reduced cutting rate.
c. CR is increased with increase of peak current because increase in discharge energy.
d. CR decreased with increase of servo gap voltage
e. The effect of Wire feed and Wire Tension is almost constant on CR.
f. Finally the ranges of control factors on are selected

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