A Research on Kerf Width And Material Removal Rate of AISI-304L by Wire-EDM Process Parameters Using Half Hard Brass Wire During Main Cut And Trim Cuts

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Abstract- *Wire-EDM can be use to machine anything which has been electrically conductive regardless of the hardness, from relatively common materials such as tool steel, aluminium, copper, and graphite to unusual space-age alloys like hastalloy, waspalloy, inconel, titanium, carbide, polycrystalline diamond compacts and conductive ceramics. Wire-EDM process is able to machining intricate specimens in different shapes and size. The material used for this experimental investigational work is AISI 304L stainless steel. AISI 304L has been used in aerospace cabin components & internal fuel tanks, Food treating equipment, and they also used in Automotive and aerospace structural use. In this investigational work, evaluate the Kerf width and Material removal rate during main cut and trim cuts at high to low discharge energy. Input process parameters are pulse on time, pulse off time, Peak current, servo voltage and servo feed.*

Keywords- Wire-EDM, Kerf width, Material removal rate, Main cut, Trim cuts.

I. INTRODUCTION

World's first WEDM was invented by the SWISS FIRM AGIE in 1969s. Which worked simply without any complication and wire choices had been limited to copper and brass. A number of researches were done on early Wire EDM to modify overall capabilities. In recent decades, many attempts were done on WEDM technology in order to satisfy various manufacturing requirements, especially in the precision mould and die industry. WEDM efficiency and productivity have been improved by different aspects of Wire EDM such as quality, accuracy, and precision. [1] The WEDM machine tool contains a main work-table (X-Y), on which the specimen has been clamped; an auxiliary table (U-V) and wire-drive system. The pulse generator unit generated a series of electrical pulses, which is applied between specimen and travelling wire electrode, to cause the electro erosion of specimen material.

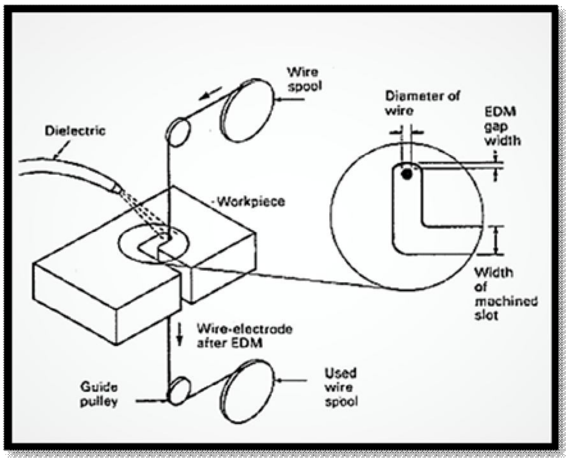

Figure 1: Diagram of Wire-EDM Process [2]

II. LITERATURE REVIEW

Dhruv H. Gajjar and Prof.Jayesh V. Desai studied Optimization of MRR, Surface Roughness and KERF Width in Wire EDM Using Molybdenum Wire. In this research WEDM experiment using 0.25 mm diameter molybdenum wire & EN-31 tool Steel work piece has been done for optimizing MRR, KERF width, Surface finish and reducing cost of manufacturing. The important machining parameters of WEDM which affecting on the performance parameters are discharge current, pulse on time, pulse off time, arc gap, flushing pressure, servo voltage and wire tension. Taguchi design of experiments is used to conduct experiments by varying the parameters servo voltage, pulse on time and pulse off time. By using multi objective optimization technique grey relational theory, the optimal value is obtained for MRR, surface roughness and KERF width. Finally it is concluded that Pulse on time found most significant parameter in all response. Surface roughness also increases with increase of pulse on time. Pulse off time has opposite effect to pulse on time. MRR decrease with increase of pulse off time, while surface roughness reduces. Servo voltage has little effect on SR and KERF width but it has more effect over MRR. Surface roughness reduces with increase of servo voltage.

Lokeswara Rao T. and N. Selvaraj have studied an optimum cutting parameters for Titanium Grade5 (Ti-6Al-4V) using Wire-cut Electrical Machining Process (WEDM). The response of Volume Material Removal Rate (MRR) and Surface Roughness (Ra) are considered for improving the machining efficiency. A brass wire of 0.25mm diameter was applied as tool electrode to cut the specimen. The Experimentation has been done by using Taguchi's L25 orthogonal array (OA) under different conditions like pulse on, pulse off, peak current, wire tension, servo voltage and servo feed settings. Regression equation is developed for the VMRR and Ra. From the results it is observed that, the pulse on, pulse off and peak current are the most significant factors for the performance measures. The wire tension, servo voltage and servo feed settings are less significant on performance measure.

M.PannerSelvam and P.Ranjith Kumar have studied to optimize the process parameters during machining of Hastelloy -C-276 by wire–cut electrical discharge machining. In the present work, the input parameters are pulse on time (Ton), pulse off time (Toff), wire feed rate and current and voltage were changed during the process and Optimize the Kerf Width and Surface Roughness in Wire cut Electrical Discharge Machining Using Brass Wire. The optimization of analysis is performed by using Genetic Algorithm (GA) method L–27 orthogonal array. Finally it is concluded that The voltage and pulse off time are have the significant effect on machining time, the higher level of current produce lower machining time. The voltage, Current, Pulse on time and pulse off time are have significant effect on surface roughness. The higher level of current, voltage, pulse on time and pulse off time are produce poor surface finish. The genetic algorithm models were developed based on design of experiment with current, voltage, pulse on time and pulse off time as an input and machining time and surface roughness were response & the developed model can be used to predict the machining time, surface roughness value in effective manner.

III. EXPERIMENTAL WORK

A. Machine

The machine used is Electronica Sprintcutwin WEDM, incorporated with Half Hard Brass electrode. Which contains a work-table, wire feed system, control unit and dielectric section.

B. Specimen Material

In this investigational work, AISI 304L Stainless Steel material is used.AISI 304L has been used in aerospace cabin components & internal fuel tanks, Food treating equipment and they also used in Automotive and aerospace structural use. The unseen layer of chromium oxide defends stainless steel and make stain and corrosion resistant, it's best choice for hospital and also hygiene conscious environments. chemical composition of material is shown in Table 1.

Table 1: Chemical composition of AISI 304L

Element	Content %
Carbon	0.026
Silicon	0.330
Sulphur	0.001
Phosphorous	0.017
Manganese	1.623
Nickel	8.050
Chromium	18.100
Molybdenum	0.350
Iron	71.503

C. Wire material

The ideal wire electrode should possess characteristics like High electrical conductivity, Sufficient tensile strength and optimum spark and flushing characteristics. For this investigationalwork selected wire is Half Hard Brass wire. The Diameter of wire to be used is 0.25 mm.

D. Kerf Width measurement

Kerf width is a one type of wasted material in machining and evaluate dimensional accuracy of finished specimen. Which has been measured in millimetres. In this research work, It would be measured by use of Leica DMI3000 B Inverted Microscopes.

E. Material removal rate (MRR)

MRR can be calculated by use of equation,

$$MRR\left(\frac{mm3}{min}\right) = Cutting\ speed\left(\frac{mm}{min}\right) \times Kerf\ width\ (mm) \times Thickness\ of\ workpiece\ (mm)$$

F. Wire EDM parameters setting

The process parameters such as Pulse on time, Pulse off time, Peak current, Servo feed and servo voltage has taken at different levels and the water pressure, wire feed rate and wire tension are taken as 1 kg/cm^2, 2 m/min and 0.8 kgf respectively at constant. The selections of these factors were based on the suggestions from the handbook recommended by the machine manufacturer, preliminary research results and journals. The influence of main cut and trim cuts on Kerf width and MRR have been studies with reference to the experimental results.

Table 2: Wire EDM Parameters

TEST	TYPE OF CUT/ WEDM PARAMETER		PULSE ON TIME (Ton)µs	PULSE OFF TIME (Toff)µs	Peak Current (IP)	SERVO VOLTAGE (V)	SERVO FEED (SF) mm/min
I	AI. Rough Cut	AI1	109	59	12	20	2100
	BI. Trim Cut in Two Steps	BI1	109	59	12	20	2100
		BI2	106	56	11	18	400
	CI. Trim Cut in Three Steps	CI1	109	59	12	20	2100
		CI2	106	56	11	18	400
		CI3	103	53	11	18	200
	DI. Trim Cut in Four Steps	DI1	109	59	12	20	2100
		DI2	106	56	11	18	400
		DI3	103	53	11	18	300
		DI4	100	50	11	18	200
II	AII. Rough Cut	AII1	110	60	12	20	2100
	BII. Trim Cut in Two Steps	BII1	110	60	12	20	2100
		BII2	107	57	11	18	450
	CII. Trim Cut in Three Steps	CII1	110	60	12	20	2100
		CII2	107	57	11	18	450
		CII3	104	54	11	18	350
	DII. Trim Cut in Four Steps	DII1	110	60	12	20	2100
		DII2	107	57	11	18	450
		DII3	104	54	11	18	350
		DII4	101	51	11	18	250
III	AIII. Rough Cut	AIII1	111	61	12	20	2100
	BIII. Trim Cut in Two Steps	BIII1	111	61	12	20	2100
		BIII2	108	58	11	18	500
	CIII. Trim Cut in Three Steps	CIII1	111	61	12	20	2100
		CIII2	108	58	11	18	500
		CIII3	105	55	11	18	400
	DIII. Trim Cut in	DIII1	111	61	12	20	2100

	Four Steps	**DIII2**	108	58	11	18	500
		DIII3	105	55	11	18	400
		DIII4	102	52	11	18	300

IV. RESULT AND DISCUSSION

From the experimental result, it is reveals that the Kerf width increase from 0.327 mm to 0.358 mm for the test I during main/rough cut to trim cuts as shown in chart 1.

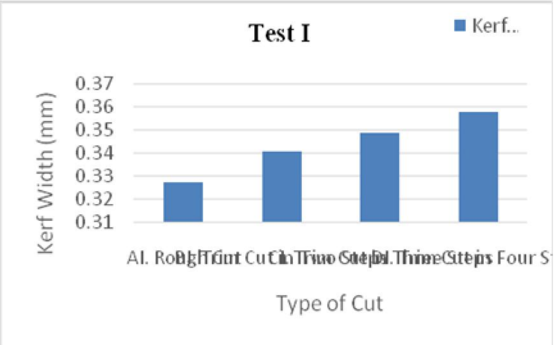

Chart 1: Kerf Width during Test I

For test II, Kerf Width increase from 0.363 mm to 0.393 mm during main cut to trim cuts as shown in chart 2.

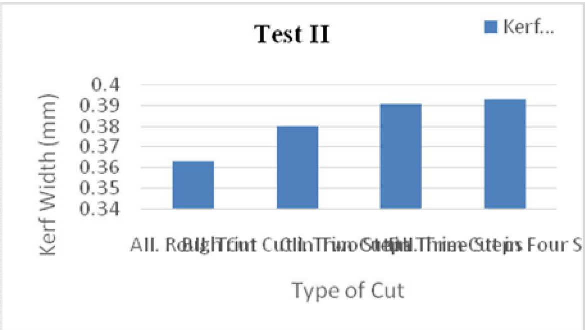

Chart 2: Kerf Width during Test II

For test III, Kerf Width increase from 0.377 mm to 0.415 mm during main cut to trim cuts as shown in chart 3.

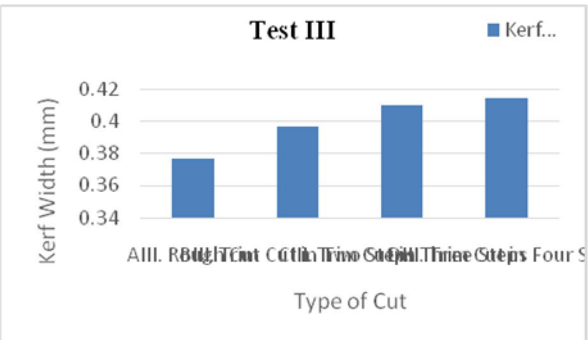

Chart 3: Kerf Width during Test III

For the trim cuts, Due to sparking happens from the side of the wire to the specimen make happen the erosion and the kerf-width rises.

From the experimental result, it is reveals that the MRR is reduced from 3.3934 mm3/min to 0.4429 mm3/min during rough cut to trim cuts for test I as shown in chart 4.

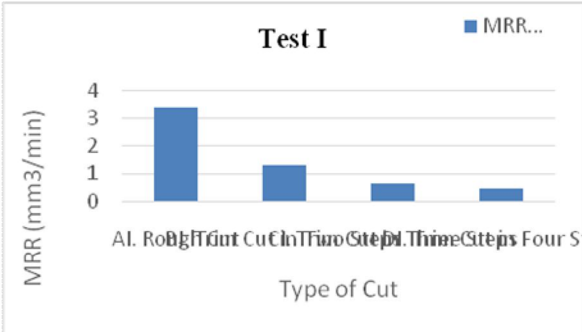

Chart 4: Material Removal Rate during Test I

For test II, material removal rate is reduced from 4.0899 mm3/min to 0.1079 mm3/min during main cut and trim cuts as shown in chart 5.

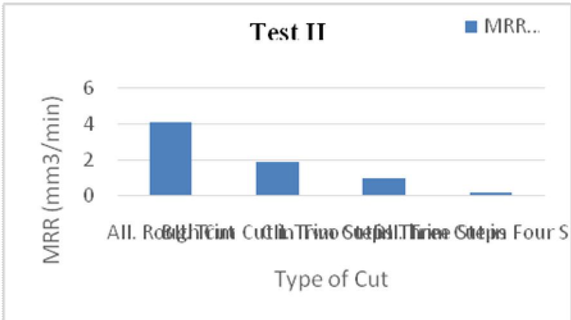

Chart 5: Material Removal Rate during Test II

For test III, material removal rate is reduced from 4.4265 mm3/min to 0.2965 mm3/min during main cut to trim cuts as shown in chart 6.

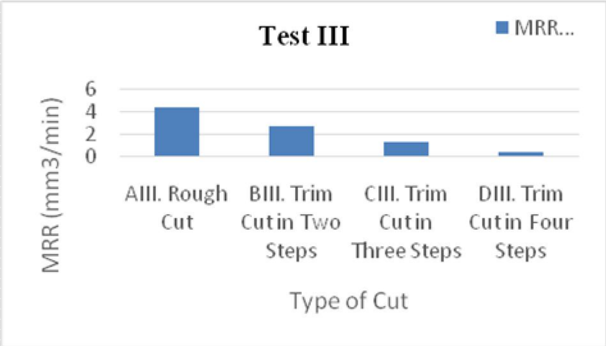

Chart 6: Material Removal Rate during Test III

From the investigational result, it is observed that MRR is high during main cut and low for the period of trim cuts. Material removal rate is reduced Because of the discharge energy is decreasing from the rough cut to trim cut.

V. CONCLUSIONS

This study focused on to investigate the effect of discharge energy on Kerf width and MRR during main cut and trim cuts of AISI 304L stainless steel.

- The experimental result reveal that the Kerf Width increase from 0.327 mm to 0.358 mm for the test I during rough cut to trim cuts. For test II, Kerf Width increase from 0.363 mm to 0.393 mm during rough cut to trim cuts. And for test III, Kerf Width increase from 0.377 mm to 0.415 mm during rough cut to trim cuts. For the trim cuts, Due to sparking happens from the side of the wire to the specimen make happen the erosion and the kerf-width rises.
- Material removal rate is reduced from 3.3934 mm3/min to 0.4429 during rough cut to trim cuts for test I. For test II, material removal rate is reduced from 4.0899 mm3/min to 0.1079 mm3/min during rough cut and trim cuts and for test III, material removal rate is reduced from 4.4265 mm3/min to 0.2965 mm3/min during rough cut to trim cuts. It was observed that the MRR is high during rough cut and low during trim cuts. Material removal rate is reduced Because of the discharge energy is decreasing from the rough cut to trim cuts.
- Based on the experimental results it is concluded that Kerf width increases from main/rough cut to trim cuts and MRR decreases from main/rough cut to trim cuts.

REFERENCES

[1] A book of Modern Machining Processes "Thermal Removal Processes" By P.C Pandey & H. S. Shan.

[2] M.PannerSelvam ,P.Ranjith Kumar "Optimization Kerf Width and Surface Roughness in Wire cut Electrical Discharge Machining Using Brass Wire" Mechanics and Mechanical Engineering, Vol. 21, No. 1,2017.

[3] Dhruv H. Gajjar,Prof. Jayesh V. Desai "Optimization of MRR, Surface Roughness and KERF Width in wire EDM Using Molybdenum Wire" International Journal for Research in Education (IJRE),Vol. 4, Issue:2, February : 2015.

[4] Lokeswara Rao T., N. Selvaraj "Optimization of WEDM Process Parameters on Titanium Alloy Using Taguchi Method" International Journal of Modern Engineering Research (IJMER), Vol. 3, Issue. 4, Jul. - Aug. 2013.