Experimental investigation of Wire EDM process parameters on surface roughness of AISI 304L during main cut and trim cuts

Mehul M. Prajapati[1], Vijay D. Patel[2], Dr. D. M. Patel[3]

[1]Post Graduate Scholar, Department of Advanced Manufacturing Systems, U.V. Patel College of Engineering, Ganpat University, Mehsana, Gujarat, India
[2]Assistant Professor, MC/ME Engineering Department, , U.V. Patel College of Engineering, Ganpat University, Mehsana, Gujarat, India
[3]Principal, Sankalchand Patel College of Engineering, Visnagar, Gujarat, India

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Abstract - *AISI 304L Stainless Steel is used in a wide variety of application, including aerospace cabin components & internal fuel tanks, Food processing equipment And they also used in Automotive and aerospace structural use. Wire EDM process is a very unforeseeable, time differing stochastic process. The process output is affected by abundant no of input variables. Wire Electrical Discharge Machining (WEDM) is used for machining of conductive material by electrical erosion. Wire EDM is essentially a thermal based process with a intricate metal removal mechanism. In this experimental investigation, AISI 304L Stainless steel is used for machining to evaluate the surface roughness for high to low discharge energy modes during main cut and trim cuts. . Input process parameter which are taken into consideration are pulse on time (Ton), pulse off time (Toff), input power (IP), servo voltage (V) and servo feed (SF). The surface roughness is selected as a response variable.*

Key Words: Wire EDM, Surface roughness, Main cut, Trim cuts

1. INTRODUCTION

As we are in the era of fastest growing technological development and advancement in manufacturing technology we need quick and better results. Nonconventional machining processes enable us to get consistency and accuracy in our desired manufacturing techniques. The conventional machining processes, in spite of recent technical advancement, are inadequate to machine complex shapes in hard, high strength temperature resistant alloys and die steels. Keeping these requirements into mind, a number of Non-traditional machining (NTM)/unconventional processes have been developed. Nevertheless, such materials are difficult to be machined by traditional machining methods. [1] The beginning of EDM came during the Second World War, when two Russian physicists B.R. and N.I. Lazarenko published their study on The Inversion of the Electric Discharge Wear Effect. which related to the application to manufacturing technology of the capacity of electrical discharges, under controlled distribution, to remove metal. [2] The world's first WEDM was produced by the SWISS FIRM ,AGIE in 1969. The first WEDM machine worked simply without any complication and wire choices were limited to copper and brass only. Several researches were done on early WEDM to modify its cutting speed and overall capabilities. In recent decades, many attempts were done on Wire EDM technology in order to satisfy various manufacturing requirements, especially in the precision mold and die industry. Wire EDM efficiency and productivity have been improved through progress in different aspects of WEDM such as quality, accuracy, and precision. [3] The WEDM machine tool comprises of a main worktable (X-Y) on which the work piece is clamped; an auxiliary table (U-V) and wire drive mechanism. A series of electrical pulses generated by the pulse generator unit is applied between the work piece and the travelling wire electrode, to cause the electro erosion of the work piece material. The volume of metal removed during this short period of spark discharge depends on the desired cutting speed and the surface finish required. The heat of each electrical spark, estimated at around 15,000° to 21,000° Fahrenheit, erodes away a tiny bit of material that is vaporized and melted from the work piece and some of the wire material is also eroded away. These particles (chips) are flushed away from the cut with a stream of de-ionized water through the top and bottom flushing nozzles.

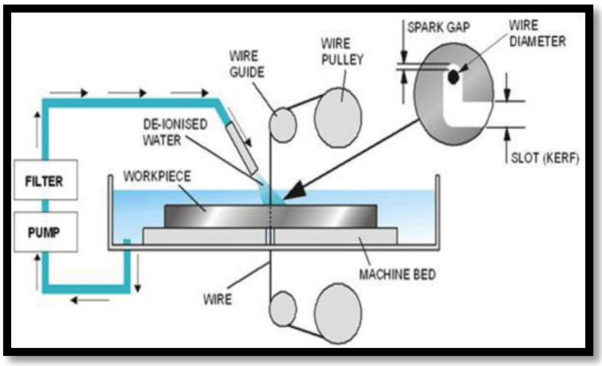

Fig – 1: Schematic Diagram of WEDM Process[4]

1.1 LITERATURE REVIEW

Pradeep Kumar Karsh and Hari Singh investigates the different process parameters like pulse on time, pulse off time and peak current for the surface roughness. Taguchi L9 orthogonal array along with ANOVA is used for optimize the different parameters so that minimum surface roughness obtained.it is concluded that Surface roughness increases with increase on pulse on time and decrease with increase in pulse off time. For surface roughness most significant factor is pulse on time (contributing 92.35 %) followed by pulse off time & Peak current is insignificant factor for surface roughness.

Prof. Mahammadumar, Nimish Kothari,Pritish Patil, Sujit Patil and Rahul Pawde have studied the Effect of Wire EDM process paramters on surface roughness of AISI-1045 (Carbon steel). In the present work , conducting the experiments to investigate the effects of various WEDM process parameters on the machining quality and to obtain the optimal sets of process parameters like Pulse-ON time, Pulse-OFF time, current, wire feed are studied by conducting an experiment. Taguchi Method is to design the experiment. L16 orthogonal array is used to conduct the experiment. From this experimental work it is concluded that the input process parameters like Pulse-ON time and current are the most influencing parameters on surface roughness of AISI-1045 (carbon steel). Surface roughness increases with increase in Pulse- ON time and current.

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.Panner Selvam 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.

2. EXPERIMENTAL WORK

2.0 Machine

The experimental work is carried out in sprintcutwin wire cut electro discharge machine (ELEKTRONICA SPRINTCUT 734) of AISI-304L material by varying machining parameters.

2.1 Workpiece Material

Selection of material for this work is AISI 304L Stainless Steel. AISI 304L Stainless Steel is used in a wide variety of application, including aerospace cabin components & internal fuel tanks, Food processing equipment and they also used in Automotive and aerospace structural use. Stainless steel is appropriately named, as it is a type of steel that has a unique ability to resist stains and corrosion. chemical composition of this material is shown in Table 1.

Table 1: Chemical composition of AISI 304L Stainless Steel

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

2.2 Wire electrode material

Selection of wire basically depends on the properties of work piece material, however an ideal wire electrode should possess following characteristics, i.e. High electrical conductivity, Sufficient tensile strength and optimum spark and flushing characteristics. For this work selected wires is Half Hard Brass wire. Diameter of wire materials to be used is 0.25 mm.

2.3 Surface Roughness measurement

Surface roughness values of finished work pieces were measured by Mitutoyo Surface Roughness Tester SJ – 201 by a proper procedure. The Mitutoyo Surface Roughness Tester SJ – 201 is an instrument that works by gently dragging a mechanical stylus across a Surface. Surface Roughness Tester acquires data by moving the sample beneath the diamond tipped stylus. Vertical movements of the stylus are sensed by an LVDT, digitalized, and stored in the instruments memory. Its output is a digital display of measured Surface roughness value Ra and other features. Surface Roughness Standard ISO was used for measurement.

2.4 Wire EDM parameters setting

The process parameters such as pulse on time, pulse off time, input power, 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 surface roughness has 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	INPUT POWER (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	AIII 1	111	61	12	20	2100
	BIII. Trim Cut in Two Steps	BIII 1	111	61	12	20	2100
		BIII 2	108	58	11	18	500
	CIII. Trim Cut in Three Steps	CIII 1	111	61	12	20	2100
		CIII 2	108	58	11	18	500
		CIII 3	105	55	11	18	400
	DIII. Trim Cut in Four Steps	DIII 1	111	61	12	20	2100
		DIII 2	108	58	11	18	500
		DIII 3	105	55	11	18	400
		DIII 4	102	52	11	18	300

3. Result and Discussion

The experimental results reveals that the average surface roughness significantly reduced from 3.029 µm to 2.1303 µm for the test I from main/rough cut to trim cuts, as shown in chart 1. For test II, Surface roughness reduced from 3.1243 µm to 1.854 µm from main/rough cut to trim cuts, as shown in chart 2. And for test III, Surface roughness reduced from 3.196 µm to 1.9756 from main/rough cut to trim cuts, as shown in chart 3. So it is observed that, from main/rough cut to trim cuts the surface roughness is decreases. This phenomenon is due to increase in pulse on time/pulse duration and input power, the discharge energy increases and which produces large craters on machined surface and increases surface roughness. It is also observed that the surface roughness can be further improved through more and more number of trim cuts.

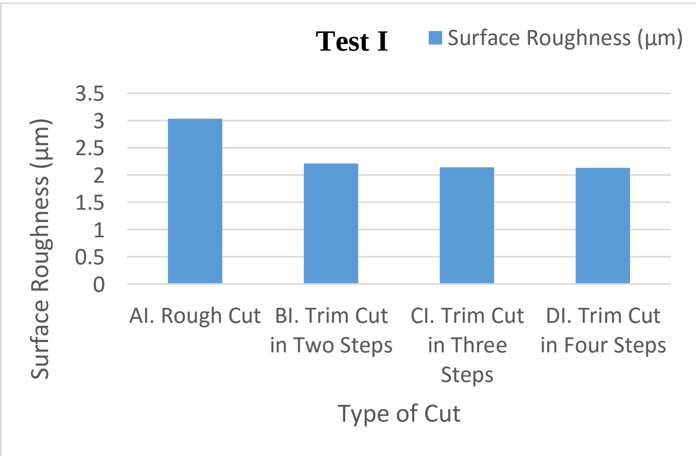

Chart – 1: Surface roughness at rough/main cut and trim cuts for Test I

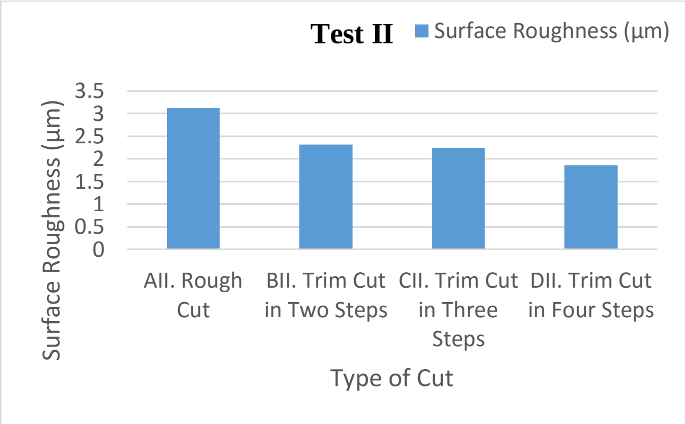

Chart – 2: Surface roughness at rough/main cut and trim cuts for Test II

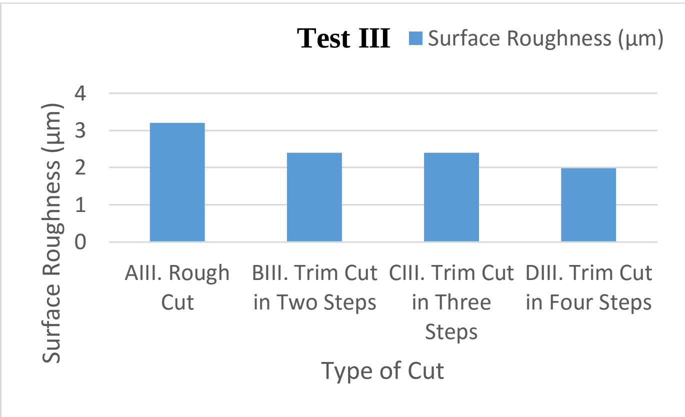

Chart – 3: Surface roughness at rough/main cut and trim cuts for Test III

4. CONCLUSIONS

In this study, surface roughness of wire electrical discharge machined surface of AISI 304L Stainless Steel workpiece was investigated. The experimental result reveal that the average surface roughness significantly reduced from 3.029 µm to 2.1303 µm for the test I from main/rough cut to trim cuts. For test II, Surface roughness reduced from 3.1243 µm to 1.854 µm from main/rough cut to trim cuts. And for test III, Surface roughness reduced from 3.196 µm to 1.9756 from main/rough cut to trim cuts. Also it is observed that from higher to lower discharge energy the surface roughness is decreases. Based on the experimental results it is concluded that surface roughness decreases from main/rough cut to trim cuts.

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BIOGRAPHIES

Mr. Mehul M. Prajapati is pursuing his M.Tech. in Advanced Manufacturing Systems from U.V. Patel College of Engineering, Ganpat University. He did his B.E. in Mechanical from Smt. S. R. Patel Engineering College, Unjha.

Mr. Vijay D. Patel is Assistant Professor of the MC/ME Engineering Department, U.V. Patel College of Engineering, Ganpat University, Mehsana. He did his B.E. in Mechatronics From Sardar Patel University and M.Tech. from Ganpat University, Mehsana. He is pursuing his ph.D. from Ganpat University.

Dr. D. M. Patel is a Principal at Sankalchand Patel College of Engineering, Visnagar.