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Effect of Process Parameters on Performance Measures of Wire EDM for AISI A2 Tool Steel

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Abstract

Wire EDM is most progressive non-conventional machining process in mechanical industries. There are so many parameter affect the performance of Wire EDM. Few of them are investigated in this research paper. 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 is studied by conducting an experiment. Response surface methodology is used to analyze the data for optimization and performance. The AISI A2 tool steel is used as work piece material in the form of square bar.

Keyword: *Wire Electrical Discharge Machining (WEDM), Taguchi Method, RSM and AISI A2.*

I. INTRODUCTION

In mechanical industry, the demands for alloy materials having high hardness, toughness and impact resistance are increasing. Nevertheless, such materials are difficult to be machined by traditional machining methods. Hence, non-traditional machining methods including electrochemical machining, ultrasonic machining, electrical discharging machine (EDM) etc. are applied to machine such difficult to machine materials. WEDM is popular in all conventional EDM process, which used a wire electrode to initialize the sparking process. WEDM process with a thin wire as an electrode transforms electrical energy to thermal energy for cutting materials. With this process, alloy steel, conductive ceramics and aerospace materials can be machined irrespective to their hardness and toughness. Furthermore, WEDM is capable of producing a fine, precise, corrosion and wear resistant surface. A continuously travelling wire electrode made of thin copper, brass or tungsten of diameter 0.05-0.30 mm, which is capable of achieving very small corner radii. There is no direct contact between the work piece and the wire, eliminating the mechanical stresses during machining. The WEDM is a well-established machining option for manufacturing geometrically complex or hard material parts that are extremely difficult-to-machine by conventional machining processes. The non-contact machining techniques have been continuously evolving in a mere tool and die making process to a micro-scale application.

II. WORKING PRINCIPLE OF WEDM

The Wire EDM machine tool has one main worktable for work piece mounting an auxiliary table and wire feed mechanism. The movements of main table call axis X and Y. The wire feed mechanism consist of wire feeder which continuously fed wire along work table. The wire tension mechanism provides tension in wire and let it in straight position. The wire is fed in few possible speeds as meter per minute. Two wire guides located at the opposite sides of the work piece. The lower wire guide is stationary where as the upper wire guide, supported by the auxiliary table. The wire is connected to negative charge and work piece is connected to positive charge. Now series of electrical pulses generated by the pulse generator unit is applied between the work piece and the wire electrode so the spark is occurs. The material is removed from work piece by electro-erosion. The feed is given to the work table by servo motor but the wire guide remains stationary. Generally CNC controller is used here. To let out the removed material from work area, during the cutting operation continuous flashing water is applied. It is called dielectric fluid and continuously filtered to maintain its conductivity. To achieve taper cutting, the upper table is tilted in U-V direction. With combination of X-Y movement and U-V movement desire taper is produced.

III. LITERATURE RIVIEW

So many research papers and articles are survey on Wire EDM those are related to know the effect of process parameter on performance of process. The materials investigated on WEDM are most of HSS, other Tool material, Hot Die material, Cold Die material, Nickel alloys and Titanium alloys which are hard compare to other material. These materials are AISI M2, AISI D2, AISI D3, AISI D5, AISI H11, AISI 4140, SKD 11, En 16, En 19, En 31, En 32, 1040, 2379, 2738, Inconel, Ti alloys, Al alloys, 7131 cemented, Tungsten Carbide (WC) etc. Different author use different combination of process parameter. They analyze the experimental data by plotting Interaction graphs, Residual plots for accuracy and Response curves. Some other methods used by different author for analysis of Taguchi's DOE data regarding to EDM and WEDM are Regression analysis, Response Surface Methodology, Central Composite Design (CCD), Feasible-Direction Algorithm, SA algorithm, Pareto, Artificial Bee Colony (ABC), Grey Relational Analysis, Genetic Algorithm, Fuzzy clustering, Artificial Neural Network, Tabu-Search Algorithm, Principle component method etc. Most of the author used L_{27} Orthogonal Array. Generally the effect of Pulse ON time, Pulse OFF time, Spark gap set Voltage, Peak current, Flushing Pressure, Work piece height, wire tension and wire feed on the material removal rate, surface roughness, kerf and gap current is investigated.

IV. DESIGN OF EXPERIMENTS

4.1 SELECTION OF ORTHOGONAL ARRAY

Taguchi method is used as Design of Experiment. Taguchi Method. Genichi Taguchi, a Japanese scientist developed a technique based on Orthogonal Array of experiments. This technique has been widely used in different fields of engineering experimental works. The control factors considered for the study are Pulse-on, Pulse- off, Bed speed and Current. Four levels for each control factor will be used. Based on number of control factors and their levels, L_{27} orthogonal array (OA) was selected. Table-1 represents various levels of control factors and Table-2 experimental plan with assigned values.
The values of constant parameters are as under.

Pulse Peak Current (IP)	210 A
Pulse Peak Voltage (VP)	2 volts
Flushing Pressure	12 kgf/cm^2
Work piece Material	Work piece Material

Table-1&2 Levels of various control factors

	Level 1	Level 2	Level 3
Pulse ON time – (A)	115	120	125
Pulse OFF time – (B)	45	50	55
Voltage – (C)	21	23	25
Wire Feed - (D)	4	6	8
Wire Tension - (E)	2	7	10

Table-2 Taguchi L_{27} OA

	(A)	(B)	(C)	(D)	(E)
1	115	45	21	4	2
2	115	45	21	4	7
3	115	45	21	4	10
4	115	50	23	6	2
5	115	50	23	6	7
6	115	50	23	6	10
7	115	55	25	8	2
8	115	55	25	8	7
9	115	55	25	8	10
10	120	45	23	8	2
11	120	45	23	8	7
12	120	45	23	8	10
13	120	50	25	4	2
14	120	50	25	4	7
15	120	50	25	4	10
16	120	55	21	6	2
17	120	55	21	6	7
18	120	55	21	6	10
19	125	45	25	6	2
20	125	45	25	6	7
21	125	45	25	6	10
22	125	50	21	8	2
23	125	50	21	8	7
24	125	50	21	8	10
25	125	55	23	4	2
26	125	55	23	4	7
27	125	55	23	4	10

4.2 SELECTION OF MATERIAL

An **AISI A2** is Air-Hardening tool steel which containing five percent chromium. They Replaces the oil hardening (O1 type) when safer hardening, less distortion and increased wear-resistance are required. They Provides an intermediate grade between the oil hardening and the high carbon, high chromium (D2) types. The Designations in other countries are as AFNOR Z 100 CDV 5 in France, DIN 1.2363 in Germany, JIS SKD 12 in Japan.

Table-3: Chemical Composition of AISI A2 Tool Steel

element	C	Mn	Si	Mo	Cr	V	Ni
%	0.95-1.05	0.95-1.05	0.95-1.05	0.95-1.05	0.95-1.05	0.95-1.05	0.95-1.05

4.3 EXPERIMENTAL WORK

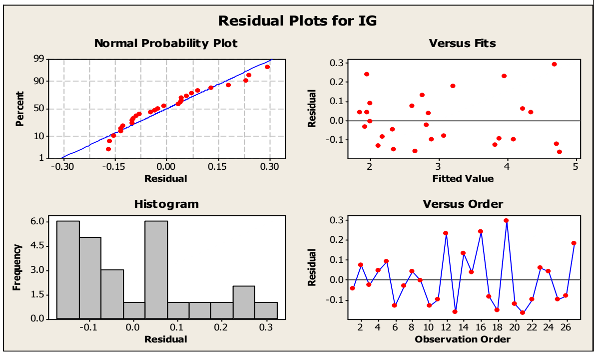
The experiments were carried out on a wire-cut EDM machine (ELEKTRA SUPERCUT 734) of HI-TECH ENGINEERS installed at Gayatri CNC Wire cut, CTM, Ahmedabad, Gujarat, India shown in figure-1

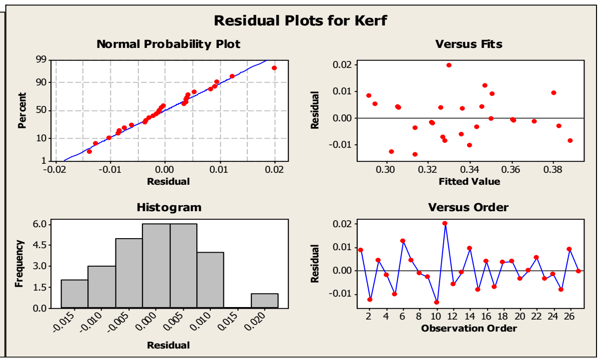
Figure- 1 Wire cut EDM Machine

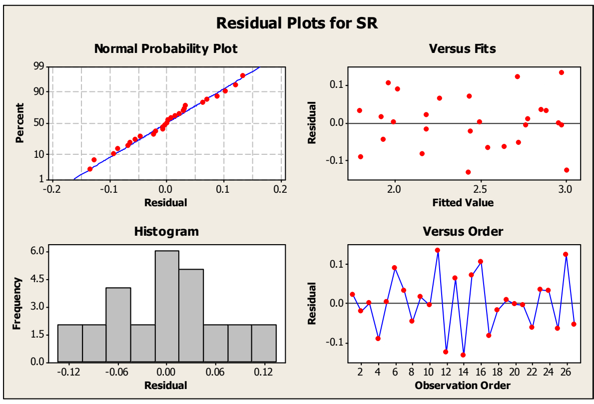
SR NO	CR	SR	KERF	IG
1	0.92	2.21	0.30	2.3
2	1.02	2.42	0.29	2.7
3	1.10	2.50	0.31	2.8
4	0.83	1.71	0.32	1.9
5	0.86	2.00	0.33	2.1
6	0.86	2.11	0.36	2.0
7	0.83	1.83	0.35	1.9
8	0.84	1.89	0.37	2.0
9	0.85	1.94	0.38	2.0
10	1.39	2.76	0.30	3.7
11	1.45	3.11	0.35	3.8
12	1.53	2.88	0.33	4.2
13	0.99	2.33	0.36	2.5
14	1.12	2.30	0.39	2.9
15	1.12	2.51	0.38	2.9
16	0.82	2.07	0.31	2.2
17	0.88	2.08	0.32	2.1
18	0.91	2.17	0.34	2.2
19	1.70	2.79	0.33	5.0
20	1.62	2.96	0.34	4.6
21	1.62	2.97	0.35	4.6
22	1.51	2.58	0.30	4.0
23	1.54	2.89	0.31	4.3
24	1.57	2.92	0.32	4.4
25	1.10	2.48	0.32	2.8
26	1.15	2.84	0.36	3.0
27	1.29	2.67	0.36	3.4

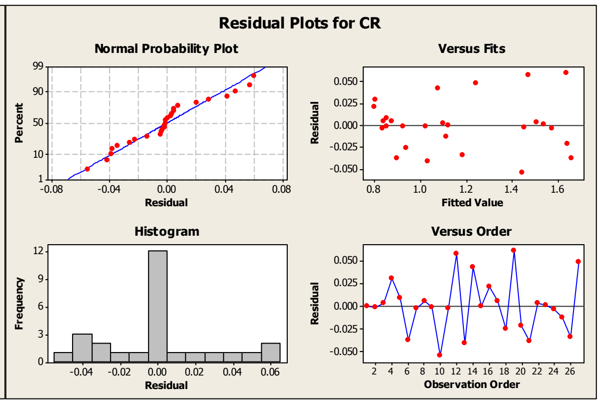
V. ANALYSIS BY RESPONSE SURFACE METHODOLOGY (RSM)

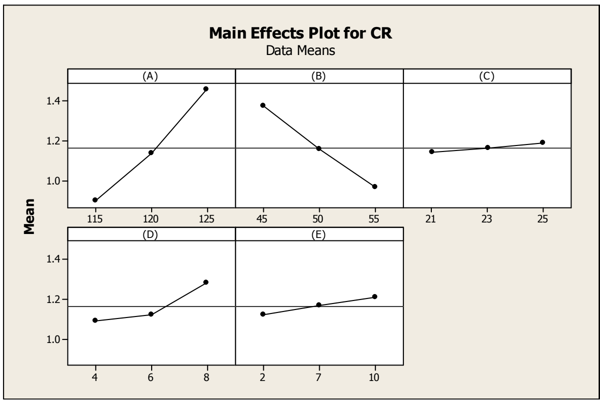
The following graph developed by RSM in MINITAB software.

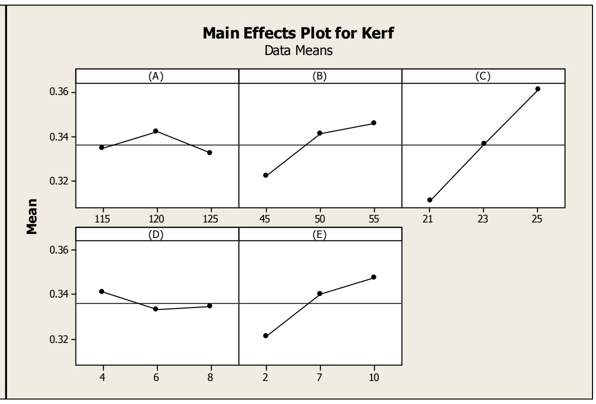


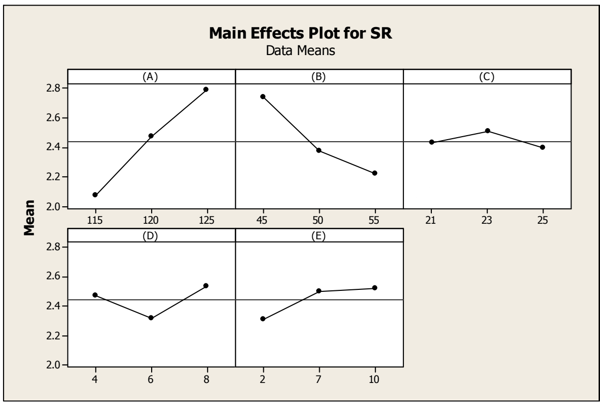


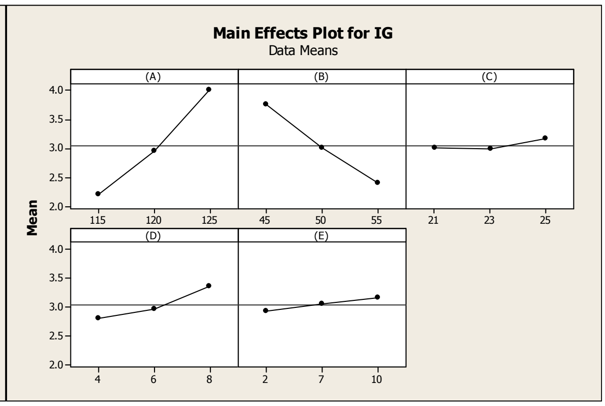












VI. CONCLUSION

It is clear from above graph that 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. The normal probability distribution for all measurement indicates high confidence.

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