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Electrode Wear Evaluation in E.D.M Process

Abstract*-Electric Discharge Machining (E.D.M) is a non-conventional machining process and has a larger extent of application in the manufacturing industry due to its accuracy. E.D.M simply uses an electrical spark between the workpiece and tool in the presence of medium dielectric to erode the workpiece in a controlled manner. This study investigates the enhance the various performance parameters measured in E.D.M process using Tagushi Technique. The main goals are to maximize the removal rate of material M.R.R and minimizing the wear rate of tool TWR.*

Keywords*- Electrical Discharge Machining (E.D.M), Electrode Wear Rate (E.W.R) and Material Removal Rate (M.R.R).*

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1. Introduction

Electrical Discharge Machining (E.D.M) is a non-regular machining process in the industry, in view of the guideline of expelling material by methods for rehashed electrical releases between the device as the cathode and the workpiece within sight of a dielectric liquid [1]. E.D.M utilizes warm vitality to accomplish a high exactness metal expulsion process from precisely controlled electrical release; the terminal was moved towards the workpiece until the point when the hole turned out to be little enough with the goal that the awed voltage is sufficiently awesome to ionize the dielectric [2] ،In this process material is removed by controlled erosion through a series of electric sparks between the tool (electrode) and the workpiece [3], as shown in Figure 1.

The start vitality of spark energy, exceptional the warmth created on the workpiece prompts vaporizes the materials workpiece [4]. The process is similar to the materials removal mechanism, as the electrode and the workpiece are considered as a set of electrodes in E.D.M [5]. Due to this wear, electrodes lose their dimensions, causing inaccuracy of the cavities formed [6]. In E.D.M process, the output parameters are materials removal rate and electrodes wear ratios. The change of different execution parameters estimated in the experimentation on E.D.M by utilizing Tagushi methods. In this study, the main goals were minimizing the Electrode Wear Rate and maximizing the Material Removal Rate.

I. Literature Review

Gakwad [7] assessed the Effect of E.D.M parameters in finding extreme M.R.R and least E.W.R by machining SS316 utilizing copper anodes. The control factor taken amid analysis was current, puls offtime, puls on time and liquid weight. Material evacuation rate and device wear rate were taken for reaction factors. Tagushi method was connected with M.R.R. Which truly helps in the essential initiative for slightest the test numbers of the botch association for tests, the outcome it demonstrates the current , puls offtime has fundamental factors, huge for material expulsion rate, and instrument, rate wear individually.

Roy [8] considered the info parameters as puls on time, puls offtime, release voltage and current and Surface unpleasantness as a response parameter. For examination work copper bar, material EN-31 utilized for device and workpiece separately. Number juggling normal of outright qualities and root mean squared esteem were examined. In the examination, copper square shape apparatus is utilized for machining. In the outcome, it was seen that present have a bigger effect on surface roughness when contrasted with different process parameters.

Kumar [9] broke down the material ejection rate of two particular materials en-19 and en-41 on failing miserably sinking E.D.M machine. Copper was used as gadget material in the experimentation. The information parameter considered was puls on time, puls off time, discharge current, and voltage. Response material parameter departure rate was considered. In the result, it was gathered that discharge current was genuine impact parameter than consider

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parameters. Furthermore, inquire about the examination of the carbon piece for the two materials. The Tagushi strategy was used for getting growth condition of response parameter for the two materials.

Chandramoli [10] investigates the ideal procedure parameters on RENE80 Nickel super composite material. The outline of the examination was contemplated based on L9 symmetrical exhibit on V3525 Precision kick the bucket sink electric release machine with Aluminum as apparatus cathode. The process and response parameters were Current, Puls offtime , Puls on time and TWR , M.R.R, SR Sequentially. The Results of M.R.R generally diminishes with increment in Puls ontime. TWR increments with the expansion of Current while SR increments with the increment of Current and Puls on time yet diminish with the expansion in Puls offtime.

The experiments of Lodi [11] were performed on intelligent ZNC-E.D.M machine with the copper of 2mm in whole Voltage and diameter, Discharge Current and Puls on time as process parameters. CFRP composite was utilized as work piece material. The outcomes demonstrate that at Vg=50v, Ton=70µsecond & Ip= 2a, and the surface roughness found to be maximum.

Sornlath [12] elevates the W.E.D.M of 5083Al alloy using Tagushi method. The experiments were done on electra super cut734 series2000 wire cut machine. Plus on time, Plus off time, Current Peak & wire tension, were chosen as information parameters and Cutting, Speed, SR as reaction parameters, L9oa was utilized for an outline of investigations.

II. Tagushi Method

In this study, four factors mixed level set up including 18 test to cut steel (1005) work pieces using copper electrode and dielectric solution (diesel oil), using DC, and it was decided to use set up with L.18 set up. The levels of experiment parameters are a voltage (V), current (A), puls on time (Ton) and applied puls off time (Toff), as listed in Table 1.

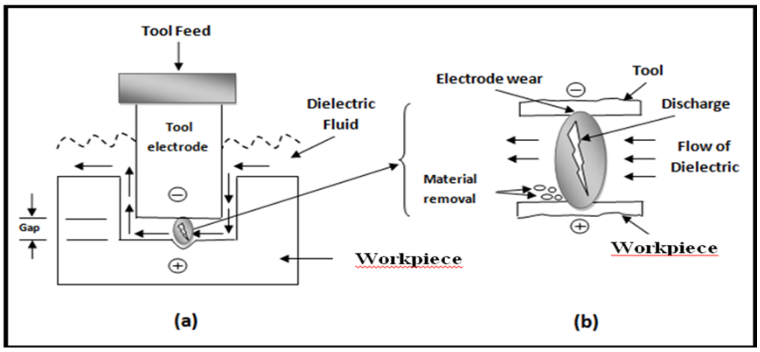

Figure 1: Electric discharge machining (E.D.M): (a) overall setup, and (b) close-up view of the gap, showing discharge, metal removal and electrode wear

Table 1: Response Parameters and control Parameters with mixed levels

Response parameters	Material Removal Rate (mm^3/min) Electrode Wear Rate (mm^3/min)			
Control parameters	Unit	Level 1	Level 2	Level 3
Voltage	(V)	140	240	----
Current	(A)	16	20	24
Pulse on time	(µs)	150	200	300
Pulse off time	(µs)	75	100	150

The M.R.R. of the workpiece is the material volume removed /minute. The following formulae can calculate it:

$$\mathbf{M.R.R} = \frac{(W_i - W_f) \times 1000}{D_w \times t} \quad (1)$$

M.R.R = Removal rate of material (mm^3/min)
W_i = Workpiece initial weight (gm.)
W_f = Workpiece final weight (gm.)
D_w = Workpiece density (gm./cm^3)
t = Period of test (min)

T.W.R. of the electrode is the tool wear amount / minute. Wear rate tool can be calculated using the following formulae:

$$\mathbf{T.W.R} = \frac{(T_i - T_f) \times 1000}{D_e \times t} \quad (2)$$

T.W.R = wear rate tool (mm^3/min)
T_i = Tool initial weight (gm.)
T_f = Tool final weight (gm.)
D_e = Tool density (gm./cm^3)
t = test period (min)

2. Experimental Work

The experiments include cutting eighteen workpieces with the same thickness (2mm). The E.D.M used in this experiment, as shown in Figure 2. All experiments have been done using CHEMER E.D.M, model (CM323C), available at Turning workshop, Training and Workshops, in the University of Technology, Baghdad-Iraq

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Figure 2: CHEMER E.D.M machine

Eighteen samples of the copper electrode have been weighted using a sensitive balance device before E.D.M machining and weights are listed in Table2. The examples were then checked before E.D.M machining utilizing laser filter gadget to examine line by line the anode top view topology and the prepared best view surface information are spared in the PC associated with the laser examine gadget, the E.D.M procedure has been accomplished utilizing the eighteen examples as per the already decided parameters; four unique parameters with blended levels were embraced in this test wear estimation, as recorded in Table 1.

After E.D.M machining process has been proficient, the eighteen copper terminals were weighted again and after that put again on the laser filter gadget to check line by line the cathode top view surface topology and the handled information are spared in the PC. A post getting ready is made normally by taking a gander at the terminal surface topology data when E.D.M process machining according to the saved data using Straumann program which is outfitted with the laser channel Device, as delineated in Figures 3 and 4 independently.

Figure 3: Straumann Program

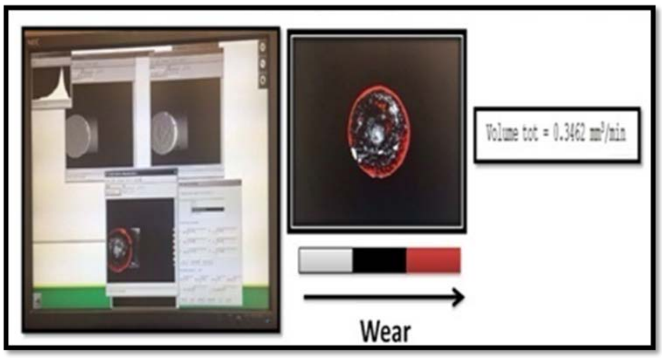

Figure 4: Comparison between Straumann Photos before and after the Program application

Table 2 records the exploratory examples with their procedure parameters and workpiece and terminal weights when E.D.M process. Table 3 records the Machining Time, Material Removal Rate (M.R.R), Electrode Wear Rate (E.W.R) got hypothetically and Electrode Wear Rate (E.W.R) was acquired the Laser Scanner and Absolute rate Error.

Table 2: Parameters that select in the experiments

NO. of sample	Voltage (V)	Current (A)	T on (μs)	T off (μs)	Weight of workpiece before (g)	Weight of workpiece After (g)	Weight of electrode before (g)	Weight of electrode After (g)
1	140	16	150	75	15.2318	14.0077	20.9815	20.9527
2	140	16	200	100	14.9715	13.7141	20.9945	20.9924
3	140	16	300	150	14.8437	13.6243	21.1381	21.0291
4	140	20	150	75	14.8585	13.5953	21.0094	21.0070
5	140	20	200	100	15.0968	13.8227	20.8923	20.8784
6	140	20	300	150	14.0243	12.7706	21.1363	21.1272
7	140	24	150	100	13.8417	12.5949	21.2532	21.1942
8	140	24	200	150	14.3291	13.0968	21.0631	21.0479
9	140	24	300	75	14.8966	13.6847	20.8602	20.8579
10	240	16	150	150	15.1801	13.9329	21.0128	20.9914
11	240	16	200	75	14.1214	12.8744	21.2216	21.2062
12	240	16	300	100	15.2653	13.9597	21.0995	21.0854
13	240	20	150	100	14.0739	12.8594	21.1486	21.1184
14	240	20	200	150	13.9930	12.8819	21.1732	21.0560
15	240	20	300	75	14.3594	13.1504	21.1957	21.1839
16	240	24	150	150	14.2696	13.0735	21.2995	21.2760
17	240	24	200	75	14.1041	12.8704	20.9750	20.9590
18	240	24	300	100	15.1116	13.8834	21.5025	21.4980

Table 3: The Experimental results

No. of sample	Machining time (min.sec)	Material removal Rate (mm^3/min)	Electrode Wear Rate by Weight (mm^3/min)	Electrode Wear Rate By Laser Scanner (mm^3/min)	Absolute Error %
1	7.18	17.0923	0.3548	0.3462	2.4239
2	7.40	15.6792	0.0231	0.0249	4.7619
3	7.10	14.7564	1.1637	1.1386	2.1569
4	8.22	17.2589	0.0289	0.0242	5.8823
5	7.64	17.6739	0.1701	0.1663	2.2339
6	8.1	19.0551	0.1220	0.1341	1.7213
7	8.15	31.1859	1.3020	1.3224	1.5668
8	8.35	15.1286	0.1646	0.1485	9.7812
9	9.06	30.2534	0.1506	0.1734	5.2456
10	6.01	25.9795	0.3932	0.3531	5.1119
11	6.14	19.5858	0.2134	0.2485	2.3898
12	6.42	46.5999	0.4440	0.4268	3.8738
13	5.25	25.3399	1.2559	1.2169	3.1053
14	5.15	26.8893	2.5026	2.5088	0.2477
15	5.45	49.7156	0.4281	0.4111	3.9710
16	7.22	21.5272	2.3731	2.3882	0.6362
17	6.35	51.2287	0.5861	0.5141	2.0474
18	6.52	22.0114	0.2711	0.2621	3.3198

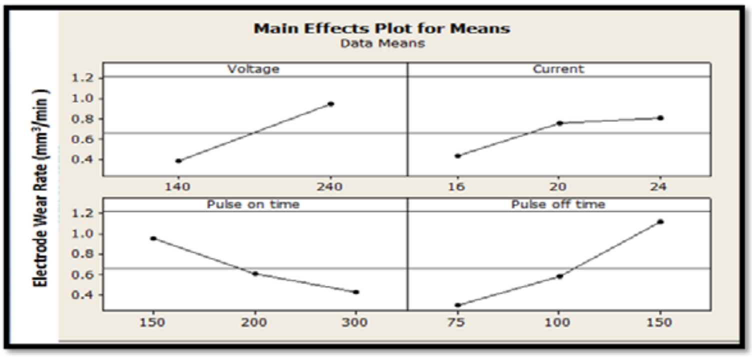

Figure 3: Main Effect Plot for Means-Material Removal Rate

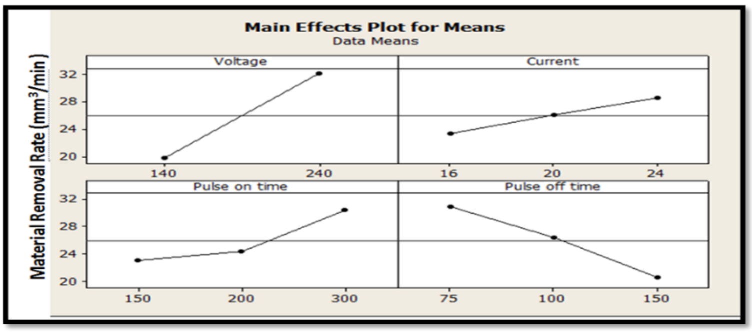

Figure 4: Main Effect Plot for Means-Tool Wear Rate

4. Conclusion

The proposed method has prevailing with regards to coordinating the hypothetical and test results which affirm the legitimacy of the methodology and demonstrated great consent to accomplish the required objective and the accompanying discoveries can be finished up-:

1) The success of this strategy to assess the wear of cathode with little mistake rate, the greatest blunder was 9.7812% and least mistake was 0.2477% .

2) Electrodes experience more wear along their cross segment contrasted with that along their length .

3) The test results uncover that the Electrode Wear rate (E.W.R) is upgraded by expanding voltage esteems .

4) The test results demonstrate that the (E.W.R) increments with increment current qualities .

5) The trial results demonstrate that the (E.W.R) ascends with abatement in the puls ontime values .

6) The trial results demonstrate that the (E.W.R) ascends with expanding the puls offtime values.

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