Experimental Investigation and Optimization of Wire Cut EDM Parameters for Performance Measures of Heat Treated SS304: Ranking Algorithm and Anova Approach

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Abstract**:** ***The execution of WEDM is discover based on Material Removal Rate (MRR), Dimensional Deviation %., KERF Width and Surface Roughness (SR). The imperative machining parameters of EDM which influencing on the execution parameters are Pulse on time (TON), Pulse off time (TOFF), Wire Feed and Peak Current. Taguchi structure of examinations is utilized to direct analyses by varying the parameters. The procedure execution is estimated regarding Material Removal Rate (MRR), KERF Width, Dimensional Deviation % and Surface Roughness (Ra). In this Study WEDM analyze utilizing 0.25 mm Brass Material (Titanium coated) and Heat Treated SS304 work piece has been improved the situation streamlining MRR, KERF width, Surface completion and increment the execution Measures By utilizing multi target advancement strategy dim social hypothesis, the ideal esteem is gotten for MRR, Surface Roughness, KERF width and Dimensional Deviation %. Furthermore, the Analysis of variance (ANOVA) is too helpful to even think about identifying the most vital factor.***

Index Terms**:** ***Response Surface Methodology, Wire EDM, MRR, Ra.***

I. INTRODUCTION

Machining expels bound components of the work pieces to shift them to conclusive parts. Machining nowadays has been characterized in 2 types: (1) Traditional Machining; (2) Non-conventional Machining. Customary Machining, furthermore radiant common machining needs the nearness of an instrument that is tougher than the work piece to be machined. This apparatus should be entered inside the work piece to an exact profundity. Also, a relative movement between the instrument and work piece is vital for producing the predefined frame[1]. The nonappearance of any of those parts in any machining strategy like the nonattendance of hardware work piece contact or relative movement, makes the technique a non-customary or non-regular one. Wire electrical release machining is one among the non-customary machining forms utilized in the field of micromachining to manufacture appallingly progressed smaller scale items like producing passes on, plastic shape, punches and form cutting and so on from hard materials that are hard to machine. The strategy creates low leftover worries amid cutting of material since it doesn't require higher cutting powers for material expulsion resulted a little alteration in mechanical properties of material once machining. Amid this strategy, the material is expelled from the bit of work by a progression of discrete start releases between a piece and device terminal drenched in a fluid material medium. The created start releases dissolve and vaporize minute measure of the work material. The evacuated material is shot out and flushed away by the material. a few scientists have done work on WEDM to discover the impact of factors on reactions for various materials [2-23]. Taguchi and Grey relative investigations to decide the ideal decision of machining parameters for the Wire electrical release Machining. They inferred that feed rate and Ton were the principal compelling elements on MRR, and Ton contains a critical impact surface Roughness.

II. EXPERIMENTAL PROCEDURE

A. Experimental Stage

In this experiment design the L9 Orthogonal Array of Grey Relation Taughi Method was employed. The three factors are taken as input parameter and three levels of each factor are considered in this experiment. the Heating the specimen was Annealed by heating the material up to the temperature of 925 °C in a muffle furnace, holding it until the temperature is uniform throughout the specimen for 2 hrs, and was slowly furnace cooled. Material removal rate are calculated by using following Formula, MRR = thickness of work piece X Cutting Velocity X Wire Diameter (mm3/min).

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Surface Roughness Value are Measured using Taylor Hobson Portable Roughness Tester Surtronic 25. Kerf or Cutting Width was measured by has been measured using shadow Principle. Dimensional Deviation % was measured with the help of digital micrometer and the deviation of the measured dimension and Actual dimension By Actual Dimension is calculated in percentage. The following process parameters a considered Pulse on Time (Ton), Pulse off Time (Toff), Peak Current (IP) and Wire Feed are change to measure the material removal rate and surface roughness value in table 1.the theory of GRA were determined by [15].

TABLE 1: INPUT PARAMETER AND THEIR LEVELS

Input	Units	A	B	C
T on	μs	105	115	125
T off	μs	43	53	63
IP	Volts	170	190	210
Wire	m/mi	2	4	6

B. Material Selection

The experiment was carried out on a wire EDM Machine (ELEKTRA MAXICUT). The wire is considered brass material and diameter of 0.25mm.de-ionized water are used as di-electric fluid. The 304 stainless steel chemical composition is shown in Table 2.

TABLE 2: CHEMICAL COMPOSITION

Alloy	C	Si	Mn	Cr	Mo	Cu	Ni
SS 304	0.01	0.4	1.8	18	0.5	0.5	8

TABLE 3: EXPERIMENTAL DESIGN MATRIX AND RESULTS

Trail No	Ton (μs)	Toff (μs)	IP (Volts)	W F - m/min	MRR, mm3/min	Kerf or Cutting Width [mm]	Ra, μm	Dimensional Deviation %
1	105	43	170	2	3.8608	0.215	2.76	0.0023
2	105	53	190	4	3.8608	0.208	2.76	0.0390
3	105	63	210	6	3.6576	0.208	2.653	0.0407
4	115	43	170	2	4.6736	0.197	2.67	0.0577
5	115	53	190	4	4.5212	0.199	2.87	0.0330
6	115	63	210	6	4.1656	0.212	2.94	0.0297
7	125	43	170	2	3.7592	0.196	2.44	0.0267
8	125	53	190	4	3.9624	0.189	2.58	0.0233
9	125	63	210	6	4.0132	0.193	3.05	0.0034

C. **Theory of Grey relation generation**

Step 1: Grey relation generation

The Initial step of grey relation analysis is supported out by pre-processing of the response data. It is achieved for normalizing the data, which is shown in Table 2. The performance characteristic is considered, and hence, it is normalized in the range between 0 to 1 using the formula (4) to avoid the effect of different units and to reduce the variability. The normalized output parameter for Maximum Thinning corresponding to the larger the better criterion is expressed as.

$$X_i^*(k) = \frac{X_i^{(0)}(k) - \min X_i^{(0)}(k)}{\max X_i^{(0)}(k) - \min X_i^{(0)}(k)} \quad (1)$$

Similarly, the normalized output parameter for Maximum Thinning corresponding to the Higher the better criterion is expressed as.

$$X_i^*(k) = \frac{\max X_i^{(0)}(k) - X_i^{(0)}(k)}{\max X_i^{(0)}(k) - \min X_i^{(0)}(k)} \quad (2)$$

Where, is the normalized value, is the maximum value of the sequence, is the desired sequence and is the minimum value of the sequence. Is the minimum value of the sequence.

Step 2: Grey relational coefficients

In the second step, the grey relation coefficient is calculated to express the correlation between the best and actual experimental results for the both the responses. The Table 2, shows the Grey relation coefficient. It is expressed as.

$$\gamma\, x_0(k), x_i^* = \frac{\Delta_{min} - \zeta\Delta_{max}}{\Delta_{oi}(k) + \zeta\Delta_{max}} \quad (3)$$

$$\Delta_{oi}(k) = \|X_0(k) - X_i^*(k)\| \quad (4)$$

Δ_{min} = Smallest value of $\Delta_{oi}(k)$

Δ_{max} = largest value of $\Delta_{oi}(k)$

: Different of obsolete value between denotes the sequences and denotes the comparability sequences. γ is distinguishing or identified coefficient. If all the process parameters have equal weightage, then it is set to be 0.5.

Step 3: Grey relational Grade

The third step of grey relation grade is to determine the average grey relational coefficient corresponding to each performance characteristics. The evaluation of the multi objective characteristic is based on the grey relation grade, which is shown. If the grey relational grade has greater value, it indicates that concerned parameters combination is the optimum value.

The grey relational grade is communicated as pursues.

$$\tau_i = \frac{1}{n}\sum_{i=1}^{n}(\gamma(x_o(k), x_i^*(k))) \quad (5)$$

Where, the grey relational grade, where n is the number of process responses. The higher grey relation grade represents that the corresponding experimental results are considered to be closer to the ideal normalized value.

III. RESULT AND DISCUSSION

The motivation behind the table 5, is to examine which of the procedure parameters essentially influence the execution qualities. This examination gives the relative commitment of Spinning parameters in controlling the reaction of WEDM execution criteria i.e. Grey Relation investigation amid WEDM. The importance of a variable on the quality trademark can be assessed by utilizing F-proportion. The F-proportion is the proportion of MS to the error. By and large, when F is more noteworthy than P-Value, it implies that the difference in test factors significantly affects the quality attributes. The ANOVA table shows that, Feed and Cutting rate are significant for every one of the reactions (F ascertained esteem is more than the table an incentive at 95% confidence level). the ANOVA results shows the T On Plays the Maximum Contribution followed by T Off proceeding the Wire Feed and IP.

Table 4: Normalized values, grey relation coefficient and grey grades of responses.

Trail No	Normalized S/N ratio				Grey relation co efficient				Grey relation	
	MRR	Kerf	Ra	Dimensional Deviation %	MRR	Kerf	Ra	Dimensional Deviation %	GRADE	RANK
1	0.779	1.000	0.552	0.000	0.694	1.000	0.527	0.333	0.639	4
2	0.779	0.743	0.552	0.878	0.694	0.660	0.527	0.804	0.671	3
3	1.000	0.743	0.375	0.892	1.000	0.660	0.444	0.822	0.732	1
4	0.000	0.321	0.404	1.000	0.333	0.424	0.456	1.000	0.553	7
5	0.135	0.400	0.728	0.827	0.366	0.455	0.647	0.742	0.553	8
6	0.469	0.891	0.835	0.794	0.485	0.821	0.752	0.708	0.692	2
7	0.888	0.282	0.000	0.761	0.817	0.411	0.333	0.676	0.559	6
8	0.674	0.000	0.250	0.719	0.605	0.333	0.400	0.640	0.495	9
9	0.621	0.163	1.000	0.121	0.569	0.374	1.000	0.363	0.576	5

Table 5: Results of ANOVA on Grey Grade

Source of variation	Sum of Squares	DOF	Mean Square	F	F table	Contribution
T on	0.0285	2	0.0143	71.37	4.2	57.62
T off	0.0157	2	0.0079	39.37	4.2	31.78
IP	0.0003	2	0.0002	0.76	4.2	0.61
Wire Feed	0.0049	2	0.0025	12.37	4.2	9.99
Error	0.002	9	0.000200	—		
SST	0.0495	17				

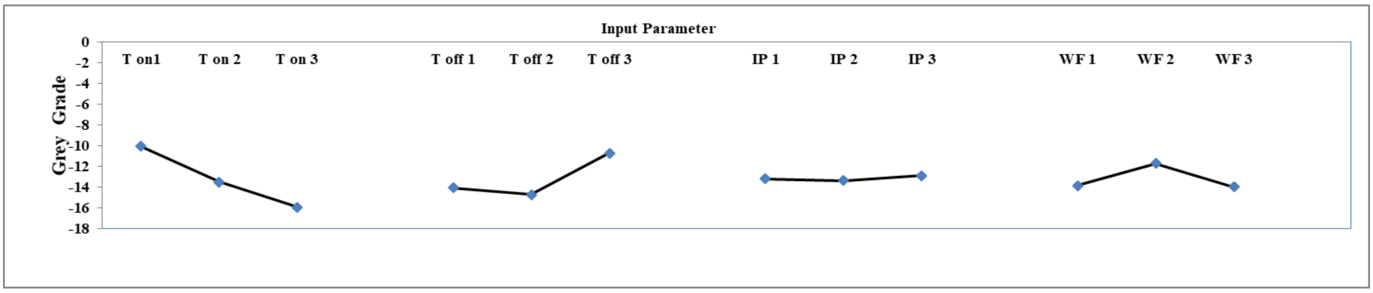

Figure.1. Factor effects on grade values

Figure 1, indicates that, T On 1 of 105 µs, T Off 3 of 63 µs, IP 3 of 210 Volts and WF 2 4 m/min most optimum conditions for obtaining Grade Value.

IV. CONFIRMATION EXPERIMENT

The affirmation analyze is directed at the ideal settings to check the quality attributes for Heat Treated WEDM process suggested by the examination. The reaction esteems by the affirmation analyze trial at the ideal settings are T On 1 of 105 µs, T Off 3 of 63 µs, IP 3 of 210 Volts and WF 2 4 m/min. The Grey Relational investigation grade an incentive according to above discussion is observed to be 0.54.

Consequently, the Grey Relation investigation for the enhancement of the multi reaction issues is an exceptionally helpful device for anticipating the Output reactions

V. CONCLUSION

Experimental Investigation on Electrical Discharge Machining material of 304 stainless steel is performed with a view to correlate the process parameter with the responses such as Surface Roughness Ra, Material Removal Rate (MRR), Kerf and Dimensional Deviation %. The effects of Pulse On time, Pulse Off time, Peak Current, IP and Wire Feed, setting are experimentally investigated in machining of

304 stainless steel using CNC Wire-cut EDM process. The various level as performed to the machining parameters on the material removal rate is determined by using Grey Relation Analysis the Optimum Parameters are T On 1 of 105 µs, T Off 3 of 63 µs, IP 3 of 210 Volts and WF 2 4 m/min most optimum conditions for obtaining Grade Value was determined and verified.

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