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PARAMETRIC OPTIMIZATION OF MACHINING PROCESS PARAMETERS OF EDM FOR WC ROLLED WORK-PIECE BY USING GRA OPTIMIZATION METHOD

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ABSTRACT

Electric discharge machining has become an important and cost-effective approach of machining very brittle and hard electrically conductive materials. It is extensively use in evaluate with the alternative machining techniques of creating dies, moulds and sections in which the complicated measurement and hard shapes can't be machined easily. The paintings-piece fabric has been selected for this trial is tungsten carbide assessing its erosion obstruction homes and extensive scope of utilizations. Out of diverse enter parameters in EDM technique this paintings became targeted on discharge current (Ip), pulse on time (Ton) and pulse off time (Toff). For layout of test a completely well-known Taguchi approach is implemented to make a L18 orthogonal cluster for enter factors. For the handled effect of the variable limitations referenced above after machining reactions, for fabric elimination rate (MRR) and Surface roughness (SR) may be performed with GRA method for optimization and investigated. Discharge current is the maximum extensive challenge at the same time as machining on our study's findings. The tool electrode has been selected as copper electrode. ANOVA have been determined for the maximum extensive parameters of MRR and SR.

Keywords: GRA Method, MRR, Conductive Materials, Pulse On Time Etc.

I. INTRODUCTION

Discharge machining, commonly known as EDM, is a unique machining method used to remove material by a number of repeated, short-duration, high-current discharges between the work-piece and the tool. EDM is an important and cost-effective method for machining extremely tough and brittle conductive materials. In EDM, since there is no direct contact between the part and the electrode, there is no mechanical force between them. Any type of conductive material can be machined with EDM, regardless of its hardness or toughness.

During this process, material is removed from the work-piece due to corrosion caused by rapidly repeated spark discharge between the work-piece and the tool electrode. There is a small gap between the tool and the work-piece. Both the work-piece and the tool are immersed in a dielectric fluid, commonly used EDM oil, deionized water, and kerosene. Therefore, the conventional EDM machine is equipped with a pulse source to accommodate the above 4 processes, but will inevitably lead to discharge for the existence of the pulse gap. In fact, there is no material removal during the discharge channel formation phase when the plasma channel occurs between the electrode and the work-piece. In addition, at the discharge stage, the electrode will be pulled up to complete the deionization and remove debris from the discharge space. Therefore, this will waste a lot of time removing material efficiently for the back and forth movement of the electrodes. EDM machining is executed through electric powered sparks that leap among electrodes subjected to a voltage and submerged in a dielectric fluid. Thus, the voltage carried out to them need to be sufficient to create an electric powered area better than the dielectric tension of the fluid used with inside the process. As a outcome of this electric powered area, tremendous ions and electrons are accelerated, generating a discharge channel that turns into conductive. It is simply at this factor while the spark jumps inflicting collisions among ions and electrons and growing a channel of plasma. A unexpected drop of the electrical resistance of the preceding channel permits that contemporary density reaches very excessive values generating an boom of ionization and the introduction of a effective magnetic area. Many researchers had accomplished a huge quantity of primary studies paintings to enhance machining performance of traditional EDM, which have been specially cognizance on machining

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mechanisms, electrodes, dielectric, extra auxiliary situations and optimization of EDM machining parameter. These results make a bit a part of steel quantity soften or maybe vaporise. In those conditions, that is, ions and electrons crashing amongst them and consequently developing excessive temperatures in each poles, a gas all or bubble is shaped across the plasma channel after which starts to develop offering simply on the cease of the release a big ball of gas. In this situation, electric powered contemporary is close off and the plasma channel collapses generating the spark to disappear. Due to the surprising lower of inner strain of the gas ball, the dielectric fluid breaks it making the ball impulse, that is, explode inwards. As a effect of this implosion, an ejection of molten steel is done and, afterwards, this ejected molten fabric solidifies withinside the shape of little balls shaped the so referred to as EDM splinter or debris.

II. METHODOLOGY

Optimizing tools combine modern computer science, statistics, and/ or artificial intelligence science for research such as the Taguchi method, grey relational analysis (GRA), response surface methodology (RSM), analysis of variance (ANOVA), particle swarm optimization (PSO), genetic algorithm (GA), and artificial intelligence (AI). The Taguchi method is used for fewer experimental combinations. It allows the experiments to investigate the importance of many factors simultaneously and find the best combination in a controlled way. Nowadays, researchers primarily select the DOE based on the assumed importance of the factors and the desired number of experimental runs.

Different Grades of Tungsten Carbide will range in Strength, Rigidity, and different properties, however all Tungsten Carbide Material falls into the simple properties. Tungsten carbide has very excessive energy for a fabric so tough and inflexible. Compressive energy is better than simply all melted and forged or solid metals and alloys. Tungsten carbide compositions variety from to 3 times as inflexible as metallic and 4 to 6 times as inflexible as forged iron and brass. Tungsten-base carbides carry out nicely as much as approximately 1000°F in oxidizing atmospheres and to 1500°F in non-oxidizing atmospheres. Thermal conductivity of tungsten carbide is withinside the variety of two times that of device metallic and carbon metallic.

Tungsten carbide rolled work-piece was procured from Industries, Raipur in shape of hollow cylindrical ring of 50 mm height for the current experimentation. Electrolytic copper tool of 10 x 4 mm^2 I section type was used due to its better electrical conductivity for the EDM process. Followed Table 1 demonstrates the percentage of chemical composition of tungsten carbide. All the experiments were conducted on a CNC EDM machine (Model Xpert-1) make by electronica india limited where in a procured work-piece and commercial rectangle shaped copper tool were used as electrodes. Machine specification followed by Table 2.

Measurement of Response:

For fabricate arrayed structure, the output response such as MRR was calculated. The dimension come up to of this output response was discussed as below: **MRR** is defined as the ratio of the variation of weight of the work piece before and after machining to the machining time and density of the material as shown in below equation.

$$\textbf{MRR} = \frac{Wi - Wf}{D * t} \quad mm^3/min. \quad \text{.....Eq.(1)}$$

Where,

Wi = weight before machining (gm),

Wf = weight after machining (gm),

D = density of work piece material (gm/mm^3)

t = time consumed for machining (min).

Surface Roughness:

The microholes produced in work-piece by means of EDM method were examined under Talysurf Profilometer. The roughness region around the machined hole is detected. The solidified debris is also seen as the debris particles are unable to escape from the machining zone and stuck to the machined surface. The removal of debris from the inter electrode gap at a high and low rotation speed of the tool electrode is schematically shown in Fig. 1. Thermal degradation of the matrix material due to immense heat generation is quite evident in the micrographic image of the hole bottom surface. The heat produced is significantly high during EDM, which causes melting or burning of the work-piece.

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III. EXPERIMENTATION AND ANALYSIS

Optimization Technique Used - Grey Relational Analysis (GRA):

Grey relational analysis (GRA) is element of grey system theory, which is intended for solving problems with problematical interrelationships between many factors and variables. GRA solve MADM complication by combining the variety of performance characteristic values being measured for every option into one particular value. This reduces the original problem toward a single-objective decision-making problem. This article suggests a grey-based Taguchi method for optimizing multi-response objective problems. An experimental model is optimized by the interaction of the Taguchi technique in which the multi-response values are processed by GRA. The Taguchi method attempts to use a small amount of computational time to conduct experiments based on orthogonal arrays to search for the maximum yield. In the Taguchi method, there are three regiments, including smaller the better (SB), nominal the best (NB), and larger the better (LB), to search for the best experimental results.

The proposed grey-based Taguchi method for simulation optimization follows the optimization method (the Taguchi method) developed by Dr Genichi Taguchi. However, the Taguchi method only works for optimization of a single performance characteristic. The GRA procedure is used to combine all the considered performance characteristics into a single value that can then be used as the single characteristic in optimization problems. The procedure of the grey-based Taguchi method is shown in Figure 1.

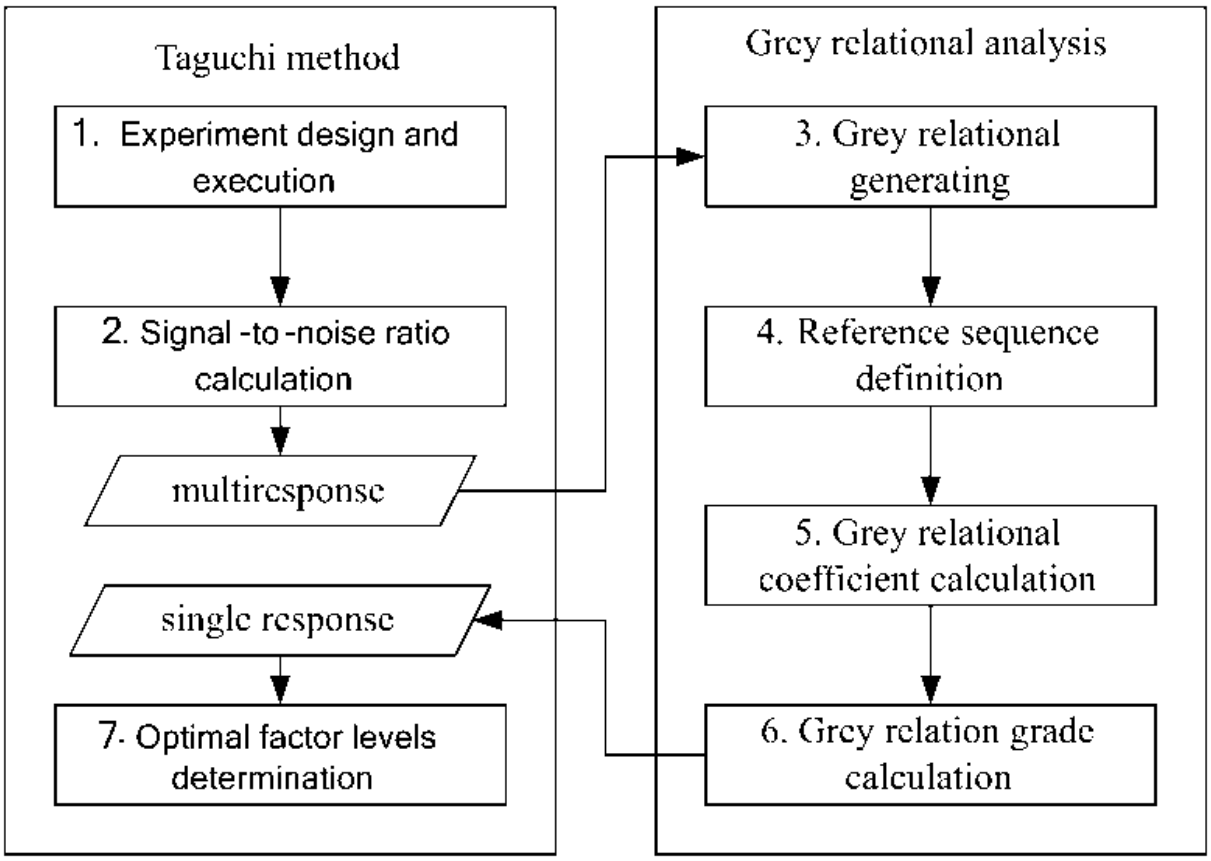

Figure 1: Procedure of the grey-based Taguchi method.

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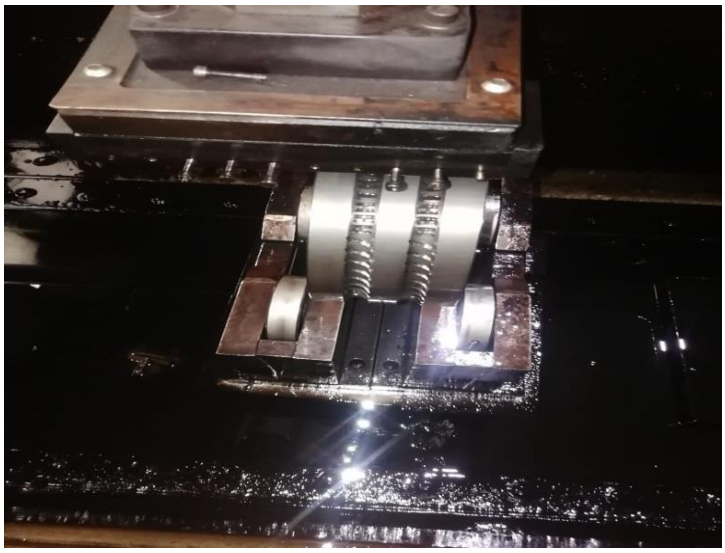

Figure 2: Experimental setup of Copper tool and Workpiece (WC Rolled).

In the current study, the machining was done by choosing discharge current (Ip), pulse-on time (Ton) and pulse-off time (Toff) as input parameters and the other parameters such as duty factor (τau) equal to 80 % and gap voltage of 50 V are kept constant throughout the experiment.

Allocated Values of EDM parameters and their levels:

Table 1

Machining parameters	Symbol	Units	Levels Level 1	Level 2	Level 3
Discharge current	I_p	amp	15	12	8
Pulse on time	T_{on}	µs	450	350	150
Pulse off time	T_{off}	µs	50	30	15

DoE (Design of experiment) Matrix of L18 Orthogonal array (OA)

Table 2. Observation Table

Experiment run no.	Discharge current Amps.	Pulse on time Ms	Pulse off time µs	MRR (mm^3/min.)	SR Microns
1	15	450	50	0.0173	5.7324
2	15	350	30	0.0119	4.2667
3	15	150	15	0.0633	4.4667
4	12	450	50	0.0101	6.5000
5	12	350	30	0.0082	6.9678
6	12	150	15	0.0036	7.8234
7	8	450	30	0.0033	8.5423
8	8	350	15	0.0019	8.0123
9	8	150	50	0.0022	7.6667
10	15	150	15	0.0155	8.3667
11	15	350	50	0.0052	8.7324
12	15	450	30	0.0201	6.3667
13	12	150	30	0.0034	9.5867

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14	12	350	15	0.0061	9.5000
15	12	450	50	0.0073	8.1324
16	8	150	15	0.0015	9.7682
17	8	350	50	0.0009	10.4333
18	8	450	30	0.0043	8.8976

IV. RESULTS AND DISCUSSION

Based on the above limitation of EDM the calculated experiment is performed and calculation is done. And found that which combination of machined parameters is best suited for industry application to get higher material removal rate over the work-piece. The present study discussed contribution of electrical process parameters for efficient EDM process in various aspects such as state of art, influence of the discharge energy, modeling of EDM process parameters, pulse generators, pulse shape, monitoring the parameters and optimization of EDM process parameters. It has been realized that the lower discharge energy has produced good surface finish. Taguchi multilevel designs tend to use fewer experimental runs, but they do not allow one to include a high number of factors. In this analysis, three designs showed very good performance: 2L + 4Lx2F (L32), 3Lx3F (L27), and 2L + 3Lx2F (L18), where the last one had the highest efficiency in comparison to all other tested designs.

Table 3. Calculated Normalization, deviation sequence, grey relational coefficient, grey relation grade and rank order

S.N.	Normalization MRR	Normalization SR	Deviation MRR	Deviation SR	GRC MRR	GRC SR	GRG	Rank
1	0.737	0.762	0.263	0.238	0.655	0.678	0.667	10
2	0.824	1.000	0.176	0.000	0.739	1.000	0.870	1
3	0.000	0.968	1.000	0.032	0.333	0.939	0.636	15
4	0.853	0.638	0.147	0.362	0.772	0.580	0.676	5
5	0.883	0.562	0.117	0.438	0.810	0.533	0.672	7
6	0.957	0.423	0.043	0.577	0.920	0.464	0.692	4
7	0.962	0.307	0.038	0.693	0.929	0.419	0.674	6
8	0.984	0.393	0.016	0.607	0.969	0.452	0.710	3
9	0.979	0.449	0.021	0.551	0.960	0.476	0.718	2
10	0.766	0.335	0.234	0.665	0.681	0.429	0.555	18
11	0.931	0.276	0.069	0.724	0.879	0.408	0.644	13
12	0.692	0.659	0.308	0.341	0.619	0.595	0.607	17
13	0.960	0.137	0.040	0.863	0.926	0.367	0.646	12
14	0.917	0.151	0.083	0.849	0.857	0.371	0.614	16
15	0.897	0.373	0.103	0.627	0.830	0.444	0.637	14
16	0.990	0.108	0.010	0.892	0.981	0.359	0.670	8
17	1.000	0.000	0.000	1.000	1.000	0.333	0.667	9
18	0.946	0.249	0.054	0.751	0.902	0.400	0.651	11

Studying the variation of the EDM process response characteristics due to change in shape of the generated pulse is one of the research aspects in the EDM process. The discharge pulse shape affects the average spark energy which is delivered on the surface. Since the machining characteristics in EDM process depend on the electrical energy, the pulse shape which has an effect on the machining characteristics such as material removal rate, surface quality and electrode wear rate.

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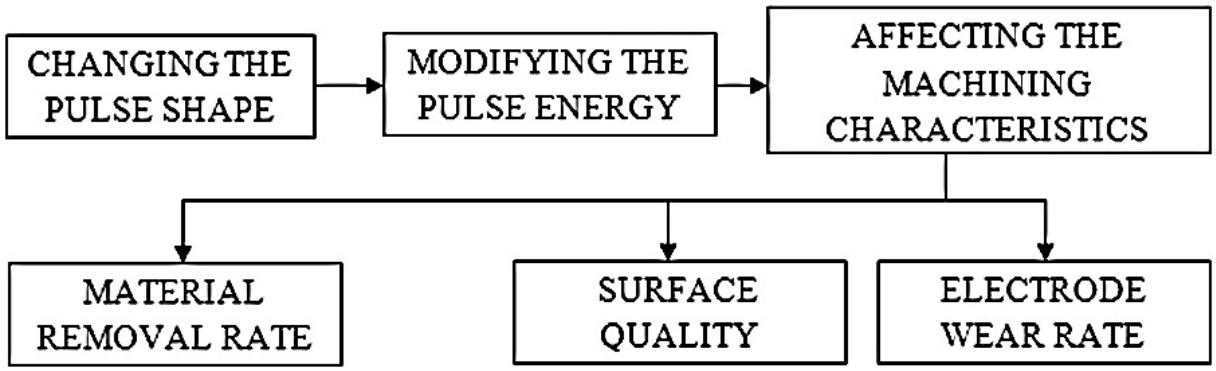

Figure 3: Relation between pulse shape and machining characteristics in EDM process.

ANOVA Analysis

Model F-value of 5.87 and the ρ-value of 0.027 means that the model is significant, while the "Lack of Fit" F-value of 0.001362 means that it is not significant relative to the pure error. The established GRA model is quite representative. The residual indicates the difference between the actual value and the estimated value, and shows that the prediction model is good enough as the sum of the square is only 0.000481. F-value is the mean square for the term divided by the mean square for the residual. As a consequence, a larger F-value means the parameter is more significant. The p-value has a trend to be inversely proportional to the F value.

ANOVA TABLE

Source	DF	Seq SS	Adj SS	Adj MS	F	P
A	2	0.000678	0.000706	0.000353	5.87	**0.027**
B	2	0.0001	0.000096	0.000048	0.8	0.484
C	2	0.000103	0.000103	0.000051	0.85	0.461
Residual Error	8	0.000481	0.000481	0.00006		
Total	14	0.001362				

V. CONCLUSION

This research proposed the grey-based Taguchi method to solve a multi-response simulation optimization problem. Following the procedure of the Taguchi method, GRA was used to transform a multi-response problem into a single-response problem. The current examination explored the reasons for different interaction boundaries on multi responses using grey relation analysis during the machining of WC Rolled work-piece using copper tool. Following are the conclusions drawn with respect to the experimentation.

- Grey relational analysis is found to be more suitable optimization tool for multi response optimization and based on the GRG the maximum value is obtained for experimental run number 3.
- In this experiment run the optimum process parameter are at 15 Amperes of discharge current, 150 µs of pulse on time and 15 µs of pulse off time for the given responses with assigned range of setting.
- The results are compared with ANOVA and form the statistical investigation. It is uncovered that the release current is mostly affecting boundary followed by pulse on time schedule and pulse off time an ideal opportunity to get the higher material evacuation. The contour analysis plot represents the optimized grey relational grade with combination of input variables.
- The degree of machining boundaries can be extended by selecting new electrically conductive materials by introducing hybrid optimization technique.

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