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# Integrating EDAS Method with MW Method to Optimize the Process Parameters in the Electro-Discharge Machining Process

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**ABSTRACT:** In today's tremendous competitive market, industrial produce should possess high precision and quality and should be manufactured in minimal time. To obtain these objectives, the input parameters are controlled to attain the desired output depending on the conditions. The optimization technique is introduced to overcome this type of problem. Here the authors introduce a multi-criteria decision-making technique to get the optimization value. As we know Electrical discharge machining (EDM) in the nonconventional machining process is applied for machining complicated or intricate geometries on raw materials. The present work attempts to optimize several responses of machining operation using multi-criteria decision making (MCDM) by employing different machining parameters like Pulse-on time (Ton), Discharge current (Ip), and Dielectric fluid pressure (Fp). The Taguchi L9 orthogonal experimental design is followed during electrical discharge machining of SAE 1015 mild steel of size 80 × 50 × 5 mm using sing tungsten as the electrode. The productivity performance of the EDM process is measured in terms of material removal rate (MRR) and its cost parameter is measured in terms of tool wear rate (TWR) and electrode wear rate (EWR). The VIKOR method is used in conjunction with mean weight (MW) for criterion weight allocation strategies.

**KEYWORDS:** MCDM, EDAS, Optimization, EDM, Taguchi Method, ANOVA

## I. INTRODUCTION

The advanced materials have attractive properties i.e., high strength, high bending stiffness, good damping capacity, low thermal expansion, and better fatigue characteristics which make them potential materials for modern-day industrial applications. Present manufacturing industries are facing challenges from these advanced materials viz. superalloys, ceramics, and composites, that are hard and difficult to machine, requiring high precision, and surface quality which increases machining cost [1].

The Electrical discharge machining process is an unconventional machining method popular for almost seven decades. Other names for this type of machining are spark machining and spark eroding. The process of EDM has gained popularity worldwide and substituted conventional machining methods. In this type of machining process, material expulsion utilizes electrical energy and transforms it into heat through a progression of rapidly repeating sparks amidst tools and workpieces immersed in a dielectric medium. One of the electrodes is a tool while the other is a workpiece. The shape of the material removed is controlled to develop an object with the required geometry and surface finish [2]. In such machining, tool and workpiece do not have immediate interaction. This process is employed to machine hard metals like titanium and pre-hardened steel and materials which can't be easily machined by employing the traditional process.

## II. RELATED WORK

Optimization refers to the technique of allocation of responsible resources to give the best possible effect. The Taguchi method is a well-known technique that provides an efficient and systematic methodology for process optimization. This is due to the advantage of the design of the experiment using Taguchi's technique which includes simplification of the experimental plan and feasibility of study of the interaction between different parameters. Analysis of Variance (ANOVA) is then used to determine which process parameter is statistically significant and the contribution of each parameter toward the output characteristic.

In this work, L9 Array has been used in experimental design for the optimization of input parameters. This paper attempt to introduce and then verify experimentally how the Taguchi design can be used in targeting the significant processing parameters and optimizing the surface roughness in the turning operation.

To optimize the turning off operation, the Taguchi method is used to find optimal parameters for the surface finish in turning, the basic parameters are feed rate, speed, and depth of cut. The selection of optimal machining parameters is critical for ensuring product quality, lowering manufacturing costs, and increasing productivity in computer-controlled manufacturing processes. Multi-objective optimization of turning based on inherent process complexity has been a competitive engineering issue for many years.

Karthikeyan [3] presented the mathematical modeling of EDM with aluminum-silicon carbide particulate composites. The effect of MRR, TWR, and SR with Process parameters that were taken into consideration was the current (I), the pulse duration (T), and the percent volume fraction of SiC (25  $\mu$  size). A three-level full factorial design was used. Finally, the significance of the models was checked by the ANOVA.

Biing Hwa [4] investigated the feasibility and optimization of a rotary EDM with ball burnishing for inspecting the machinability of Al<sub>2</sub>O<sub>3</sub>/6061Al composite using the Taguchi method. Three ZrO<sub>2</sub> balls attached as additional components behind the electrode tool offer immediate burnishing followed by EDM. The design of the tool electrode was Copper ring-shaped EDM. This EDM process approaches both a higher machining rate and a finer surface roughness.

Tsai et al [5] studied that the electrodes made by powder metallurgy technology from special powders were used to modify EDM surfaces in recent years, to improve wear and corrosion resistance. Electrodes were made at low pressure (20 MPa) and temperature (200 °C) in a hot mounting machine. The recast layer was thinner and fewer cracks were present on the machined surface. P. Narender Singh [6] discussed the evolution of the effect of the EDM current (C), Pulse ON-time (P), and flushing pressure (F) on MRR, TWR, taper (T), OC, and surface roughness (SR) on machining as-cast Al with 10% SiCp. ELEKTRAPULS spark erosion machine was used for the purpose and jet flushing of the dielectric fluid, kerosene, was employed. A brass tool with a diameter of 2.7mm was chosen to drill the specimens. ANOVA was performed and the optimal levels for maximizing the responses were established.

## III. METHODOLOGY

### 3.1 Experimental Design

In the current thesis work, the value of Material Removal Rate (MRR) is maximized and the tool wear rate (TWR) and electrode wear rate (EWR) are minimized. Using an Electric Discharge Machine, experiments were carried out on die-sinking machines. To maximize the rate of material removal and minimize surface roughness, they used the Simulated Annealing optimization technique. For their experimental work, they selected Pulse-on time (Ton), Discharge current (Ip), and Dielectric fluid pressure (Fp) as process parameters.

To optimize the material removal rate, tool wear rate, and electrode wear rate, we applied the Taguchi method and Taguchi-based ANOVA analysis after doing some experiments. For the current work, various experimental parameters, symbols, units, and levels are provided in Table.1.

Table 1. Input parameters and their levels

| Process parameter | Units            | Level 1 | Level 2 | Level 3 |
|-------------------|------------------|---------|---------|---------|
| Pulse-on time     | $\mu\text{s}$    | 50      | 100     | 200     |
| Flushing Pressure | $\text{Kg/cm}^2$ | 0.3     | 0.4     | 0.5     |
| Discharge Current | A                | 18      | 20      | 22      |

Table 2. Experimental results

| Experiment No. | Pulse-on time | Flushing Pressure | Discharge Current | MMR    | TWR    | EWR    |
|----------------|---------------|-------------------|-------------------|--------|--------|--------|
| 1              | 50            | 0.3               | 18                | 0.0760 | 0.0119 | 0.2949 |
| 2              | 100           | 0.4               | 18                | 0.1225 | 0.0121 | 0.2320 |
| 3              | 200           | 0.5               | 18                | 0.1119 | 0.0149 | 0.2848 |
| 4              | 50            | 0.4               | 20                | 0.1426 | 0.0182 | 0.2998 |
| 5              | 100           | 0.5               | 20                | 0.1983 | 0.0215 | 0.2546 |
| 6              | 200           | 0.3               | 20                | 0.1989 | 0.0232 | 0.2744 |
| 7              | 50            | 0.5               | 22                | 0.1253 | 0.0199 | 0.1848 |
| 8              | 100           | 0.3               | 22                | 0.2001 | 0.0259 | 0.3036 |
| 9              | 200           | 0.4               | 22                | 0.2088 | 0.0150 | 0.1659 |

### 3.2 Weight allocation using the Mean weight method

This method is based on the principle of equal weight distribution to all output responses. Equal weights are assigned in this approach to give equal importance to each parameter while evaluating the influence of each parameter on selecting an optimal set for machining. For the current three criteria (MMR, TWR, and EWR) EDM optimal process parameter selection problem, the weight vector is expressed as,  $W=[0.33 \ 0.33 \ 0.33]$ . Henceforth, in this study, for ease of reference, the solutions from these weights applied to EDAS are called as MW-EDAS.

### 3.3 Evaluation based on distance from average solution (EDAS) method

This section presents a newly developed method called EDAS to deal with MCDM problems [7]. This newly developed method uses the average solution for appraising the alternatives. Positive distance average (PDA) and negative distance average (NDA) are considered two measures for the appraisal of alternatives. These measures can demonstrate the difference between each alternative and the average solution. Moreover, measures are calculated according to the type of criteria (beneficial or non-beneficial). The best solution in the EDAS method is calculated based on the distance from the average solution (AV). Higher values of PDA and/or lower values of NDA indicate that the alternative is better than the average solution [8]. Moreover, the necessity for calculating the ideal and nadir solution is eliminated in the proposed methodology, as required in other MCDM techniques, such as VIKOR and TOPSIS.

The main steps of the EDAS method are presented as follows

Step 1. Select the most important criteria that describe alternatives.

Step 2. Construct the decision-making matrix  $X$ , shown as follows:

$$X = [x_{ij}]_{n \times m} = \begin{bmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{bmatrix}$$

where  $x_{ij}$  ( $x_{ij} \geq 0$ ) denotes the performance value of  $i$ -th alternative on  $j$ -th criterion ( $i \in \{1, 2, \dots, n\}$  and  $j \in \{1, 2, \dots, m\}$ ).

Step 3. Determine the average solution according to all criteria, shown as follows:

$$AV = [AV_j]_{1 \times m}$$

Where,

$$AV_j = \frac{\sum_{i=1}^n X_{ij}}{n}$$

Step 4: Calculate the positive distance from average (PDA) and the negative distance from average (NDA) matrixes according to the type of criteria (benefit and cost), shown as follows:

$$PDA = [PDA_{ij}]_{n \times m}$$

$$NDA = [NDA_{ij}]_{n \times m}$$

If the  $j$ th criterion is beneficial

$$PDA_{ij} = \frac{\max(0, (X_{ij} - AV_j))}{AV_j}$$

$$NDA_{ij} = \frac{\max(0, (AV_j - X_{ij}))}{AV_j}$$

And if the  $j$ th criterion is non-beneficial

$$PDA_{ij} = \frac{\max(0, (AV_j - X_{ij}))}{AV_j}$$

$$NDA_{ij} = \frac{\max(0, (X_{ij} - AV_j))}{AV_j}$$

where  $PDA_{ij}$  and  $NDA_{ij}$  denote the positive and negative distance of the  $i$ -th alternative from the average solution in terms of the  $j$ th criterion, respectively.

Step 5. Determine the weighted sum of PDA and NDA for all alternatives, shown as follows:

$$SP_i = \sum_{j=1}^m w_j PDA_{ij}$$

$$NP_i = \sum_{j=1}^m w_j NDA_{ij}$$

where  $w_j$  is the weight of the  $j$ th criterion.

Step 6. Normalize the values of SP and SN for all alternatives, shown as follows:

$$NSP_i = \frac{SP_i}{\max_i(SP_i)}$$

$$NSN_i = 1 - \frac{SN_i}{\max_i(SN_i)}$$

Step 7. Calculate the appraisal score (AS) for all the alternatives, shown as follows:

$$AS_i = \frac{1}{2} (NSP_i + NSN_i)$$

where  $0 \leq AS_i \leq 1$ .

#### IV. EXPERIMENTAL RESULTS

This methodology is based on ranking and selecting the best alternative by eliminating the units of all criteria through the normalization process listed in Table 2. Then, the desirable (beneficial) solution and non-desirable (non-beneficial) solution were computed. The EWR and TWR are considered as Lower-is-better (LB) type characteristics while Higher-is better (HB) criteria were preferred for MRR.

Table 3. Decision Matrix of Output

|            | MMR    | TWR    | EWR    |
|------------|--------|--------|--------|
| EXP. 1     | 0.0760 | 0.0119 | 0.2949 |
| EXP. 2     | 0.1225 | 0.0121 | 0.2320 |
| EXP. 3     | 0.1119 | 0.0149 | 0.2848 |
| EXP. 4     | 0.1426 | 0.0182 | 0.2998 |
| EXP. 5     | 0.1983 | 0.0215 | 0.2546 |
| EXP. 6     | 0.1989 | 0.0232 | 0.2744 |
| EXP. 7     | 0.1253 | 0.0199 | 0.1848 |
| EXP. 8     | 0.2001 | 0.0259 | 0.3036 |
| EXP. 9     | 0.2088 | 0.0150 | 0.1659 |
| Total      | 1.3843 | 0.1626 | 2.2947 |
| Avg.       | 0.1538 | 0.0181 | 0.2550 |
| Weight(Wi) | 0.3300 | 0.3300 | 0.3300 |

Calculate the positive distance from average (PDA) and the negative distance from average (NDA) matrixes according to the type of criteria (beneficial and non-beneficial)

Table 4. Average Values of PDA and NDA

| Positive distance from average (PDA) |        |        |        | Negative distance from average (NDA) |        |        |        |
|--------------------------------------|--------|--------|--------|--------------------------------------|--------|--------|--------|
|                                      | MMR    | TWR    | EWR    |                                      | MMR    | TWR    | EWR    |
| EXP. 1                               | 0.0000 | 0.3401 | 0.0000 | EXP. 1                               | 0.5061 | 0.0000 | 0.1565 |
| EXP. 2                               | 0.0000 | 0.3301 | 0.0903 | EXP. 2                               | 0.2036 | 0.0000 | 0.0000 |
| EXP. 3                               | 0.0000 | 0.1748 | 0.0000 | EXP. 3                               | 0.2725 | 0.0000 | 0.1168 |
| EXP. 4                               | 0.0000 | 0.0000 | 0.0000 | EXP. 4                               | 0.0731 | 0.0070 | 0.1760 |
| EXP. 5                               | 0.2889 | 0.0000 | 0.0015 | EXP. 5                               | 0.0000 | 0.1897 | 0.0000 |
| EXP. 6                               | 0.2929 | 0.0000 | 0.0000 | EXP. 6                               | 0.0000 | 0.2862 | 0.0761 |
| EXP. 7                               | 0.0000 | 0.0000 | 0.2752 | EXP. 7                               | 0.1852 | 0.0995 | 0.0000 |
| EXP. 8                               | 0.3009 | 0.0000 | 0.0000 | EXP. 8                               | 0.0000 | 0.4320 | 0.1908 |
| EXP. 9                               | 0.3576 | 0.1693 | 0.3493 | EXP. 9                               | 0.0000 | 0.0000 | 0.0000 |

determine the weighted sum of PDA ( $WP_i$ ) by taking the sum of multiplication of weight vector ( $w_j$ ) with  $PDA_{ij}$  and a weighted sum of NDA ( $WN_i$ ) by taking the sum of multiplication of weight vector with  $NDA_{ij}$  for all the alternatives

Table 5. Weighted Values of PDA and NDA

| Positive distance from average (PDA) |        |        |        | Negative distance from average (NDA) |        |        |        |
|--------------------------------------|--------|--------|--------|--------------------------------------|--------|--------|--------|
|                                      | MMR    | TWR    | EWR    |                                      | MMR    | TWR    | EWR    |
| EXP. 1                               | 0.0000 | 0.1122 | 0.0000 | EXP. 1                               | 0.1670 | 0.0000 | 0.0516 |
| EXP. 2                               | 0.0000 | 0.1089 | 0.0298 | EXP. 2                               | 0.0672 | 0.0000 | 0.0000 |
| EXP. 3                               | 0.0000 | 0.0577 | 0.0000 | EXP. 3                               | 0.0899 | 0.0000 | 0.0385 |
| EXP. 4                               | 0.0000 | 0.0000 | 0.0000 | EXP. 4                               | 0.0241 | 0.0023 | 0.0581 |
| EXP. 5                               | 0.0954 | 0.0000 | 0.0005 | EXP. 5                               | 0.0000 | 0.0626 | 0.0000 |
| EXP. 6                               | 0.0967 | 0.0000 | 0.0000 | EXP. 6                               | 0.0000 | 0.0944 | 0.0251 |
| EXP. 7                               | 0.0000 | 0.0000 | 0.0908 | EXP. 7                               | 0.0611 | 0.0328 | 0.0000 |
| EXP. 8                               | 0.0993 | 0.0000 | 0.0000 | EXP. 8                               | 0.0000 | 0.1426 | 0.0630 |
| EXP. 9                               | 0.1180 | 0.0559 | 0.1153 | EXP. 9                               | 0.0000 | 0.0000 | 0.0000 |

Alternatives are ranked from best to worst alternatives based on decreasing appraisal scores. Among the alternatives, the one with the highest  $AS_i$  value is the best choice. The values of  $NPW_i$ ,  $NWN_i$ , appraisal score, and associated rank were produced using the mean weight-based EDAS technique.

Table 6. Appraisal score and corresponding Rank

|        | Pulse-on time | Flushing Pressure | Discharge Current | NSPi   | NSNi   | Asi    | Rank |
|--------|---------------|-------------------|-------------------|--------|--------|--------|------|
| EXP. 1 | 50            | 0.3               | 18                | 0.3882 | 0.7813 | 0.5848 | 6    |
| EXP. 2 | 100           | 0.4               | 18                | 0.4797 | 0.9328 | 0.7063 | 2    |
| EXP. 3 | 200           | 0.5               | 18                | 0.1995 | 0.8715 | 0.5355 | 8    |
| EXP. 4 | 50            | 0.4               | 20                | 0.0000 | 0.9155 | 0.4578 | 9    |
| EXP. 5 | 100           | 0.5               | 20                | 0.3315 | 0.9374 | 0.6344 | 3    |
| EXP. 6 | 200           | 0.3               | 20                | 0.3343 | 0.8804 | 0.6074 | 5    |
| EXP. 7 | 50            | 0.5               | 22                | 0.3140 | 0.9060 | 0.6100 | 4    |
| EXP. 8 | 100           | 0.3               | 22                | 0.3434 | 0.7945 | 0.5690 | 7    |
| EXP. 9 | 200           | 0.4               | 22                | 1.0000 | 1.0000 | 1.0000 | 1    |

The optimal level of selection of the main effects parameter is evaluated based on each level result of the EDAS method Index as shown in Table 6. The best level for each factor is identified by the highest Index Value is considered. From the table, it is found that experiment no. 9 is the most optimal process parameter for the Electro Discharge Machining Process followed by experiment no. 2 and experiment no. 5.

## V. CONCLUSION

This research has concluded that of the nine experiment parameters, calculated with the Taguchi method and Taguchi-based ANOVA analysis after doing many experiments, an attempt has been made to show the applicability of the MCDM based EDAS method in combination with MW has been utilized for optimization of multiple quality characteristics in an EDM operation. Hence this study is simple and successfully optimized the multi machining problem in both the researchers and industries to solve the machining selection problem for any type of



nonconventional machining process. Also from the ANOVA analysis, the selected model is a more than 95% confidence level.

#### REFERENCES

- [1] Kozak, J.; Rajurkar, K.P. (2001): Hybrid machining processes, Evaluation and development, Proceedings of 2nd International Conference on Machining and measurement of sculptured surfaces, Krakow, pp.501-536.
- [2] Saha, A & Mandal, N. (2013). Optimization of machining parameters of turning operations based on multi-performance criteria. International Journal of Industrial Engineering Computations, 4(1), 51-60.
- [3] R. Karthikeyan, P.R. Lakshmi Narayanan, and R.S. Naagarazan, "Mathematical modeling for electric discharge machining of aluminium-silicon carbide particulate composites", Journal of Materials Processing Technology, vol. 87 (1-3), 1999, pp. 59-63.
- [4] H. Yan, C.C. Wang, H.M. Chow, and Y.C.Lin, "Feasibility study of rotary electrical discharge machining with ball burnishing for Al<sub>2</sub>O<sub>3</sub>/6061Al composite", International Journal of Machine Tools and Manufacture, vol. 40(10), 2000, pp. 1403-1421.
- [5] H. C. Tsai, B. H. Yan, and F.Y. Huang, "EDM performance of Cr/Cu-based composite electrodes", International Journal of Machine Tools and Manufacture, vol. 43(3), 2003, pp. 245-252.
- [6] P.N. Singh, K. Raghukandan, M. Rathinasabapathi, And B.C. Pai, "Electric discharge machining of Al-10%SiCp as-cast metal matrix composites", Journal of Materials Processing Technology, vol. 155-156(1-3), 2004,
- [7] Ghorabae M.K., Zavadskas E. K., Olfat L., Turskis Z., Multi-criteria inventory classification using a new method of evaluation based on distance from average solution (EDAS), Informatica, 26(3): 435–451, 2015, DOI: 10.15388/Informatica.2015.57. 34.
- [8] Ghorabae M. K., Zavadskas E. K., Amiri M., Turskis Z., Extended EDAS method for fuzzy multi-criteria decision-making: an application to supplier selection, International Journal of Computers Communications & Control, 11(3): 358–371, 2016, DOI: 10.15837/ijccc.2016.3.2557.



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