Optimization of WEDM process parameters using standard deviation and MOORA method

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Abstract. In this present experimental work, the effect and advancement of machining control parameters over kerf and surface quality in wire cut electrical discharge machining operations were analyzed. The hybrid metal reinforced composite was manufactured by process named as stir casting utilizing particulates of graphite & Silicon carbide each in Al6061 combination. The analyses were outlined with Taguchi L27 design matrix. WEDM parameters resemble pulse Pulse on time, current, Pulse off time, gap set voltage, wire tension &feed are considered. The impact of the machining parameters on the kerf width (KW) and surface roughness (SR) is dictated by utilizing examination of fluctuation. MOORA in blend with standard deviation (SDV) was utilized for the enhancement procedure. SDV was utilized to decide the weights that were utilized for normalizing the reactions acquired from the mechanical test outcomes. The parameters corresponding to experiment run number 7 are Pulse on time 108 units (Level 1), Pulse off time 50 units (Level 2), peak current 230 units (Level 3), gap set voltage 50 units (Level 3), wire feed 5 units (Level 3) and wire tension 12 units (Level 3) are the best combination to achieve better surface roughness & kerf width.

Keywords: MOORA, WEDM, SDV, Taguchi method, Hybrid composite, Surface roughness.

1. Introduction

Composite materials had grown rapidly over recent few decades to encompass metal matrix composites, ceramic composites and polymer matrix composites [1-3]. Metal grid composites have pulled in significant consideration because of their capacity to give an extensive variety of microstructures & properties [4]. The underlying philosophy of metal composite design is that an continuous metallic matrix, with its ductility and formability, is combined with the stiffness and load withstanding property of a ceramic or refractory reinforcements to produce material with superior properties [5]. Metal Composites possess good properties over metals alloys with high specific strengths, better properties of metal composite at elevated high temperatures, minimum thermal expansion, very good wear resistance & high structural strength. These properties are predominantly suited to application in an automotive, aerospace and electronic sectors [6-7].

Fabrication, shaping and joining with good surface quality can be done easily [8-9]. The reinforced particles in composites provide strength to the composite and also serve the other additional...
purposes like heat resistance, thermal conduction, resistance to corrosion & rigidity. The reinforcement particles always possess much stronger and much stiffer properties than the base metals. fibers and ceramics particulates are generally considered as reinforcement particles. The approach used for fabrication of the MMC may be different route\[10-11\]. The techniques can be labeled into 5 extraordinary categories: (i) Liquid state strategies (ii) solid phase techniques (iii) two segment methods (iv) Deposition techniques (v) In situ methods. In stir cast processing, the reinforced particulates are very well blended right into a nicely molten metallic matrix.

Manufacturing sector is growing rapidly by accommodating technology modernization. The mechanism for machining hard reinforced materials, intricate shapes and contours which are very difficult to cut by conventional methods which created many unconventional methods\[12\]. CNC wire cut machine was developed in the year 1969. WEDM which involves moving very thin wire electrode continuously. Wire electrode materials such as brass and zinc coated brass wire of diameter ranges from 0.05-0.35 are widely applied in industry. The gap between work and wire electrode is generally ranges from 0.025mm to 0.050mm and is continuously maintained by a computer controlled coordinating system. To achieve better surface quality on the tool as well as in the component, optimum process parameter setting is a very important factor. Machining control parameters are optimized by using different methods for the improvement of the quality. Taguchi method which is widely applied mainly experimental design in manufacturing application. It allows the optimization of parameters in machining by turning, milling, Electro Discharge Machining, wire cut EDM, welding, grinding etc. The optimization is achieved with lesser number of experiments by this overall cost and time is saved.

2. Materials & Method

2.1. Preparation of Hybrid Composite

In this investigation, the hybrid MMC has been created by stir casting process. The crossover composite comprises of 10 wt% SiC and 5 wt% Graphite particulates in metal lattice Al6061 compound. The Al combination of 6xxx arrangement is having the capacity to be used in aviation and car ventures in light of its high quality to-weight proportion and great protection from consumption. Composition of Al6061 composite is appeared in Table 1. Fortifications SiC and graphite in particulate frame are utilized to create the hybrid composite. The easiest and the most savvy technique for fluid state creation is stir casting \[19\]. Figure1 demonstrates the stircast equipment utilized for manufacture of hybrid composite.

Table 1. Composition of Al6061 alloy

|   | Mg | Si | Fe | Cu | Cr | Al       |
|---|----|----|----|----|----|----------|
|   | 1.1| 0.64| 0.48| 0.33| 0.04| Remaining |
2.2. Machining Parameters and Response

Machining process parameters in WEDM, Pulse on time, Pulse off time, current, gap voltage, wire speed and wire tension were considered as input parameters. Responses SR and kerf width were measured after machining for investigation. The scopes of these procedure parameters were chosen on the premise of the pilot tests. The levels of different parameters and its assignments are exhibited in Table 2.

![Figure 1. Stir casting set up](image)

### Table 2. Three levels of process parameters

| Process parameter  | Level 1 | Level 2 | Level 3 |
|--------------------|---------|---------|---------|
| Pulse on time (A)  | 108     | 117     | 126     |
| Pulse off time (B) | 40      | 50      | 60      |
| Pulse current (C)  | 90      | 160     | 230     |
| Gap voltage (D)    | 10      | 30      | 50      |
| Wire speed (E)     | 3       | 4       | 5       |
| Wire tension (F)   | 4       | 8       | 12      |

2.3. Taguchi’s Experimental Design

Taguchi strategy is a proficient apparatus for the outline of a great assembling framework. It also effectively solves some complex problems in manufacturing (Roy 1990). It is a strategy in view of OA tests, which give much decreased change to the try different things with ideal setting of process control parameters. The six control parameters, that is, Pulse on time (A), Pulse off time (B), current (C), Gap voltage (D), wire drum speed (E) and wire tension (F) at three levels were chosen in this examination. The tests were finished by Table 3. This table just speaks to specific level of the different elements of the procedure at which the examinations would be directed. Kerf width ought to be as least as conceivable in the WEDM procedure. Kerf width is an imperative component of the laser cutting procedure that gives the benefit of this innovation contrasted with different strategies for form cutting.

2.4. Experimental Set Up
Analyses were led on Electronica Sprint cut CNC wire cut electrical discharge machine to think about the surface quality and kerf width influenced by the machining parameters at various levels. WEDM is a start disintegration process. The flashes are produced between the work piece and the wire terminal. The dielectric liquid is ceaselessly encouraged into the machining zone with required weight. The material is getting expelled by a progression of discrete sparks occurring at the zone to be machined through electro-warm system. Test set up of the wire electrical release machine is appeared in Figure 2.

Amid machining process little hole kept up between the work and wire material. The wire is held by a stick direct at the upper and lower parts of the work piece. The work example measure utilized as a part of this examination is 95 x 80 x 8 mm rectangular plate. Zinc covered metal cathode wire of 0.25 mm width was utilized as a part of this investigation. Deionized water was utilized dielectric liquid at room temperature. In the wake of machining, the examples were cleaned with acid after machining. The kerf was measured utilizing profile projector measuring framework. The kerf esteems were measured at six spots spread over the full length of cut. The kerf esteems utilized a part of this examination are the numerical normal of three estimations produced using the example in each cut.
| Experimental run | Control factors and levels |
|------------------|-----------------------------|
|                  | A  | B  | C  | D  | E  | F  |
| 1                | 1  | 1  | 1  | 1  | 1  | 1  |
| 2                | 1  | 1  | 1  | 1  | 2  | 2  |
| 3                | 1  | 1  | 1  | 1  | 3  | 3  |
| 4                | 1  | 2  | 2  | 2  | 1  | 1  |
| 5                | 1  | 2  | 2  | 2  | 2  | 2  |
| 6                | 1  | 2  | 2  | 2  | 3  | 3  |
| 7                | 1  | 3  | 3  | 3  | 1  | 1  |
| 8                | 1  | 3  | 3  | 3  | 2  | 2  |
| 9                | 1  | 3  | 3  | 3  | 3  | 3  |
| 10               | 2  | 1  | 2  | 3  | 1  | 2  |
| 11               | 2  | 1  | 2  | 3  | 2  | 3  |
| 12               | 2  | 1  | 2  | 3  | 3  | 1  |
| 13               | 2  | 2  | 3  | 1  | 1  | 2  |
| 14               | 2  | 2  | 3  | 1  | 2  | 3  |
| 15               | 2  | 2  | 3  | 1  | 3  | 1  |
| 16               | 2  | 3  | 1  | 2  | 1  | 2  |
| 17               | 2  | 3  | 1  | 2  | 2  | 3  |
| 18               | 2  | 3  | 1  | 2  | 3  | 1  |
| 19               | 3  | 1  | 3  | 2  | 1  | 3  |
| 20               | 3  | 1  | 3  | 2  | 2  | 1  |
| 21               | 3  | 1  | 3  | 2  | 3  | 2  |
| 22               | 3  | 2  | 1  | 3  | 1  | 3  |
| 23               | 3  | 2  | 1  | 3  | 2  | 1  |
| 24               | 3  | 2  | 1  | 3  | 3  | 2  |
| 25               | 3  | 3  | 2  | 1  | 1  | 3  |
| 26               | 3  | 3  | 2  | 1  | 2  | 1  |
| 27               | 3  | 3  | 2  | 1  | 3  | 2  |

2.5. Weight Criteria Calculation using SDV Concept

Standard deviation is connected to this examination for unprejudiced assignment of weights. The significance of weights in illuminating MCDM issues cannot be over stressed. To decide the standard deviation, the range institutionalization was finished utilizing Equation (1) to change diverse scales and units among different criteria into regular quantifiable units so as to figure their weights.
\[ X'_{ij} = \frac{X_{ij} - \min_{1 \leq j \leq n} X_{ij}}{\max_{1 \leq j \leq n} X_{ij} - \min_{1 \leq j \leq n} X_{ij}} \]  

(1)

where \( \max X_{ij} \), \( \min X_{ij} \) are the maxima and minimum values of the criterion \( j \) respectively. The Standard deviation (SDV) is calculated for every criterion using Equation (2)

\[ \text{SDV}_j = \sqrt{\frac{1}{m} \sum_{i=1}^{m} (X_{ij} - \overline{X_j})^2} \]  

(2)

where \( \overline{X_j} \) is the mean of the values of the \( j \)th criterion after normalization and \( j = 1, 2, \ldots, n \). After calculating for \( \text{SDV} \) for all criteria, the next step is to determine the weights, \( W_j \) of all the criteria considered.

\[ w_j = \frac{\text{SDV}_j}{\sum_{j=1}^{n} \text{SDV}_j} \]  

(3)

where \( j = 1, 2, \ldots, n \).

**Figure 2.** WEDM experimental set up (Electronica Sprint cut)

### 2.6 MOORA Methodology

MOORA is one of the MCDM techniques used to choose best options among a given number of choices [13-16]. This issue includes different goals or criteria and furthermore struggle with each other. They are advantageous (amplification) furthermore, non-valuable (minimization) targets. MOORA technique considers both advantageous and non gainful targets for illuminating and positioning ideal options all the while [17].

**Step 1** Problem description and establishment of objectives. In the present work, surface roughness and kerf width are selected as non beneficial attribute.

**Step 2** Construction of decision matrix. The decision matrix is used to represent the experimental results with respect to various output parameters.

The decision matrix \( D_{\max} \) is represented as
where \( X_{ij} \) indicates the experimental result of \( i \)th alternative on \( j \)th attribute, \( m \) indicates the number of experiments, and \( n \) refers to the number of output parameters. The decision matrix \( D_{m \times n} \) is given in Table 4.

**Step 3** Normalization of input data.

Generally, normalization is needed, as the variety and unit of output value may be different from others. The meaning of normalization is converting the original score into a comparable score. The output values presented in the decision matrix are normalized with the help of equation (3). The value of normalized decision matrix \( N_{m \times n} \) is presented in Table 4. The expression used to determine the normalized decision matrix \( (N_{ij}) \) is given by

\[
N_{ij} = \frac{X_{ij}}{\sqrt{\sum_{j' \in J} X_{ij}^2}} \quad \text{for} \quad i = 1, m; \quad j = 1, ..., n,
\]

where \( X_{ij} \) and \( N_{ij} \) are original and normalized score of decision matrix, respectively.

**Step 4** Determination of solution.

The standardized scores are included the instance of valuable or amplification objective and subtracted on account of non-helpful or minimization objective. At that point the multi-target streamlining moves toward becoming

where \( g \) speaks to the quantity of properties for maximization, \((n-g)\) speaks to the quantity of traits for minimization, and \( Y_i \) is the standardized evaluation estimation of \( i \)th elective regarding all characteristics. Table 4 demonstrates the standardized appraisal estimation of chose yield parameters

\[
Y_i = \sum_{j=1}^{g} N_{ij} - \sum_{j=g+1}^{n} N_{ij}
\]

**Step 5** The attributes being considered are more important than others in practical situations.

To identify the important attribute, it must be multiplied with its relative importance. If relative importance is considered, then the equation is modified as

\[
Y_i = \sum_{j=1}^{g} W_j N_{ij} - \sum_{j=g+1}^{n} W_j N_{ij} \quad (j = 1, 2, ..., n),
\]

where \( W_j \) represents weight of \( j \)th attribute and it is calculated by entropy measurement method.
3. Result and Discussion

3.1 Weight Allocation

In this study, the weight allocation for each of the output parameters, that is surface roughness and kerf width. The range of standardized decision matrix is determined using equation (1). Table 4 shows the summary of the range of standardized decision matrix. The standard deviation and weights are calculated using the formula (2) & (3). The calculated weight values are 0.575 for surface roughness and 0.425 for kerf width.

3.2 Result Analysis

Table 5 shows the square of Xi, normalized matrix for Xi and rank calculated by MOORA method. The normalized SR & KW are multiplied with their corresponding weights. These values are listed in the table 6. The parameters, higher the better 9 (maximum) and smaller the better (minimum) respectively added for rank calculation. The surface roughness observed in the experiment is in the range of from 2.252 to 4.256. Similarly, the kerf width observed in the experiment is in the range of from 292 to 327. From these observations, experiment number 7 has the best rank. The parameters corresponding to experiment run number 7 are pulse on time 108 units (Level1), pulse off time 60 units (Level3), peak current 230 units (Level3), gap set voltage 60 units (Level3), wire feed 3 units (Level1) and wire tension 4 units (Level1).

Table 4. Kerf width & Surface roughness

| Ex. No. | Pulse on Time | Pulse off Time | Peak Current | Gap set voltage | Wire Feed | Wire Tension | KW    | SR |
|---------|---------------|----------------|-------------|-----------------|-----------|--------------|-------|----|
| 1       | 108           | 40             | 90          | 10              | 3         | 4            | 0.300 | 3.56|
| 2       | 108           | 40             | 90          | 10              | 4         | 8            | 0.300 | 3.32|
| 3       | 108           | 40             | 90          | 10              | 5         | 12           | 0.295 | 3.15|
| 4       | 108           | 50             | 160         | 30              | 3         | 4            | 0.304 | 2.59|
| 5       | 108           | 50             | 160         | 30              | 4         | 8            | 0.312 | 2.59|
| 6       | 108           | 50             | 160         | 30              | 5         | 12           | 0.302 | 2.57|
| 7       | 108           | 60             | 230         | 50              | 3         | 4            | 0.313 | 2.36|
| 8       | 108           | 60             | 230         | 50              | 4         | 8            | 0.316 | 2.78|
| 9       | 108           | 60             | 230         | 50              | 5         | 12           | 0.305 | 2.01|
| 10      | 117           | 40             | 160         | 50              | 3         | 8            | 0.316 | 3.43|
| 11      | 117           | 40             | 160         | 50              | 4         | 12           | 0.310 | 3.04|
| 12      | 117           | 40             | 160         | 50              | 5         | 4            | 0.313 | 3.48|
| 13      | 117           | 50             | 230         | 10              | 3         | 8            | 0.314 | 3.22|
| 14      | 117           | 50             | 230         | 10              | 4         | 12           | 0.312 | 2.78|
| 15      | 117           | 50             | 230         | 10              | 5         | 4            | 0.306 | 3.45|
| 16      | 117           | 60             | 90          | 30              | 3         | 8            | 0.306 | 2.55|
| 17      | 117           | 60             | 90          | 30              | 4         | 12           | 0.304 | 2.6 |
| 18      | 117           | 60             | 90          | 30              | 5         | 4            | 0.308 | 2.21|
| 19      | 126           | 40             | 230         | 30              | 3         | 12           | 0.312 | 2.28|
| 20      | 126           | 40             | 230         | 30              | 4         | 4            | 0.320 | 2.87|
| 21      | 126           | 40             | 230         | 30              | 5         | 8            | 0.310 | 3.05|
| 22      | 126           | 50             | 90          | 50              | 3         | 12           | 0.313 | 3.01|
| 23      | 126           | 50             | 90          | 50              | 4         | 4            | 0.322 | 2.75|
| 24      | 126           | 50             | 90          | 50              | 5         | 8            | 0.314 | 3.18|
| 25      | 126           | 60             | 160         | 10              | 3         | 12           | 0.312 | 4.23|
| 26      | 126           | 60             | 160         | 10              | 4         | 4            | 0.314 | 4.17|
| 27      | 126           | 60             | 160         | 10              | 5         | 8            | 0.317 | 3.8 |
### Table 5. Standardized Surface roughness & Kerf width

| Ex.No. | Pulse on Time | Pulse off Time | Peak Current | Gap set voltage | Wire Feed | Wire Tension | SR     | kerf width |
|--------|--------------|----------------|--------------|-----------------|-----------|--------------|--------|------------|
| 1      | 108          | 40             | 90           | 10              | 3         | 4            | 0.04896 | 0.28571    |
| 2      | 108          | 40             | 90           | 10              | 4         | 8            | 0.17281 | 0.22857    |
| 3      | 108          | 40             | 90           | 10              | 5         | 12           | 0.38306 | 0.00000    |
| 4      | 108          | 50             | 160          | 30              | 3         | 4            | 0.02016 | 0.34286    |
| 5      | 108          | 50             | 160          | 30              | 4         | 8            | 0.06048 | 0.22857    |
| 6      | 108          | 50             | 160          | 30              | 5         | 12           | 0.26786 | 0.25714    |
| 7      | 108          | 60             | 230          | 50              | 3         | 4            | 0.00000 | 0.28571    |
| 8      | 108          | 60             | 230          | 50              | 4         | 8            | 0.25634 | 0.31429    |
| 9      | 108          | 60             | 230          | 50              | 5         | 12           | 0.34274 | 0.14286    |
| 10     | 117          | 40             | 160          | 50              | 3         | 8            | 0.63652 | 0.31429    |
| 11     | 117          | 40             | 160          | 50              | 4         | 12           | 0.55300 | 0.48571    |
| 12     | 117          | 40             | 160          | 50              | 5         | 4            | 0.55012 | 0.62857    |
| 13     | 117          | 50             | 230          | 10              | 3         | 8            | 0.60484 | 0.71429    |
| 14     | 117          | 50             | 230          | 10              | 4         | 12           | 0.61636 | 0.60000    |
| 15     | 117          | 50             | 230          | 10              | 5         | 4            | 0.83813 | 0.85714    |
| 16     | 117          | 60             | 90           | 30              | 3         | 8            | 0.10369 | 0.71429    |
| 17     | 117          | 60             | 90           | 30              | 4         | 12           | 0.34850 | 0.60000    |
| 18     | 117          | 60             | 90           | 30              | 5         | 4            | 0.02880 | 1.00000    |
| 19     | 126          | 40             | 230          | 30              | 3         | 12           | 0.57316 | 0.28571    |
| 20     | 126          | 40             | 230          | 30              | 4         | 4            | 0.69412 | 0.71429    |
| 21     | 126          | 40             | 230          | 30              | 5         | 8            | 0.74309 | 0.28571    |
| 22     | 126          | 50             | 90           | 50              | 3         | 12           | 0.66244 | 0.51429    |
| 23     | 126          | 50             | 90           | 50              | 4         | 4            | 0.46083 | 0.91429    |
| 24     | 126          | 50             | 90           | 50              | 5         | 8            | 0.54724 | 0.85714    |
| 25     | 126          | 60             | 160          | 10              | 3         | 12           | 0.92454 | 0.68571    |
| 26     | 126          | 60             | 160          | 10              | 4         | 4            | 1.00000 | 0.94286    |
| 27     | 126          | 60             | 160          | 10              | 5         | 8            | 0.91590 | 0.74286    |
Table. 6 Normalized decision matrix and MOORA rank

| Ex. No. | Square of Xi | Normalized Xi | Wj*Xj | $\Sigma_{\max} - \Sigma_{\min}$ | Rank |
|---------|--------------|---------------|-------|------------------------------|------|
|         | SR           | KW            | SR    | KW                           |      |
| 1       | 0.09         | 12.6736       | 0.186203 | 0.224511 | 0.12910 | 0.07914 | -0.2082 | 23 |
| 2       | 0.09         | 11.0224       | 0.186203 | 0.209375 | 0.12040 | 0.07914 | -0.1995 | 19 |
| 3       | 0.087025     | 9.9225        | 0.1831  | 0.198654 | 0.11423 | 0.07782 | -0.1921 | 16 |
| 4       | 0.092416     | 6.7081        | 0.188686 | 0.163338 | 0.09392 | 0.08019 | -0.1741 | 7  |
| 5       | 0.097344     | 6.7081        | 0.193651 | 0.163338 | 0.09392 | 0.08230 | -0.1762 | 9  |
| 6       | 0.091204     | 6.6049        | 0.187445 | 0.162077 | 0.09320 | 0.07967 | -0.1729 | 5  |
| 7       | 0.097969     | 5.5696        | 0.194272 | 0.148833 | 0.08558 | 0.08257 | -0.1682 | 4  |
| 8       | 0.099856     | 7.7284        | 0.196134 | 0.17532  | 0.10081 | 0.08336 | -0.1842 | 11 |
| 9       | 0.093052     | 4.0401        | 0.189307 | 0.12676  | 0.07289 | 0.08046 | -0.1533 | 1  |
| 10      | 0.099856     | 11.7649       | 0.196134 | 0.216312 | 0.12439 | 0.08336 | -0.2077 | 22 |
| 11      | 0.0961       | 9.2416        | 0.192411 | 0.191717 | 0.11024 | 0.08178 | -0.1920 | 15 |
| 12      | 0.097969     | 12.1104       | 0.194272 | 0.219466 | 0.12620 | 0.08257 | -0.2088 | 24 |
| 13      | 0.098596     | 10.3684       | 0.194893 | 0.203069 | 0.11677 | 0.08283 | -0.1996 | 20 |
| 14      | 0.097344     | 7.7284        | 0.193651 | 0.17532  | 0.10081 | 0.08230 | -0.1831 | 10 |
| 15      | 0.093636     | 11.9025       | 0.189927 | 0.217574 | 0.12511 | 0.08072 | -0.2058 | 21 |
| 16      | 0.093636     | 6.5025        | 0.189927 | 0.160815 | 0.09247 | 0.08072 | -0.1732 | 6  |
| 17      | 0.092416     | 6.76          | 0.188686 | 0.163969 | 0.09429 | 0.08019 | -0.1745 | 8  |
| 18      | 0.094864     | 4.8841        | 0.191169 | 0.139373 | 0.08014 | 0.08125 | -0.1614 | 2  |
| 19      | 0.097344     | 5.1984        | 0.193651 | 0.143788 | 0.08268 | 0.08230 | -0.1650 | 3  |
| 20      | 0.1024       | 8.2369        | 0.198617 | 0.180996 | 0.10408 | 0.08441 | -0.1885 | 13 |
| 21      | 0.0961       | 9.3025        | 0.192411 | 0.192348 | 0.11060 | 0.08178 | -0.1924 | 17 |
| 22      | 0.097969     | 9.0601        | 0.194272 | 0.189825 | 0.10915 | 0.08257 | -0.1917 | 14 |
| 23      | 0.103684     | 7.5625        | 0.199858 | 0.173428 | 0.09973 | 0.08494 | -0.1847 | 12 |
| 24      | 0.098596     | 10.1124       | 0.194893 | 0.200546 | 0.11532 | 0.08283 | -0.1982 | 18 |
| 25      | 0.097344     | 17.8929       | 0.193651 | 0.266764 | 0.15340 | 0.08230 | -0.2357 | 27 |
| 26      | 0.098596     | 17.3889       | 0.194893 | 0.26298  | 0.15122 | 0.08283 | -0.2341 | 26 |
| 27      | 0.100489     | 14.44         | 0.196755 | 0.239646 | 0.13780 | 0.08362 | -0.2214 | 25 |

4. Conclusion

In this experimental study, the combined MOORA and SDV method is applied for the estimation of optimum machining parameters to minimize surface roughness and kerf width. The conclusions drawn from this study are as follows:

1. Combined MOORA and SDV method is employed to select the optimum machining parameters in WEDM machining of Al6061/SiC/graphite with brass wire electrode.

2. From these observations, experiment number 9 has the best rank. The parameters corresponding to experiment run number 9 are $P_{on}$ time 108 units (Level1), $P_{off}$ time 50
units (Level 2), peak current 230 units (Level3), gap set voltage 50 units (Level3), W feed 5 units (Level3) and W tension 12 units (Level3).

3. Standard Deviation (SDV) method is also employed to find the relative importance of surface roughness 7 kerf width. The weight ratios are found to be 0.575 for surface roughness and 0.425 for kerf width.

4. The optimum results are adopted in validation study and the results based on WEDM process responses can be effectively improved.

5. References

[1] Tatar, C., Ozdemir, N. (2010). “Investigation of thermal conductivity and microstructure of the a-Al₂O₃ particulate reinforced aluminium composites (Al/Al₂O₃-MMC) by powder metallurgy method”. Physica B Condensed Matter. Vol.405, pp.896-899.

[2] Manna, A., Bains, H.S., Mahapatra. P.B. (2011). “Experimental study on fabrication of Al–Al2O3/Grp metal matrix composites”. Journal of Composite Materials, Vol.45, No.19, pp.2003-2010.

[3] Tosun N., Cogun C. and Tosun G. 2004. A study on kerf and material removal rate in wire electrical discharge machining based on Taguchi method. Journal of Materials Processing Technology. 152, pp 316-322.

[4] Hung, N.P., Loh, N.L., Xu, Z.M . (1996). “Cumulative tool wear in machining metal matrix composites part II: machinability”. Journal of Material Processing Technology, Vol.58, pp.114–120.

[5] Surappa M.K., (2003) Aluminium matrix composites: Challenges and opportunities Sadhana, Vol. 28, Part 1 & 2, pp. 319-334.

[6] Snoeys R, Staelens F, Dekeyser W. “Current trends in non – conventional material removal process” Annals of CIRP, Vol. 35/2 (1986), pp. 467-480.

[7] Clyne, T.W., Whithers, P.J. (1992) An introduction to metal matrix composites. Cambridge University Press. London

[8] Miracle D.B. (2005) Metal matrix composites: from science to technological significance. Composites Science and Technology, Vol. 65, 15-16, pp. 2526-2540

[9] Singh, M., Prasad, B.K., Mondal, D.P., and Jha, A.K. (2001). “Drysliding wear behaviour of an aluminium alloy – granite particle composite”. Tribology International, Vol.34, pp.557-567.

[10] Pedersen, W., Ramulu, M. (2006). “Facing SiCp /Mg metal matrix composites with carbide tools”. Journal of Materials Processing Technology, Vol.172, pp.417–423.

[11] Görener, A., Dinçer, H. and Hacıoğlu, Ü. (2013) Application of Multi-Objective Optimization on the Basis of RatioAnalysis (MOORA) Method for Bank Branch Location Selection. International Journal of Finance & Banking Studies, 2, 41-52.

[12] Brauers, W.K. (2003) Optimization Methods for a Stakeholder Society, a Revolution in Economic Thinking by Multi-Objective Optimization. Series: No convex Optimization and Its Applications, 73. Kluwer Academic Publishers, Boston, 342.

[13] Brauers, W.K.M., Zavadskas, E.K., Turskis, Z. and Vilutiene, T. (2008) Multi-Objective Contractors’s Ranking by Applying the MOORA Method. Journal of Business Economics and Management, 9, 245-255.
[14] Brauers, W.K.M., Ginevičius, R. and Podvezko, V. (2010) Regional Development in Lithuania Considering Multiple Objectives by the MOORA Method. Technological and Economic Development of Economy, 16, 613-640.

[15] Brauers, W.K.M. and Zavadskas E.K. (2006) The MOORA Method and Its Applications to Privatization in a Transition Economy. Control and Cybernetics, 35, 445-469.

[16] Kalibatas, D. and Turskis, Z. (2008) Multicriteria Evaluation of Inner Climate by Using MOORA Method. Information Technology and Control, 37, 79-83.

[17] Lootsma, F. A., (1999). Multicriteria decision analysis via ratio and difference judgement, Springer, London.

[18] Yan BH, Tsai HC, Huang FY, Lee LC (2005) Examination of wire electrical discharge machining of Al₂O₃p/6061Al composites. Int J Mach Tools Manuf 45:251–259

[19] Rajan, T.P.D., Pillai, P.M., Pai, B.C., Satyanarayana, K.G., Rohatgi, P.K . (2007). “Fabrication and characterization of Al–7Si–0.35Mg/fly ash metal matrix composites processed by different stir casting routes”. Journal of Composites and Technology, Vol.67, pp.15-16.

[20] Noor Zamankhan, Suha k Shihab, Nidhi Sharma, Atif Wahid, Arshad N Siddique & Zahid A Khan (2015), Investigation on the effect of WEDM process parameters on surface roughness, Global Sci-Tech, pp. 1-9.