PAPER

Influence of silicon carbide mixed used engine oil dielectric fluid on EDM characteristics of AA7075/SiCp/B4Cp hybrid composites

S Ganapathi Iyyappan*, R Sudhakarapandian† and M Sakthivel†

1 Department of Aeronautical Engineering, Adhiyamaan College of Engineering, Hosur, Tamil Nadu, India
2 School of Mechanical Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India
3 Department of Mechanical Engineering, Adhiyamaan College of Engineering, Hosur, Tamil Nadu, India

E-mail: iyyapanganapathy@gmail.com

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Abstract

In this study, AA7050/SiC/B4C hybrid composites were machined using the Electric Discharge Machining process, used engine oil as the dielectric fluid to obtain wealth from waste. The experiments were conducted by varying Silicon Carbide (SiC) powder concentration, electrode material (copper and brass), discharge current, pulse on time and reinforcement wt%. The Material Removal Rate (MRR), Tool Wear Rate (TWR), Surface Roughness (Ra) and machined surface hardness were recorded as responses. The inclusion of SiC particles increases the MRR because of the bridging effect, whereas the Ra value was improved due to the complete flushing of the dielectric fluid. Owing to the existence of carbon content in used engine oil, black spots were found on the machined topography. The specimens machined with a brass electrode offer better machining performance as compared with those machined with a copper electrode. The results revealed that the MRR, TWR and Ra upsurge with the intensification of discharge current and pulse on time. Owing to the absence of a re-melted layer, composites with lower machined surface hardness have a higher surface finish. The parameters were optimized using the TOPSIS method, and it was found that under used engine oil dielectric medium with a powder concentration of 3 g l⁻¹, parametric value sets of pulse on time 45 s, current 6 A, and machined with brass electrode offers superior machining efficiency.

Introduction

Composite materials are tough to machine utilizing conventional machining methods owing to the presence of reinforcing particles [1]. Electric Discharge Machining (EDM), one of the most prominently used unconventional machining processes utilized to machine the materials with high precision and accuracy [2]. EDM industries have an objective of attaining higher Material Removal Rate (MRR), lower Tool Wear Rate (TWR) and better Surface roughness (Ra) value [3]. The current, pulse on time, tool materials, pulse off time, voltage and the gap distance are the prominent process parameters which greatly impact the machining characteristics [4]. The copper, brass, graphite, copper-tungsten and zinc are the various tool materials used for machining. Selection of proper combination of tool and work piece was required for achieving better machining performance [5]. Adding foreign particles in the dielectric fluid improves the machine productivity [6].

The powder material, size, density and concentration of powder are the key factors which controls the proficiency of the Powder Mixed Electric Discharge Machining (PMEDM) [7]. Numerous studies have been conducted by varying the size, powder materials, and concentration of the powder [8]. Silicon Carbide (SiC), Boron Carbide (B4C), Aluminium Oxide (Al2O3), Chromium (Cr) and Graphite (Gr) are some of the powders frequently used in PMEDM [9]. Most of the results stated that the addition of powder particles stipulates lesser gap expansion which increases MRR [10, 11]. The improvement in MRR was achieved because of uniform distribution of discharge energy [12]. Adding powder particle beyond the limit creates short circuit which drastically reduces the MRR [13, 14]. A particle suspended in the gap distance eliminates the creation of microcracks, voids and recast layers on the material surface which enhances Ra [15]. Nor Ain Jamil Hosni et al [16] experimented by adding
chromium powder in the kerosene dielectric. According to the findings, adding chromium powder into dielectric fluid increases MRR and Ra by 45 and 68 percent, respectively. Jeavudeen et al [17] performed PMEDM in which four distinct materials were used as powders and the dielectric fluid breakdown was measured as a response. The results revealed that the breakdown of dielectric decreases as the powder concentration increases.

The fluids used as dielectric medium are classified as hydrocarbon based, vegetable based and synthetic oil based [18]. Kerosine, EDM oil and de-ionised water are most commonly utilized dielectric fluids [19]. The characteristics of the plasma channel, such as arc plasma diameter, plasma width, and temperature, are influenced by the nature of the dielectric fluids, which impacts the machining rate [20]. Machined by these conventional fluids liberates toxic gases which is hazardous to environment [21]. Saman Fattahi et al [22] machined HSS-M35 utilizing different gases as dielectric medium viz argon, nitrogen and air. The results revealed that the enhanced material removal and best surface quality was attained when nitrogen and argon gas was used as dielectric medium respectively. Muhammad Imran et al [23] machined AA6061 aluminum alloy exploiting distilled water and paraffin oil as dielectric medium. The results revealed that a thicker white layer was formed if purified H2O was used as a dielectric as compared with paraffin oil. It was also stated that severe surface pits and larger globules was observed under paraffin medium.

Khan et al [24] deliberated characteristics of jatropha biodiesel as dielectric fluid. It offers better machining performance as compared with kerosine and inferior performance as compared with synthetic EDM oil. For the machining of high carbon high chromium steel, Manjunath et al [25] used pure H2O and kerosine as the dielectric medium. The machining was performed by utilizing copper, graphite and brass as tool and by altering current and pulse on time. It was perceived that machined under kerosine environment deposit carbon on surface. It was determined that machining using graphite tool under distilled water medium yields specimens with higher MRR and lower Rv. Muthuramalingam et al [26] used tap H2O blended deionised water as electric discharge medium. It was revealed that machining occurred by creating the craters which results in reduction in surface quality. Bajaj et al [27] utilized multiwall carbon nanotube mixed Kusum edible oil as dielectric fluid for the machining of EN-31 high carbon alloy steel. According to the findings, Kusum oil offers 57.14% higher MRR in comparison with EDM oil.

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is the Multi Criteria Decision Making (MCDM) technique. Of various Available MCDM technique TOPSIS was very effective for resolving material election problem [28]. The optimum parameters were calculated by finding the ideal best solution, which is the closest space from the finest value, and the ideal natiest resolution, which is the furthest distance from the worst value [29]. Rahul Nadda et al performed EDM experiments by varying four distinct process parameters [30]. It was stated that optimal parametric value for machining are pulse on time 90 μs, pulse off time 63 μs, pulse current 12 A and voltage 50 V. The optimal process parameter for power mixed electric discharge drilling [31] and abrasive water jet machining [32] were identified by TOPSIS technique. Tien-Chin Wang et al developed integrated fuzzy TOPSIS approach for solving MCDM problems [33]. According to the scientific report, there were numerous works published on electric discharge machining using different dielectric fluids and by mixing various powder on dielectric fluids. No researches were conducted by using waste engine oil as dielectric fluid. In this work an attempt was made to perform the EDM on AA7050 hybrid composites by utilizing used engine oil as dielectric fluid with the objective of obtaining wealth from waste. In order to increase the machining efficiency SiC particles were added as dielectric additive. The experiments were conducted by varying tool material, powder concentration, pulse on time, current and weight percentage of reinforcement. The surface topography was analysed with the aid of Scanning Electron Microscope (SEM).

### Materials and methods

AA7075 aluminium used for the production of aerospace structural elements was nominated as matrix material and its element proportion was depicted in the table 1. The SiC and B4C of average particle size 5 μm was selected as reinforcement. The composite was produced utilizing modified stir casting. The alloy was kept in the graphite receptacle and boiled to the hotness of 850 °C. The preheated SiC and B4C particles are introduced to the melt and stirred at 1000 rpm for 180 s. As a flux, magnesium powder was introduced. The mixture was then cooled to 400 C and stirred for 120 s before being heated to 850 C and stirred for another 120 s. The charge was discharged into the preheated die steel and the same technique has been replicated for engineering composites of various
weight percentage. PMEDM was performed on the composites by varying current, pulse on time, powder concentration and tool materials. The Copper and brass were used as electrode, SiC powder of varying concentration 0, 3 and 6 g l\(^{-1}\) has been included in the dielectric to augment the machining characteristics. Used engine oil collected from the automobile show room was used as a dielectric fluid and its properties was depicted in table 2. The PMEDM tank consists of 12 litre tank, mechanical stirrer and a submersible flushing pump [10].

Preliminary tests were conducted to determine the variable ranges. The fundamental assumption was that all of the trials would result in a stable discharge. The input variables and its levels were depicted in the table 3. The MRR, TWR, Ra and Surface Hardness \((SH)\) were recorded as response. Each experimental run was performed for the machining time of 10 min. The specimens were weighed before and after the machining and difference in weight was taken as MRR and TWR as shown in the equations (1) and (2). SJR210 surface roughness tester was utilized to ascertain the Ra of the specimen, it was calculated on 10 different places and average was taken as Ra. The surface hardness value after machining was determined as per ASTM standard E18 using Rockwell hardness testing machine. The optimal process parametric value was identified using the TOPSIS optimization technique.

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MRR = (W_b - W_a). \tag{1}
\]

\[
TWR = (T_b - T_a). \tag{2}
\]

**Results and discussion**

According to the figure 1, it was cleared revealed that parameters such as powder concentration, pulse on time, weight percentage and current considerably effect the MRR. It was observed that the MRR increases when the powder concentration was 3 g l\(^{-1}\) and it declines when it was added at the concentration of 6 g l\(^{-1}\). When the particles are added it suspended inside the spark gap which reduces the breakdown strength of the dielectric [34] owing to the bridging effect [35]. The suspended particles ultimately increase the spark gap [36], when voltage is applied these particles viaduct the gap linking tool and the work piece which increases the sparking frequency and energy intensity [37] hence MRR raises. The investigation values were depicted in the table 4. The result was well correlated with the previous findings [38–41]. With further upsurge in powder concentration owing to the further increase in spark gap more heat was dissipated. The heat produced was not sufficient for machining [42] of work piece which eventually reduces the MRR. The samples machined with copper electrode offers better MRR compared with brass tools. When machined in PMEDM condition owing to the increase in sparking

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**Table 2. Properties of dielectric fluid.**

| S. no | Properties | EDM oil | Used engine oil | Advantages of using used engine oil as a Di-Electric fluid |
|------|------------|---------|----------------|----------------------------------------------------------|
| 1    | Colour     | Colourless | Black           | Work piece is not visible hence it is not a favorable condition. |
| 2    | Flash Point | 112 °C | 194 °C | Higher flash point Enhances worker safety |
| 3    | Density    | 810 Kg m\(^{-3}\) | 881 kg m\(^{-3}\) | High density improves flushing |
| 4    | Dielectric Strength | 45 KVA | 60 KVA | Higher dielectric strength increases machining efficiency |
| 5    | Kinematic Viscosity at 40°C | 2.37 mm\(^2\) s\(^{-1}\) | 2.4 mm\(^2\) s\(^{-1}\) | Low viscosity increases heat transfer hence it is not a favorable condition. |
| 6    | Carbon Content | 90% | 95%–97% | High carbon content leaves black spots on machined surface |
| 7    | Thermal Conductivity | 0.124 W/m.k | 0.142 W/m.k | High Thermal Conductivity increases heat dissipation |
| 8    | Specific Heat | 2.06 KJ Kg\(^{-1}\) K\(^{-1}\) | 1.796 KJ Kg\(^{-1}\) K\(^{-1}\) | Used engine oil has low specific heat than EDM oil which is not a favorable condition. |

**Table 3. Process parameters and its level.**

| Parameter       | Levels                      |
|-----------------|-----------------------------|
| Current         | 3, 6, 9 A                   |
| Pulse on Time   | 10, 20, 30 μs               |
| Powder Concentration | 0, 3, 6 g l\(^{-1}\)     |
| Electrode Material | Copper, Brass               |
| Dielectric Fluid | Used engine oil             |
| Voltage         | 30 V                        |
| Weight percentage of composite | 4, 8, 12 wt% |
| Work piece      | AA7050/SiC/B\(_4\)C         |
frequency, the copper electrode with high thermal conductivity (401 w/m.k) generates more heat as compared with brass electrode (159 w/m.k) [43]. Further it was detected, with upsurge in current MRR increases till a saddle point of 6 A thereafter it declines. This increment in MRR was due to the higher current intensity formed because of denser plasma channel [44] which obviously increases with increase in current. At higher current, this plasma channel widens hence MRR declines. On the other hand, when machined with the powder concentration of 3 g l\(^{-1}\) higher MRR was achieved for the current of 9 A. This was attributed to the fact that the plasma channel narrows and produces more heat as the spark gap upsurges due to the addition of powder. Spark energy increases as the pulse on time increases [45], hastening melting and vapourisation and thus increasing MRR. The highest MRR was obtained when the unit was run at a pulse on time of 45 s and a powder concentration of 3 g l\(^{-1}\). The MRR reduces with upsurge in the weight percentage of strengthening particles, the findings were in good agreement with previous results [46–49].

In comparison to brass electrodes, the copper electrode has a lower TWR as depicted in figure 2. This reduction in TWR was related to the material’s physical property and was nominally lower for the electrode with a high melting point [12]. Hence, copper with higher melting temperature possess lower TWR as compared with brass. With the addition of powder particles TWR reduces until the saddle point of 3 g l\(^{-1}\) after that it began to upsurge. Owing to small arcs generated during the processing, intense electrons movement can reverse the feed direction in order to keep a wider spark gap [50]. As a consequence, the value of TWR could be easily reduced as most of the negative ions moves through the process gap. At higher powder concentration, TWR increases owing to the occurrence of short circuit [51]. As current intensity increases with increase in discharge it erodes higher amount of electrode material hence TWR increases. As previously mentioned, increasing in pulse on time induces an increase in spark energy, resulting in augmentation in TWR. When machined at a discharge current of 3 A, pulse on time 15 \(\mu\)s and a powder concentration of 3 g l\(^{-1}\), minimal TWR was observed. The TWR for composites having 4 & 8% reinforcing particles are minimal but it increases rapidly when machined the samples having 12% reinforcing particles.

Adding of SiC powder in the dielectric medium drastically decreases Ra as depicted in the figure 3. When the particles are added, the gap distance between the electrode and work piece upsurges. As a result, melted and vapourised materials are completely flushed away from the gap, preventing the formation of remelted layers and globules and increases Ra. When the powder strength was augmented to 6 g l\(^{-1}\), the gap distance further increases which leads to the lower heat generation. This causes voids and micro cracks to form on the surface [52], resulting in a reduction in surface quality. Higher current causes the discharge to intensify and blitzkrieg the surface, resulting in the creation of pits [53] and a higher Ra value. As 3 g l\(^{-1}\) particles are applied, the discharge energy is distributed evenly over the surface area, culminating in a better surface finish. Higher pulse-on-time intensified spark bombardment with the surface, hence Ra value increases. Better surface quality was attained when machined at the process value of pulse on time 15 \(\mu\)s, current 3 A and powder concentration of

![Main Effects Plot for MRR (mg)](image-url)
| S. no | Tool materials | Powder concentration | Current (A) | Pulse on time (μs) | Weight percentage | MRR (mg) | TWR (mg) | Ra (μm) | Hardness (HRB) | MRR (mg) | TWR (mg) | Ra (μm) | Hardness (HRB) |
|-------|----------------|----------------------|-------------|-------------------|------------------|----------|----------|---------|----------------|----------|----------|---------|----------------|
| 1     | Cu             | 0                    | 3           | 15                | 4                | 287      | 54       | 4.38    | 91             | 300.6    | 52.7     | 4.5     | 89.2           |
| 2     | Cu             | 0                    | 6           | 30                | 8                | 337      | 67       | 4.9     | 94             | 321.1    | 69.7     | 4.7     | 94.3           |
| 3     | Cu             | 0                    | 9           | 45                | 12               | 338      | 78       | 5.35    | 100            | 346.7    | 78.7     | 5.6     | 101.3          |
| 4     | Cu             | 3                    | 3           | 15                | 8                | 377      | 49       | 2.07    | 86             | 367.7    | 49.4     | 2.2     | 87.9           |
| 5     | Cu             | 3                    | 6           | 30                | 12               | 408      | 58       | 3.35    | 95             | 393.4    | 60.3     | 3.4     | 93.0           |
| 6     | Cu             | 3                    | 9           | 45                | 4                | 512      | 76       | 3.61    | 87             | 488.7    | 79.2     | 3.4     | 84.7           |
| 7     | Cu             | 6                    | 3           | 30                | 4                | 387      | 64       | 4.77    | 88             | 374.0    | 64.2     | 4.5     | 86.5           |
| 8     | Cu             | 6                    | 6           | 45                | 8                | 329      | 71       | 5.07    | 98             | 346.2    | 69.2     | 4.8     | 97.4           |
| 9     | Cu             | 6                    | 9           | 15                | 12               | 289      | 65       | 4.79    | 97             | 275.4    | 66.3     | 4.7     | 98.8           |
| 10    | Br             | 0                    | 3           | 45                | 12               | 301      | 88       | 5.62    | 99             | 292.3    | 87.3     | 5.4     | 97.7           |
| 11    | Br             | 0                    | 6           | 15                | 4                | 320      | 84       | 3.78    | 89             | 306.4    | 85.3     | 3.7     | 90.8           |
| 12    | Br             | 0                    | 9           | 30                | 8                | 290      | 91       | 4.25    | 94             | 302.9    | 87.3     | 4.5     | 93.7           |
| 13    | Br             | 3                    | 3           | 30                | 12               | 322      | 70       | 2.46    | 87             | 336.6    | 67.7     | 2.9     | 89.0           |
| 14    | Br             | 3                    | 6           | 45                | 4                | 448      | 77       | 1.78    | 83             | 469.3    | 74.8     | 1.7     | 85.3           |
| 15    | Br             | 3                    | 9           | 15                | 8                | 347      | 69       | 2.09    | 93             | 356.3    | 68.6     | 2.0     | 91.1           |
| 16    | Br             | 6                    | 3           | 45                | 8                | 374      | 76       | 3.93    | 93             | 356.8    | 78.8     | 4.1     | 93.6           |
| 17    | Br             | 6                    | 6           | 15                | 12               | 279      | 81       | 3.88    | 99             | 292.6    | 79.7     | 4.0     | 97.2           |
| 18    | Br             | 6                    | 9           | 30                | 4                | 295      | 73       | 4.12    | 88             | 308.0    | 72.8     | 4.3     | 89.5           |
3 g l⁻¹. The surface quality reduces with surge in weight fraction of composites. When strengthening particles are extracted from the surface during machining, micro pits form on the surface, increasing the Ra value, which is in line with previous findings [54–57].

Before machining, the hardness values of composites containing 4, 8, and 12% reinforcing particles were 82, 89, and 95HRB, respectively. Owing to the existence of hard ceramic particles [58], the hardness values increased as the weight percentage increased. From the results it was clearly visible, After machining with powder particles at a concentration of 3 g l⁻¹, the hardness value of the composites reduces as shown in figure 4. This was owing to the fact that no remelted layers were founded on the surface as a result of the increased spark gap resulting from the inclusion of SiC particles which ultimately increases the surface quality [59, 60]. This was also attributed to
the fact that removing reinforcing particles from the surface reduces machined surface hardness. Machining composites results in a remelted layer and globules that are shoddier by the addition of powder. Higher pulse on time produces higher energy sparks, resulting in the majority of the molten material redeposited on the surface as a result of inadequate flushing. This problem was solved when SiC particles were applied to the dielectric fluid, as the increased spark gap resulted in sufficient flushing. The regression coefficients of the second order equation were calculated using the experimental data that was utilised in the prediction computation. The discrepancy between the experimental and predicted values was found to be less than 5%.

### Surface topography

Figure 5(a) exemplifies the topography of the surface machined with used engine oil. Black spots were found on the composite surface, which can be caused by the presence of carbon content in the used engine oil. A huge crack was observed on the surface as a result of the uneven distribution of discharge energy, which results in a poor surface finish; this observation was well correlated with the experimental findings. Deeper pit, remelted layers, globules are clearly visible on the surface which greatly reduces the surface quality. At a higher magnification of 2000X, the surface topography revealed craters, micro holes, and micro pits as shown in figure 5(b). A crater valley of approximately 20 μm length was formed, which increased the surface roughness value. The cluster of remelted layers was clearly noticeable, resulting in specimens with higher hardness value after machining.

When the SiC particles of 6 g l⁻¹ was promoted to the dielectric fluid, the surface topography showed huge number of macro pits, larger cracks and voids as depicted in the figure 6(a). A crater valley of approximately 80 μm length was observed, which ended due to the formation of a massive pit in its path. Owing to the poor heat generation, the surface was deformed and leads to worse surface finish. On the surface, a large number of smaller black spots emerged. At higher magnification, a crater valley of guesstimate 200 μm length was formed as shown in figure 6(b), which passes through deeper pits and craters, greatly reduces the surface quality. The remelted layer was clearly visible which was formed to poor heat generation, it increases surface roughness value.

When SiC particles of concentration 3 g l⁻¹ was suspended in the dielectric fluid, the topography showed globules and micro cracks as shown in figure 7(a). Since no remelted layer was found on the surface of the composites, machined composites have a lower hardness. This is because the inclusion of particles widens the gap between the work piece and the electrode, causing melted debris to be completely flushed away from the spark gap, resulting in improved surface quality. Similar observation was reported by previous researchers [61]. At higher magnification carbon black spots, micro cracks and micro pits are formed as depicted in figure 7(b).
which was compensated by the higher spark frequency. As a result, for the machining of AA7050 hybrid composites the increase in spark gap was found to be most desirable for fine-finish operation.

**Technique for order of preference by similarity to ideal solution (TOPSIS)**

The optimal parametric combination was determined by the TOPSIS optimization technique. The suggested solution has the advantage of using policy makers’ experience while still including end-users.
in the decision-making process. The best arrangement is a theoretical answer for which all quality qualities relate to the most extreme trait esteems in the data set incorporating the perfect arrangements, the most noticeably terrible arrangement is the speculative answer for which all characteristic qualities compare to the base property estimations in the data set. TOPSIS consequently gives an answer that just closest to the best, yet additionally the farthest from the most exceedingly terrible. To enhance the boundaries, the TOPSIS was applied independently or three trial runs and a correlation were made between them toward the end. The optimization techniques include following steps.

Figure 6. Surface topography of AA7075 hybrid composites machined at used engine oil + 6 g l⁻¹ powder suspended dielectric medium (a) At lower magnification (b) At higher magnification.
As the research comprises of 18 experimental runs with 3 response, a decisive matrix of 18X3 was formed as shown in table 4. The technique begins with the normalization of data sets, it was done according to the equation (3). Where Bij is the normalization matrix, i is the number of experimental runs and j is number of responses. Following that, the weights of each variables were bourgeoned by these normalized matrices to create a weighted normalized decision matrix (Cij) as depicted in the equation (4).

$$B_{ij} = \frac{A_{ij}}{\sum_{i=1}^{n}(A_{ij})^2}$$  \hspace{1cm} (3)
The eigenvalues are calculated from the weighted normalized decision matrix, for beneficiary attributes $\lambda^+$ is the maximum value and $\lambda^-$ is the minimum value of weighted normalized matrix as depicted in the equation (5).

For non-beneficiary attributes it was calculated vice versa as shown in equation (6).

For Beneficiaries

$$\lambda^+ = \text{Max}(C_{ij})_{i=1}^n, \quad \lambda^- = \text{Min}(C_{ij})_{i=1}^n.$$  \hspace{1cm} (5)

For Non-Beneficiaries

$$\lambda^+ = \text{Min}(C_{ij})_{i=1}^n, \quad \lambda^- = \text{Max}(C_{ij})_{i=1}^n.$$  \hspace{1cm} (6)

The next step was the calculation of ideal best ($P^+$) and ideal worst ($P^-$) solution as per the equation (7). The dispersions between the ideals and the non-ideals are determined by the commensurate Euclidean distances, as indicated in the equation (8) and its values are portrayed in table 5.

$$P^+ = \sum_{j=1}^{n} \sqrt{(C_{ij} - \lambda^+)^2 + (C_{ij} - \lambda^i)^2}.$$  \hspace{1cm} (7)

$$O^j = \left( \frac{P^-}{P^+ + P^-} \right).$$  \hspace{1cm} (8)

When machined utilizing a brass electrode with a powder mixture concentration of 3 g l$^{-1}$, the optimal combination of parametric values was discharge current 6 A and pulse on time 45 s.

**Conclusion**

AA7050/SiC/B$_4$C hybrid composites were successfully machined using utilized engine oil as dielectric fluid. The machining performance was characterized in terms of MRR, TWR and $R_a$ by varying electrode material, powder concentration in dielectric, current and pulse on time. The following conclusions are drawn from the research.

1. Owing to the bridging effect, the addition of SiC particles increased the spark frequency and energy strength, thus increasing the MRR. When added beyond the saddle point short circuit occurs. Specimens machined with brass tool offers highest MRR as compared with copper tool. MRR increases with increase in discharge current and pulse on time because of the generation of denser plasma channel and superior spark energy respectively.
(2) Because of its higher melting point, the copper electrode has the lowest TWR as compared to the brass electrode. TWR decreases with the addition of SiC particles due to the decreased mobility of negative ions through the gap size. Increases in pulse on time and discharge current result in an increases TWR.

(3) Suspension of SiC particles improves surface quality owing to complete flushing of dielectric fluid caused by expanded spark gap. When added beyond the threshold leads to lower heat generation which creates voids and pits. $R_a$ value increases with in increase in pulse on time and current because of bombardment and surface blitzkrieg respectively.

(4) The MRR and Ra of the composites reduces with increase in the weight percentage of reinforcing particles. Remelted layer formation and globules has greater influence on Machined surface hardness, Specimen with lower machined hardness possess better surface quality.

(5) The presence of carbon content in the used engine oil resulted in the occurrence of black spots on the machined surface. The surface topography showed crater valley, pits globules and remelted layers. Addition of SiC particles prevents the formation of re-melted layer hence surface roughness value decreases. Adding SiC particles at the concentration of 6 g l$^{-1}$ increases the length of crater valley hence surface quality worsens.

(6) The input variables are optimized by TOPSIS optimization technique. Optimal process variable for the machining of AA7050/SiC/B$_4$C under-utilized engine oil di-electric medium was Pulse on time 45 $\mu$s, current 6 A and working tool, brass.

Data availability statement
All data that support the findings of this study are included within the article (and any supplementary files).

ORCID iDs
S Ganapathi Iyyappan https://orcid.org/0000-0001-5365-7151

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