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EXPLORING SWIRL CASTING AND COMBINED WIRE ELECTRICAL DISCHARGE MACHINING FOR ENHANCED PERFORMANCE IN Al-7075/Al_2O_3 AND SiC

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Abstract

Aluminum metal matrix composites are used in science and engineering, defense, auto parts, aerobics instruction components, and telecommunications equipment due to their synergistic properties like low light density, increased implementation, and quick thermoelectric advancement. Al-7075 aluminum is widely utilized in aeronautics components to enhance structural mechanisms. Despite increasing SiC& Al_2O_3privilege by 2%, 4%, 6%, and 8%, to be man-made and with the same stir casting procedure. Measurements of position stiffness, deformation, effect, and wear are made using international standards. This identical pouring technique is done, but close to SiC& Al_2O_3@8% will be successfully absorbed into aluminum using stir casting gearbox to create a hybrid aluminum metal matrix composite. By adding silicon carbide and aluminum oxide, AL-HMC improved stiffness and mechanical properties. Increased Al_2O_3&SiC in aluminum metal composites reduces fatigue and frictional strength. Despite the MMC's high SiC&Al_2O_3 content, this alteration tends to decrease with obstacle frequency. In one exploratory method, L9 Arrays are used with DOE Strategies to introduce new WEDM process variables, enhance marginal interface irregularity, and measure material removal for Al-7075/SiC&Al_2O_3. Investigations must be made to maintain the same weight proportion of SiC& Al_2O_3 pilot while minimizing material removal and maximizing external irregularity. Current study results are used to identify the fastest and most accurate WEDM Process variables for producing Al-7075/SiC&Al_2O_3 at varied influence percentages.

Keywords: WEDM, Stir Casting, Wear Test and Orthogonal Array(L9)

1. Introduction

1.1 Metal Matrix Composite

Expand to nefarious (MMC) metal matrix composite materials and combine to get unique products like porcelain and minerals. The centre between porcelain and its composite alloy reinforcements has a much higher approximate value for a robust enlightened essential component beneath fabrication metallic compositional structure containing active substance reinforcements. The chosen compounds seem to be effective and helpful mixes. These include higher effectiveness, aluminum's conceptual capacity to bend under compression during heat battle, and selected ceramics' rigidity and imperviousness when delicate. Silicon carbide and aluminium have differing Young's module strengths of 70 and 400 Gpa, thermal efficiency of 2416,4106/0C, and yield strength of 35 and 600 Mpa. Were (T6 conditioned A6061/SiC/17p) aluminium matrix metal composites with 96.6 Gpa Young's modulus and 510 Mpa yield strength preserved due to additives [1]. A similar volume's straightforward layout might strengthen these traits. We also considered religious accommodation while allocating such ingredient, even genuine synthesis. WEDM, among other processes, gives its most flexible tool, which is challenging yet employs complicated morphologies to deliver its finest metalworking activities inside this synthetic structure orientation. After a modest amount of hard metal machining, investigators can classify various Metal Matrix composite materials using Wired Dielectric Fluid machining procedures [2]. Wired Electrical Discharging machining cutting components were often brass or copper wire, 1mm to 2.5mm in diameter. Since there seems to be little close communication between this same workpiece surface and the wire tool in just this methodology, something suggesting that while embers were always developed in both this same work piece material and this same tool with the same great assistance of piezoelectric liquid, individuals have been repeatedly furnished inside an equipment territory, and the material removal method has also been finished because [3,4]. Therefore, its tools and functioning components did not experience stress or resistance while cutting. Industry uses the aforementioned technique to make mechanical dies, tooling, measures, and fasteners. Workpiece, insulating liquid, and cutting ability affect several Wire EDM operating factors. Selecting operation factors including shape, waviness, and (MMR) material removal rate is a complicated task for engineers and researchers, even if slight adjustments might affect cutting performance [4,5] In order to achieve the objective of incorporating diverse characteristics and substances, it is possible to include hybrid metal matrix composite materials in the same electrical discharge machining (EDM) process. Additionally, under certain circumstances, the process can lead to the acquisition of a significant external domain between multiple dominant entities, as a consequence of different parameters affecting its material removal capabilities[6] The statement discusses the objective of developing a nano composite material that incorporates a hard ingredient arrangement. This material exhibits various stages of development and is characterised by its strength, density allowances, and different transition periods. The nano composite consists of tough substances bonded to a matrix of composite structures, which can either strengthen or weaken the material depending on the amount and reliability of nanoparticles present. This material is referred to as a hybrid nano composite [7] Nano particle additives were reasonably priced and readily accessible. This specific casting plays a vital role in facilitating the development of improved metal-matrix nano composite accessories in the current setting. Expenditure might be reduced by using cost-effective measures such as reinforcing the most essential component and utilising advanced production processes that provide improved mechanical capabilities. The selection of stir casting was necessary. Nano particle additions are much more cost-effective and readily accessible. The fabrication process is arguably the most cost-effective means of manufacturing. The intricate arrangement of elements and the use of durable metalworking techniques have significant production demands, especially with the introduction of mechanization in the industrialization of evacuation routes and the rise of new corporate expectations. The major focus is on achieving high productivity and dependability of a component, while simultaneously managing reductions in time and costs. Therefore, it is crucial to improve the overall manufacturing quality of the component metal matrix composites by focusing on achieving higher surface smoothness and perfection [8].

1.2 Aluminum Stand Metal Matrix Composite

Aluminum composite materials have consistently shown to be the preferred choice for aluminum metal matrix material (AMMM), facilitating the advancement of aluminum Metal Matrix Composites (MMCs). This is particularly notable due to its extensive range of high-quality dwellings that are available at a very modest starting price. Aluminum-based metal matrix composites (AMMCs) possess several desirable characteristics, such as increased specific stiffness and tensile strength, enhanced high-temperature performance (compared to pure metals), greater thermal stability, and reduced heat dissipation. AMMCs possess versatile properties and have been employed in various applications such as electronics heating, aeronautical manufacturing, astrophysics for layering with efficient absorbers, engine impeller fins, combustion steam locomotives, gasoline automotive parts and other similar functional uses. The bulk of manufacturing working components used in this company's products are constructed of aluminium alloys, namely Al 7075, Al 6061, A357, A359, Al 2618, and Al 2214. The spectrophotometric evaluations of the Al 7075 production material are shown in Table 1. The present inquiry is driven by the employment of a binder to explore the potential of employing Al-7075 alloys in hardened aluminium alloy-metal matrix composites. This exploration aims to improve appearance and reduce costs. In order to create composite materials, the process of manufacturing involves adding metal reinforcements to an aluminium matrix and subjecting it to intense heating. This method requires a very high temperature. The stir casting method is a conventional technique known for its inherent flexibility, making it highly suitable for producing hybrid composites. If the process of stir-casting using whirling poles has to be repeated, the same structure can be seen in Figure 1. The aforementioned

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design employs steel as the principal material for the propeller, mostly because of its enhanced heat distribution uniformity [9,10].

Table 1 AL-7075 Composition

Elements	Cr	Cu	Fe	Ma	Mg	Si	Zi	Ti	Al
%	0.8	1.35	0.3	2.21	0.08	0.4	5.67	0.06	Balance

1.3 Stir Casting Technique

Swirling Moulding refers to a method of making products by combining a detachable phase consisting of small fibres and porcelain elements. This is achieved by transforming already solid metals into liquids via mechanical means. Any occurrence during the transportation of a liquid mixture containing MMC has the potential to be considered a predetermined series of events. Metal synthesis capability. Swirl Casting is particularly notable during its subsequent face presentation. The retractable part is actively operational, although with restricted convenience (volume set at 30%, sometimes lower). Additionally, there is the option of a quasi-standard constant constituent gearbox design available. Subsequently, diminutive condensate fibres were included into the mixture. There is a noteworthy difference that stands out due to a discrepancy in its strength compared to its structural part, while also being separate from it. The mechanical agitation used for the swirling cast process is seen in Fig1. Acquiring this skill was simple to master and reasonably priced.

2. Experimental procedure

The present experiment utilises the swirl casting process to generate sample materials. The current study used Al 7075 composite materials that included reinforcing components such as silicon carbide and 200 lattice structures of aluminium oxide. MMC production involves the use of stir casting and a saltwater fluid to generate a sparking voltage gap between the cutting wire and the product components. This technique is comparable to how WEDM employs a brass filament with a diameter of 0.025 cm for cutting. Figure 2 (Wire Electric Discharge Machine) illustrates this List II demonstrates multiple operational variables investigated through the utilisation of Design of Experiments (DOE) methodology.

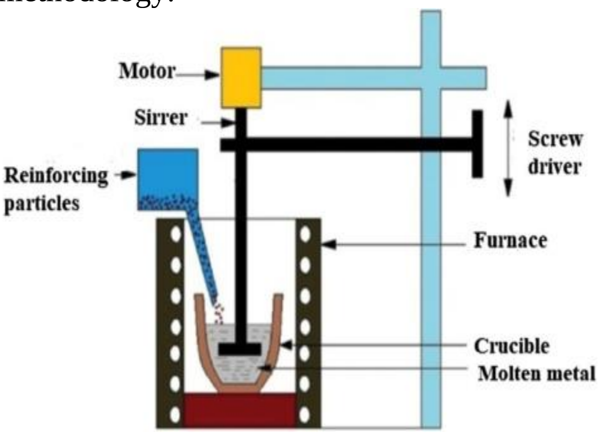

Fig. 1. Stir casting-Set-UP

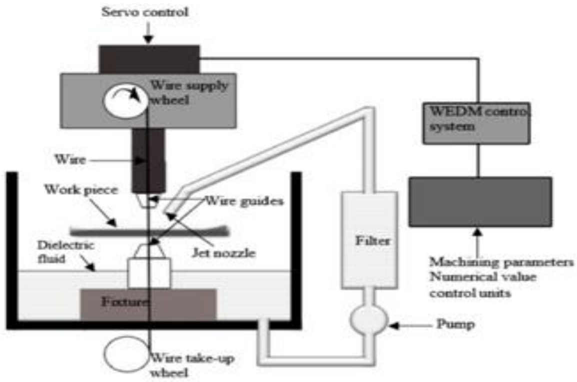

Fig.2. Set-Up of WEDM

An oblique pattern with L9 was employed, and four factors were selected: Pulse-off time, Volts, Pulse-ON duration, and Feed rate. Additionally, the surface area of the cut specimen components was enhanced by employing abrasive sandpaper of different grades. By using equipment that has been polished with a wheel, we were able to achieve a mirrored polishing effect on all the experimental product items. Additionally, we applied a layer of aluminium over a soft substance. Morphologies were generated by the use of a visual microscope and scanning electron microscopy (SEM). Keller's approach is used for the erosion of specimen parts with a complex structure. Following the collection of preliminary microscopic photographs, the physical strength of the sample components was assessed using Vickers hardness testing, applying a 50-gram weight on top of each individual specimen. The overall surface morphology and surface finish of both the EDM-machined porous objects were assessed using a Mitutoyo surface morphology ruggedness instrument[11,12].

Table 2 Input Process Parameters on WEDM

Stages	Input Process Parameters			
	TON(Pulse On Time)	TOFF(Pulse Off Time)	V(Voltage GAP)	F(Feed Rate of Wire)
1	6	10	45	5
2	8	8	65	7
3	10	6	85	9

3. Results and discussion

3.1 Hardness Test

The stir casting process is used to enhance the hardness of ALMMC composite specimens. Consequently, the addition of 4-6% weight percentage of Al_2O_3&SiC led to a hardness augmentation of 2-4%, while a weight percentage above that resulted in a higher rise of 6-8%. The higher the weight proportion of reinforcing components (Al_2O_3 and SiC) in this composition, the greater the improvement in stiffness. The distribution of collective stiffness aimed at unreliable weight proportions of its specific added material is shown in 3.a, Figure. In summary, the research demonstrates the efficacy of swirl casting in enhancing the hardness of ALMMC. Additionally, it offers useful insights into the influence of weight percentages of reinforcement on the hardness of the composite.

Table.3. Average Mechanical Test Results

Specimen	Hardness(VHN)	Tensile Strength (Mpa)	Impact Strength(J)	Wear rate
1-(Al-7075,2%Al_2O_3& SiC)	181	195	2.9	412
2-(Al-7075,4%Al_2O_3& SiC)	186	224	4.3	402
3-(Al-7075,6%Al_2O_3& SiC)	194	312	5.5	310
4-(Al-7075,8%Al_2O_3& SiC)	198	342	9.7	286

3.2. Impact test

The influence of weight percentages of selected ingredients (Al_2O_3 and SiC) on the toughness of the synthetic composite material is shown in Figure 3.c. The objective of the research was to enhance the durability of the specimen in the ALMMC compound by including 8wt% of Al_2O_3&SiC reinforcement, resulting in increased collision strength.

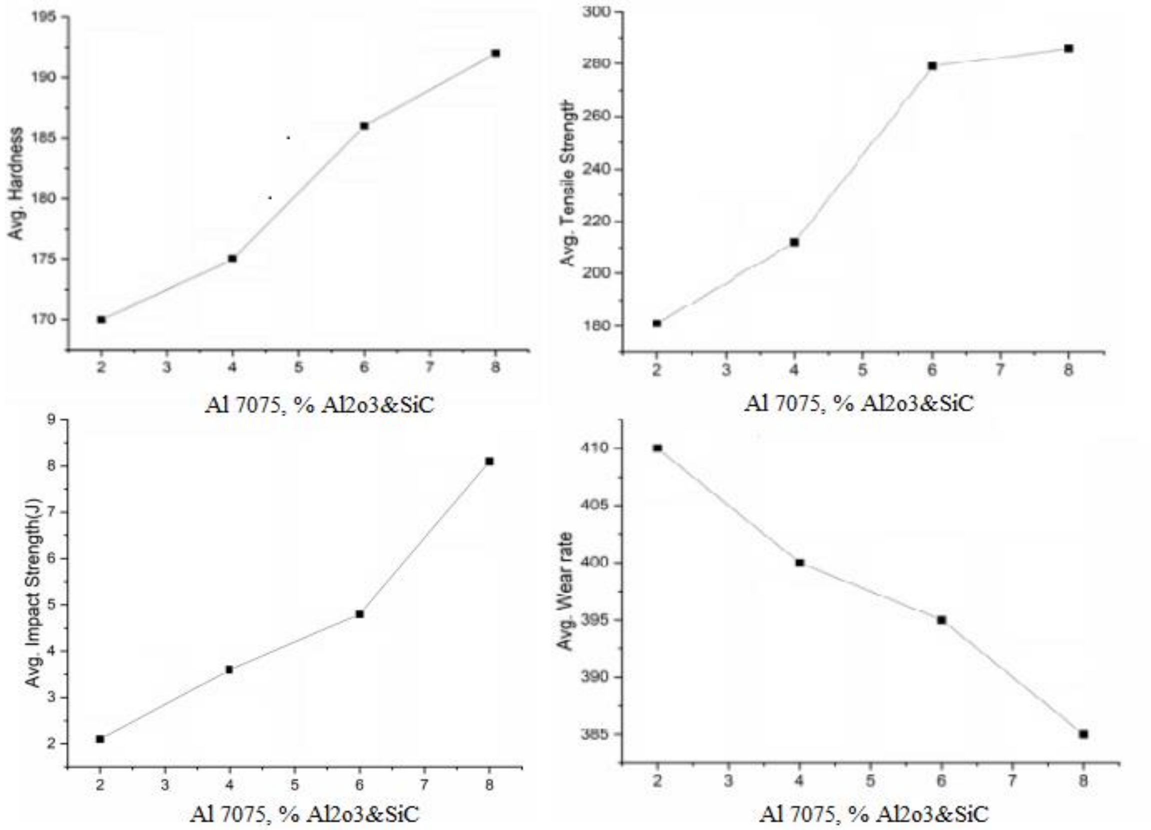

Fig.3. (a) Hardness vs. Al_2O_3&SiC wt% (b) Tensile strength vs. Al_2O_3&SiC wt% (c) Impact strength vs. Al_2O_3&SiC wt% (d). Wear vs. weight percentage Al_2O_3&SiC

The purpose of incorporating reinforcements in ALMMC by Swirl Casting is to enhance the durability of the composite specimen. During the experiment, we performed a detailed analysis of cracked inspection specimens to evaluate their impact resistance and elongation. The results clearly showed that the compound specimen exhibited a yielding character and experienced a rupture. The research observed that the toughness of the compound specimen fluctuated depending on the weight percentages of $Al_2O_3$and SiC. The final outcomes of this study suggest that the careful selection of weight percentages of reinforcements is vital for attaining the necessary toughness and mechanical qualities of the casted compound. In summary, this work demonstrates the possibility of using Al_2O_3&SiC ash reinforcement and Swirl Casting to improve the toughness and mechanical capabilities of ALMMC composite material.

3.3 Tensile Test

The research sought to examine the influence of different weight percentages of Al_2O_3 and SiC ash reinforcement on the tensile strength of ALMMC. Tensile tests were conducted using a Tensometer. The findings shown in Table 3 demonstrated that the incorporation of Al_2O_3&SiC ash reinforcement in the form of weight percentages led to an augmentation in the tensile values and compound potency. Furthermore, the results indicated that an increase in the weight % of Al_2O_3&SiC ash in the composition led to a corresponding rise in the amount of improvement in tensile strength, as shown in Figure 3.b. The research emphasises the beneficial effect of incorporating Al_2O_3&SiC ash reinforcement on the tensile strength of ALMMC, which is crucial for enhancing the mechanical properties of the composite. These findings highlight the significance of meticulously choosing the weight % of composition additives to get best outcomes in the mechanical characteristics of this composite.

3.4 Wear Test

This research involves doing wear testing on specific specimens using a pin-on-disc-test setup. The findings of this investigation, as shown in Figure 3.d, demonstrate that the wear rate percentage lowers as the weight percentage of Al_2O_3&SiC additives in Al-7075 rises. In contrast, a higher level of decrease in wear rate was seen when using additives such as Al_2O_3 and SiC reinforcement, even when their effect percentages were quite low. The inclusion of graphite in weight percentages aids to the decrease in wear rate due to its self-lubricating characteristic. The research emphasises the need of meticulously choosing the weight % of reinforcements to get optimum outcomes in the wear resistance of the composite material. The results indicate that the incorporation of advanced effect percentage additives such as $Al_2O_3$and SiC reinforcement into Al-7075 may result in reduced wear rates, hence presenting a favourable choice for applications demanding elevated wear resistance.

3.5 The Influence of processing variables on machining process performance

The date specified in table 4 displays many factors for executing the investigative outcomes, including material removal rate and surface roughness. The primary objective of this work is to regulate four specific process parameters in precision machining: Voltage-Gap, TON, TOFF, and feed rate (wire). These factors are crucial since they have the ability to impact the machine's performance and the quality of the final output. The research establishes precise ranges of values for each of these factors, drawing on the experimental data. The findings indicate that modifying these parameters may have a substantial effect on the MRR (Material Removal Rate) and Ra (Surface Roughness) values of the machined material. Hence, comprehending and maximising these variables is vital in order to get the intended results in precision machining. The present discoveries in this study may be used to impact the development of data for standards and suggested practises in precision machining, as well as to boost the effectiveness and quality of the machining process[13,14].

The gap voltage and wire feed rate play a vital role in evaluating the material removal rate (MRR) of Al-7075 compound matrices. An increase in both the gap voltage and wire feed rate leads to a rise in the rate of material removal in the compound, as seen in Table 4. Nevertheless, the pulse-off time (TOFF) did not significantly affect the total material removal rate (MRR).The impact of surface roughness on the machined Al-7075 MMCs was also assessed, and the findings are shown in Table 4. It was later shown that increasing the weight percentage of Al_2O_3 and SiC in MMCs led to a decrease in surface roughness. This occurs as a result of the reinforcing particles effectively occupying the spaces between the aluminium matrix and minimising the surface imperfections.

Table.4. Material removal rate and Surface Roughness are also investigated as process factors

	Input Process parameters				Output Responses MRR(mm3/min)				Surface Roughness(Ra)			
E. No	TON (Pulse On Time)	TOFF (Pulse Off Time)	V (Voltage GAP)	F (Feed Rate of Wire)	1-Al 7075, 2% Al_2O_3& SiC	2-Al 7075, 4% Al_2O_3 &SiC	3-Al 7075, 6% Al_2O_3&SiC	4-Al 7075, 8% Al_2O_3&SiC	1-Al 7075, 2% Al_2O_3& SiC	2-Al 7075, 4% Al_2O_3&SiC	3-Al 7075, 6% Al_2O_3 &SiC	4-Al 7075, 8% Al_2O_3&SiC
1	6	10	45	5	24.62	23.91	24.19	25.81	0.60	0.96	1.63	1.67
2	6	8	65	7	18.22	20.284	21.70	21.93	1.31	1.61	1.72	1.81
3	6	6	85	9	16.18	20.42	17.61	17.91	1.40	1.64	1.45	1.45
4	8	10	65	9	19.22	22.41	21.27	21.81	1.60	1.38	1.64	1.82
5	8	8	85	5	18.48	16.21	14.51	14.90	1.14	1.28	1.55	1.63

6	8	6	45	7	33.14	28.27	21.22	21.60	1.24	1.72	1.72	1.87
7	10	10	85	7	18.44	21.05	15.22	15.27	1.45	1.64	1.86	1.91
8	10	8	45	5	29.56	28.14	22.31	22.65	0.93	1.50	1.17	1.37
9	10	6	65	9	19.12	21.49	21.16	21.58	1.03	1.13	1.31	1.61

3.6 Material removal rate (MRR)

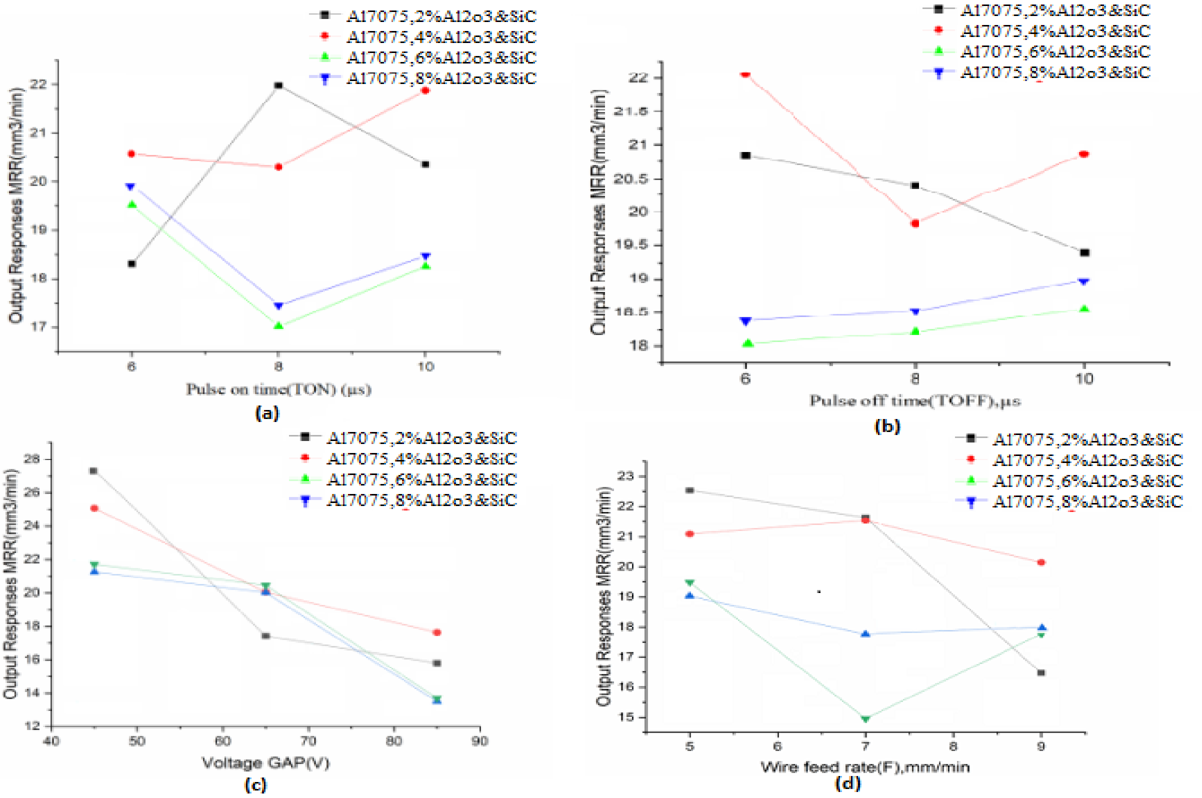

Fig.4. Material Removal Rate Response Graphs

This study concludes that the incorporation of Al_2O_3 and SiC additives in Al-7075 MMCs results in a decrease in the material removal rate (MRR) and surface roughness. The ideal weight percentage of reinforcement must be determined in order to achieve the best material removal rate and external quality. The pulse-on time (TONNE), gap voltage, and wire feed rate are important input factors that significantly impact the material rate (MRR) of Al-7075 metal matrix composites (MMCs) during wire electrical discharge machining (WEDM)[15,16].

3.7 Surface roughness (RA)

The study on Al-7075 alloy with $Al_2O_3$and SiC also examined the surface roughness of the material. The results are shown in Figures 5a-d. The data illustrates the mean surface roughness values for different compositions of Al_2O_3&SiC (2%, 4%, 6%, and 8% by weight) incorporated into Al-7075. The calculated cumulative surface roughness, Ra, was determined to be 1.31 metres. The surface roughness cumulative value rose as the proportion of Al_2O_3&SiC grew by 2%, 4%, 6%, and 8% by weight inside Al-7075. The corresponding values were 1.21m, 1.28m, 1.32m, and 1.42m, respectively. The surface roughness of the material increased when more additives were added in the form of weight % of reinforcements in MMCs, which included hard particles.

The study also discovered that increasing the pulse-on time (TONNE) in the WEDM process leads to a reduction in surface details. This occurred as a result of an ignition that included both the wire and the specimen, leading to a decrease in the roughness of the surface. Conversely, an increased pulse-off time (TOFF) led to an improvement in surface roughness. By increasing the pulse-on time (TON), it was seen that the compaction of the specimen compound improved by the repeated ON-OFF pulse expulsions. This led to a greater attention in generating a reflecting and less positioned surface, resulting in improved surface roughness. Overall, the results indicate that the quantity of additives, expressed as a weight % of Al_2O_3&SiC, in the al-7075 compound material, as well as the pulse-on (TON) and pulse-off (TOFF) periods in the WEDM process, have a substantial impact on the surface roughness of the compound materials[17].

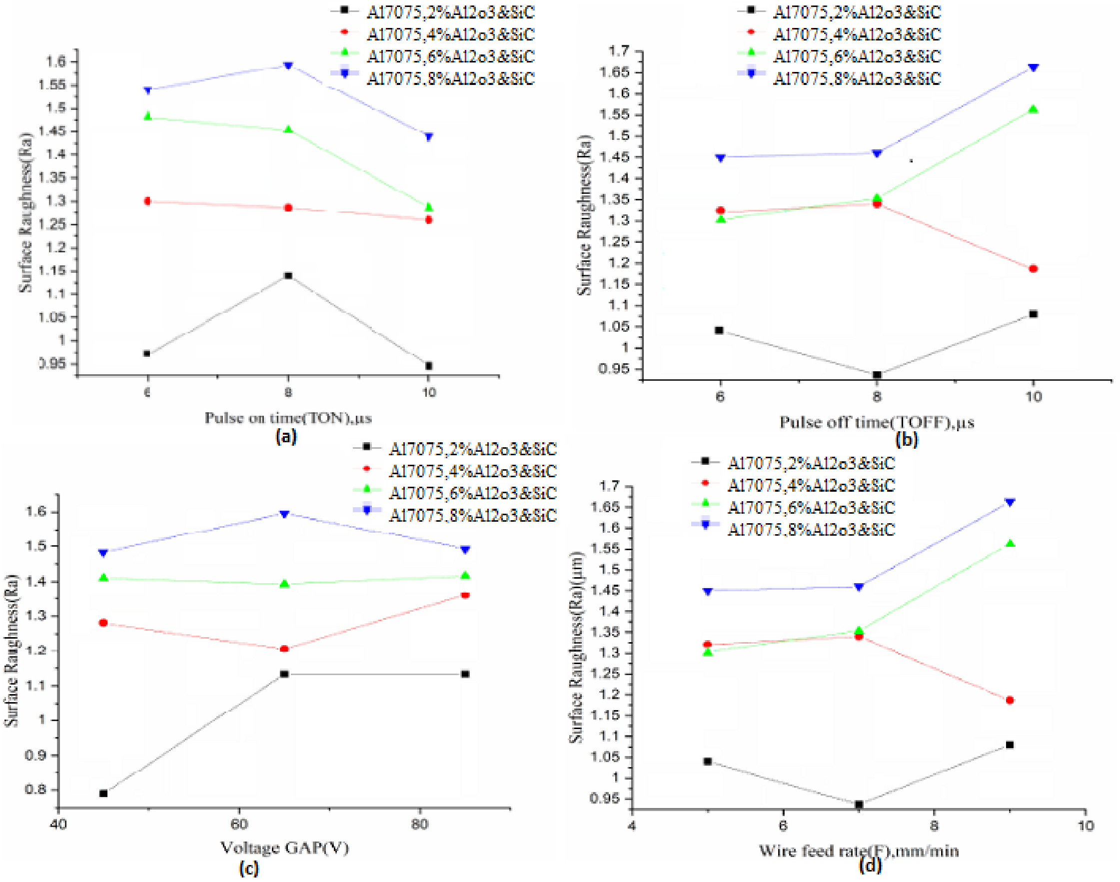

Fig.5. Surface Roughness Response Graphs

3.8 Microstructure and SEM

Figure 6-(a-d) depicts the association between the distributions of the additional additives (Al_2O_3&SiC) and their properties, as seen using a scanning electron microscope (SEM). The uniform distribution of additives (Al_2O_3 and SiC) throughout the sample specimens enables unambiguous parallels to be made using SEM (Scanning Electron Microscopy). The microscopic structure of the specimen near the breaking point in the tensile test piece is examined using a high-intensity electron beam that scans in a raster pattern.

The schematic exhibited is the 6th-b, showing the microstructure of a, b, and c. The magnification used was 300X using a visual microscope, which allowed for a clear view of the superior distribution. As the weight % of additives (Al_2O_3 and SiC) in the compound matrix grows, the amount of extra additive particles similarly increases, but the space occupied by these secondary particulates decreases. Occasionally, the use of additives (Al_2O_3&SiC) in the Al-7075 compound matrix might exhibit a rejection indication.

The use of scanning electron microscopy (SEM) in figure 6-a, together with optical microscopy, offers a comprehensive examination of the microstructure of the matrix consisting of (Al_2O_3&SiC) and its distribution of reinforcing subdivisions. These approaches enable the analysis of the space between particles and the quantity of reinforcing particles, which are vital elements in determining the material's strength and durability.

In summary, the research highlights the significance of comprehending the microstructure of materials and its correlation with their qualities. Through the use of sophisticated imaging methodologies, scientists may get a deeper understanding of the conduct of substances under many circumstances, hence facilitating the creation of sturdier and longer-lasting materials suitable for a broad spectrum of uses.

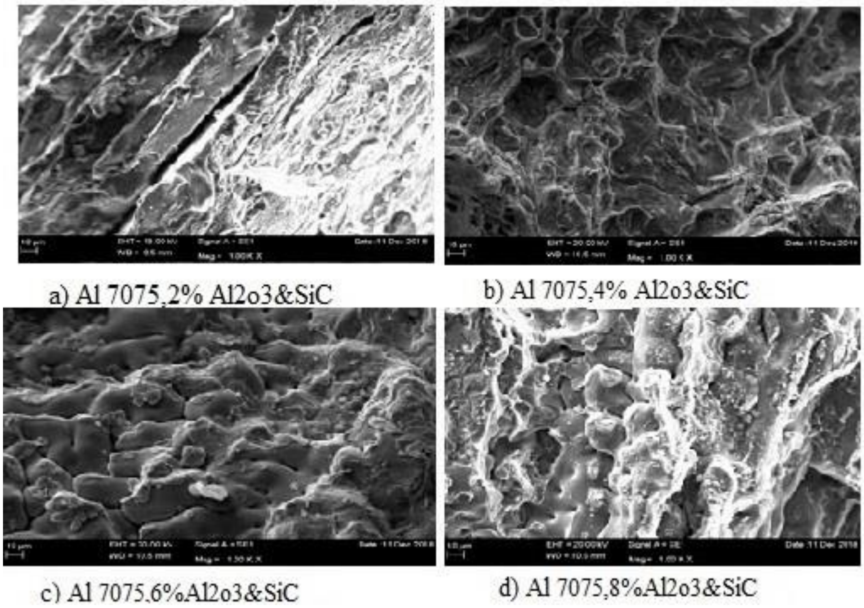

Fig.6.a SEM

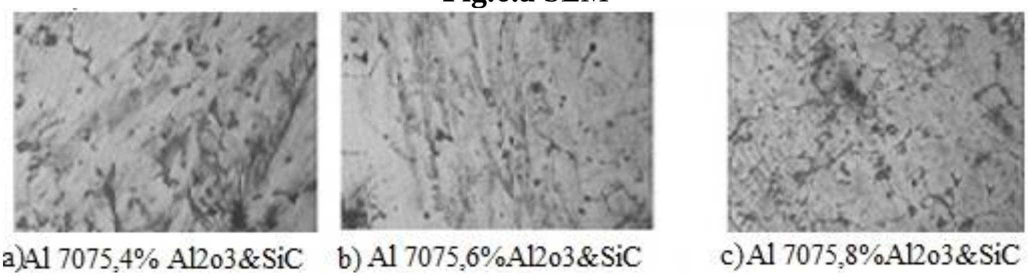

Fig.6-b Microstructure

4. Conclusions

Al-7075/ Al_2O_3&SiC composites were fabricated with weight percentages of 2, 4, 6, and 8% using the liquid-state technique. These composites were then analysed using wire-cut-electric-discharge-machining (WEDM) to assess their material removal rate (MRR) and surface roughness (RA). These findings indicate that increasing the weight percentage of (Al_2O_3&SiC) inside the Al-7075 composite results in a reduction in the material removal rate and an improvement in the surface roughness (RA). This suggests that higher concentrations of (Al_2O_3&SiC) make Al-7075 a more difficult material to machine, but also result in a more polished surface quality. The following remarks are summarised in this report.

A cost-effective and widely used technique called stir casting is used to produce a metal matrix composite consisting of Al-7075/ Al_2O_3&SiC with high efficiency.

The addition of $Al_2O_3$and SiC to Al-7075 composite materials resulted in a higher level of hardness compared to Al-7075 without any additives.

The scanning electron microscopy (SEM) analysis showed that the Al_2O_3 and SiC particles were uniformly distributed throughout the Al-7075 material.

The TOFF (pulse-off time) and the provided voltage gap between the wire and specimen of the Al-composite are crucial process parameters for the MRR (Material Removal Rate) test employing wire feed.

The TON is particularly important and must meet the minimal requirement. The clearance rate of the Al compound matrix material, expressed as a percentage, consistently decreases in Al-7075 when it is reinforced with Al_2O_3 and SiC.

Incorporating reinforcing materials into Al-7075 results in an elevation of surface roughness. However, the proportion of additives added to the Al compound metal matrix (MMCs) has no effect on the material removal rate. This is because WEDM is proficient in machining difficult-to-cut composites.

5. Acknowledgements

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References

[1] B. F. Abu-Sharkh and H. Hamid, "Degradation study of date palm fibre/polypropylene composites in natural and artificial weathering: mechanical and thermal analysis," Polymer Degradation and Stability, vol. 85, pp. 967-973, 2004. (Reference to a journal)
[2] I. M. Daniel and O. Ishai, Engineering mechanics of composite materials. New York: Oxford University Press, Inc., 1994. (Reference to a book)
[3] A. Dufresne, "8 - Cellulose-Based Composites and Nanocomposites," in Handbook of Biopolymers and Biodegradable Plastics, ed Boston: William Andrew Publishing, 2013, pp. 153-169. (Reference to a chapter in an edited book)
[1]Introduction to Composite Materials, F.C. Campbell, Structural Composite Materialsttp://machinedesign.com/article/metal-matrix-composites-1115, Nov- 15, 2010 .
[2] Pradeep K. Rohatgi (1993) Metal-matrix Composites, Defence Science Journal, Vol 43(4) , pp 323-349.
[3] N.G. Patil, P.K. Brahmankar, D.G. Thakur, On the effects of wire electrode and ceramic volume fraction in wire electrical discharge machining of ceramic particulate reinforced aluminum matrix composites. Proceedings CIRP 42, 286–291 (2016).
[4] J. Zhao, J.C. Jie, C. Fei, C. Hang, T. Li, Z. Cao, Effect of immersion Ni plating on interface microstructure and mechanical properties of Al/Cu bimetal. Trans. Nonferrous Met. Soc. China 24, 1659–1665 (2014).
[5] H.K. Garg, K. Verma, A. Manna, R. Kumar, Hybrid Metal Matrix Composites and a further improvement in their machinability—a review. Int. J. Latest Res. Sci. Technol. 1(1), 36–44 (2012)
[6] K.B. Vijay, S. Dharminder, S. Puneet, Research work on composite epoxy matrix and Ep polyester-reinforced material. Int. J. Eng. Res. Technol. 2(1), 1–20 (2013)
[7] B.S. Yigezu, P.K. Jha, M.M. Mahapatra, The key attributes of synthesizing ceramic particulate reinforced Al-based matrix composites through stir casting process: a review. Mater. Manuf. Processes 28(9), 969–979 (2013)
[8] Y.C. Shin, C. Dandekar, in Mechanics and modeling of Chip Formation in Machining of MMC, ed. by J.P. Davim, Machining of Metal Matrix Composites (Springer-Verlag London Limited, 2012) https://doi.org/10.1007/978-0-85729-938-3-1
[9] B.C. Kandpala, J. Kumar, H. Singh, Machining of aluminum metal matrix composites with electrical discharge machining—a review. Mater. Today Proc. 2, 1665–1671 (2015)
[10] A. Kumar, D.K. Bagal, K.P. Maity, Numerical modeling of wire electrical discharge machining of super alloy Inconel 718. Proc. Eng. 97, 1512–1523 (2014)
[11]S. Prashanth, R.B. Veeresha, S.M. Shashidhara, U.S. Mallikarjun, A.G. Shiva siddaramaiah, A study on machining characteristics of Al6061-SiC metal matrix composite through wire—cut electro discharge machining. Mater. Today Proc. 4(10), 10779–10785 (2017)
[12] Y. Pachaury, P. Tandon, An overview of electric discharge machining of ceramics and ceramic-based composites. J. Manuf. Process. 25, 369–390 (2017)

[13] S. Mohanty, B.C. Routara, A review on machining of metal matrix composites using nano-particle mixed dielectric in electro- discharge machining. Int. J. Automot. Mech. Eng. 13(2), 3518–3539 (2016)

[14] G. Talla, D.K. Sahoo, S. Gangopadhyay, C.K. Biswas, Modeling and multi-objective optimization of powder mixed electric dis- charge machining process of aluminum/alumina metal matrix composite. Eng. Sci. Technol. Int. J. 18, 369–373 (2015)

[15] P. Sivaprakasam, P. Hariharan, S. Gowri, Optimization of micro- WEDM process of aluminum matrix composite (A413-B4C): a response surface approach. Mater. Manuf. Process. 28, 1340–1347 (2013)

[16] P. Shandilya, P.K. Jain, N.K. Jain, Prediction of surface rough- ness during wire electrical discharge machining of SiCp/6061 Al metal matrix composite. Int. J. Ind. Syst. Eng. 12(3), 301–315 (2012)

[17] H. Singh, H. Kumar, Review on wire electrical discharge machining (WEDM) of aluminum matrix composites. Int. J. Mech. Product. Eng., ISSN: 2320-2092 3(10) (2015).

[18] Michael Oluwatosin Bodunrin, Kenneth Kanayo, Alaneme Lesley Heath Chown(2015), Aluminium matrix hybrid composites: a review of reinforcement philosophies; mechanical, corrosion and tribological characteristics, Journal of materials research and technology, vol 4(4) Dec 2015, pp 434-445.

[19] H. Warren, Hunt, Darrell R. Herling (2004), Text book, Aluminium Metal Matrix Composites, Advanced Materials and rocesseshttp://www.science.org.au/nova/059/059