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Enhancement in Mechanical Properties of Al-7175/SiC/B_4C Composite

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Abstract

Machining the growth of the manufacturing sector has led to an increased utilization of aluminum metal matrix composites (AMMCs). These composites have gained significant interest worldwide, particularly in the automotive, architectural, and aerospace sectors, due to their exceptional mechanical and tribological properties. AMMCs exhibit high specific strength, improved strength-to-weight ratio at high temperatures, and superior wear resistance compared to the matrix phase alone. To enhance the metallurgical and mechanical properties of the base matrix, various types of particulate reinforcements such as SiC (silicon carbide), Al_2O_3 (alumina), B_4C, TiC, and $ZrSiO_4$ are employed. To fabricate AMMCs, authors have employed different manufacturing processes including solid-state techniques like powder metallurgy and liquid-state processes such as stir casting, compo-casting, squeeze casting, and *in-situ* casting routes. Among these methods, stir casting is the most cost-effective and straight forward approach for producing AMMCs. This article provides a comprehensive explanation of the process involved in fabricating AMMCs using Al-7175 as the matrix material, with B_4C and SiC as the reinforcements, via the stir casting process.

Keywords

Stir casting, Tensile, Wear, Impact

Introduction

The matrix metal alloy designation, reinforcing material, volume percentage, and shape all play a role in the categorization of metal matrix composites (MMCs). These lightweight structural materials are utilized in a limited number of aircraft, helicopters, and spacecraft. MMCs consist of a metal matrix phase with embedded hard reinforcing particles. The matrix phase is typically composed of lightweight alloy metals, such as aluminum, aviation constructions often use aluminum, magnesium, or titanium alloys (Al-2024, Al-7075, Ti-6Al-4V, etc.). Nickel superalloys might be used as the matrix phase in MMCs for use in high temperature applications. The metal matrix phase is reinforced by incorporating ceramic or metal oxide in various forms such as continuous fibers, whiskers, or particles. Continuous fiber reinforcements like boron (or borsic, which is boron coated with SiC), carbon, and SiC are commonly used and distributed throughout the matrix phase. Particle reinforcements like SiC, Al_2O_3, also B_4C are also popular choices. The volume fraction of reinforcement in MMCs typically remains below 30%, which is lower compared to the fiber content found in aerospace carbon-epoxy composites (55 - 65% by volume). Higher reinforcement contents above 30% are often avoided due to challenges in processing, forming, and machining the MMCs caused by their high hardness and low ductility. MMCs exhibit several distinctions from other composite materials.

The liquid-state approach was used to create Al-7075/Al_2O_3&SiC at (2, 4, 6, and 8% wt.). To efficiently produce MMCs of Al-7075, Al_2O_3, and SiC, a typical cost-effective stir casting approach is adopted. Compound resources constructed for Al7075/Al_2O_3/SiC have a greater stiffness number than non-reinforced Al-7075 [1]. Using Al7075 with grey cast iron and also ash dust metal matrix compound, a classic, economically viable stirring casting technique has been effectively performed. If compared with non-reinforced Al-7075 with ash dust also grey cast iron compound materials, Al-7075 with ash dust along with grey cast iron compound materials had a higher rigidity number [2]. The demand for lightweight materials has driven this employ for compounds, such as AMMCs, to achieve enhanced substance presentation. Currently, aluminum composite materials are regarded as highly promising materials for both structural and functional applications. These composite materials find application in various industries, including marine, defense, automotive, aerospace, and high-temperature environments. Stir casting has emerged as a prominent method of fabricating AMMCs due to this convenience and low cast, enabling bulk manufacturing. The review article covers essential aspects of the stir casting process, including physical characterization, its impact for different strengthening's, disputes faced, also potential upcoming investigate directions within composite expansion [3]. It is mentioned that composite materials possess several unique properties that are not commonly found in conventional materials. One significant advantage is their superior volume-to-weight ratio, making them valuable for designing components in industries like aerospace, automotive, household appliances, and electronics. However, the development of composites creates difficulty because of having matrices while reinforcing substances that have distinct stages. Three particular AMMCs were analyzed by adjusting the matrix ratios (Al-6063) to reinforcement (fly ash and Al_2O_3) components during the stir casting process. Hardness also toughness was evaluated, and the results indicated with the purpose of Al_2O_3 subdivision played a vital responsibility within the composite material's strength [4].

It is expressed that advancements of substance knowledge facilitated innovation with production for new substances with the aim of can potentially swap presented ones in various applications. In this study, the researchers focused on comparing and characterizing Al-6061 and Al-2024 MMCs with selected reinforcing materials. These reinforcements include B_4C, SiC_p, and graphite in the form of particles. This adds together to these strengthening's of aluminum mold has the potential to enhance its physical and tribological characterizations for the composites. The MMCs are fabricated using the stir casting technique, and their mechanical properties are compared with pure Al-6061 and Al-2024, following ASTM E10/2018 standards. The investigation involves analyzing the tensile strength, hardness, and wear resistance of the AMMCs [5]. The researchers stated that they fabricated Al-7075 alloy composites among Si_3N_4 reinforcement within concentrations for 4, 8, and 12% by means of the stir casting method. Heat treatment was applied to the cast specimens to remove porosity, and porosity measurements were carried out using a computed tomography X-ray and an image analyzer. Additionally, the cast specimens underwent substance combinations analysis by means of spectra examination, and microhardness and images tests were carried out. The distribution of Si_3N_4 in the aluminum alloy is practical by means of a scanning electron microscope [6]. An AMMC be a compound substance consisting of one or more components, in recent times, cast AMMCs contains high rate of attractiveness across various industrial manufacturing with expertise due to its outstanding properties. The way these cast MMCs solidify has a major impact on whether or not they end up with the intended qualities. This research aimed to investigate and predict the most optimal results while conducting experimental stir casting processes within compound substances. This study revealed significant effects on physical characterization like hardness with tensile, also provided an analysis for the microstructure of A-359/Al_2O_3 composites [7]. The study focused on the fabrication of Al-8011/SiC composites with its stir casting technique among three dissimilar particle range of SiC with varying wt.% (2, 4, and 6%). The paper reports held its physical characterization for Al-8011-SiC compounds in relation to its effects for element size and SiC weight fraction. The ANOVA (Analysis of variance) and Taguchi method were utilized to determine the optimal variables of achieving its highest physical characterization, like stiffness, elongation potency, and toughness for the compounds. These results were validated through confirmation tests. It was observed that decreasing the subdivision dimensions and escalating its wt.% fraction for SiC led toward enhanced physical characterization for its compounds. Among the different particle sizes (63 µm, 76 µm, and 89 µm), the fine particles of SiC (63 µm) exhibited superior hardness, tensile strength, elongation, and toughness compared to the intermediate (76 µm) and coarse particles (89 µm). Specifically, Al-8011-6 wt.% SiC showed superior hardness and tensile strength, while Al-8011-2 wt.% SiC exhibited superior elongation and toughness. The particle size was found to be the most significant factor influencing its physical characterization for its compounds, followed by its amount for reinforcement [8]. The widespread applications of aluminum or AMMCs in industries such as aerospace and automobile outstanding into their low weight, elevated tensile potency, and dendrites conflict. SiC subdivisions are detached within the aluminum by liquor condition dispensation with solid-state dealing out direction. Among the liquor dealing out methods, stir casting is widely used by investigators outstanding this minimalism with price-effectiveness. Additionally, a tiny quantity of magnesium is additional to enhance its wettability for SiC within liquid aluminum during reinforcement. SiC reinforcement of aluminum or aluminum alloy greatly enhances its mechanical and tribological characteristics. The effects of SiC subdivision dimension, wt./vol.% on various properties such as fatigue strength, durability against corrosion, as well as abrasion-corrosion resilience of aluminum and aluminum hybrid MMCs; densities; permeability; stiffness; shock hardness; longitudinal stiffness; elasticity; sliding damage protection; liquid abrasion protection; abrasion-corrosion protection; corrode protection. Furthermore, its impact for elongation with machining for

SiC toughened AMMCs is as well converse. The study provides valuable insights into the enhanced properties of AMMCs and highlights its significance for SiC reinforcement in the advancement of these composite materials [9]. In recent times, there has been significant examination with development into field of AMMCs, driven by its potential to achieve excellent mechanical properties for various high-end applications. The factors influencing its physical characterization for Al-6061 MMCs produced during the stir casting method highlight the advancements prepared in this area. This physical characterization for its compound affected through weight percentage with strengthening subdivision, melting temperature. This selection for suitable reinforcement materials and optimizing different stir casting parameters present challenges in fabricating new materials while maintaining their desired mechanical properties. Despite these challenges, the increasing attention towards AMMCs is driven by the potential benefits they offer in terms of mechanical performance across a wide range of precision applications [10]. An innovative stir molding, as well as spacing holding method, produced open-celled Al-360/B$_4$C combination builds containing evenly proportioned along with dispersed porosity. Strengthening grain ratios for weight were 0.5%, 1%, 1.5%, and 2%. Its morphology along with the physical behavior of hybrid builds have been comprehensively examined with granular augmentation. Microstructural investigation was done employing an optical microscope and scanning electron microscope. The compression while softness experiments examined how reinforcing affected physical characteristics. The combination of composite foams' compressing durability is enhanced without ceramics strengthening. When achieving 0.5 wt.% augmentation proportion, hybrid foaming thermoplastic durability decreased. The live lines inclusion characteristics for its compound froth exhibited a similar trend to the compressive strength properties [11]. The researchers adopted a fusion approach to optimize swirl-cast variables. These numerous variables with its interactions can impact it even allocation of reinforcement subdivision. While promising outcomes have been achieved in specific scenarios, further work is required to simplify the conclusion and optimize stirrer intent for professional integration. To enhance precision and reliability, investigators combine hypothetical, investigational, geometric, with statistical recreation methods. Design of experiments, particularly Taguchi, along with ANOVA and regression, were commonly used statistical techniques. Ultimately, the lessons outcomes and recommendations are compiled, compared, refined, and presented to provide a comprehensive and straightforward guide on the appropriate stirrer design, stages, and positioning, making the paper distinctive [12].

Experimentation

Preheating

Al-7175/B$_4$C&SiC compound materials selected for experimental steady as work piece. To eliminate agglomeration, moisture, and gases contained in the reinforcement, preheating is necessary. SiC and B$_4$C are preheated into muffle heater with 300 °C before their utilization. Figure 1 presents SiC powder. Figure 2 presents B$_4$C powder.

Figure 1: SiC powder.

Figure 2: B$_4$C powder.

Stir casting

The Al-7175 is placed inside the vessel, with a quantity of approximately 800 gm - 1000 gm, according to our desired die-casting requirements, as depicted in figure 3 and figure 4. After closing the lid of the vessel, we wait for the base material to melt and then add the reinforcements, comprising 1% to 2% of the weight of the Al-7175 in the chamber. Stir casting is a highly effective liquid-state technique employed in the production of composite materials, wherein dispersed particles are intimately mixed with a molten metal matrix through

Figure 3: Stir casting furnace.

Figure 4: Pouring the molten liquid into the finger die.

mechanical stirring. This process offers significant advantages, being straightforward, cost-effective, and versatile for manufacturing MMCs with varying combinations of ceramics and metals. Its simplicity and lower production costs have made it widely adopted in diverse industries. Chemical and mechanical properties of Al-7175 (Table 1 and table 2), SiC (Table 3 and table 4), and B_4C (Table 5 and table 6) are also determined.

Crucible

A crucible plays a crucial role in metallurgical and casting processes as it serves as the vessel in which metal is melted to a molten state and then poured into molds for casting various shapes. The choice of crucible material is of utmost importance to ensure effective and efficient melting and casting operations. There are several materials available for crucibles, including SiC, solid steel, and graphite. Each material has its advantages and limitations. For the specific requirements in our case, a graphite vessel is chosen due to its exceptional properties. Graphite boasts a melting temperature of 2700 °C, far exceeding the operating temperature, making it an ideal choice for our high-temperature applications.

Table 1: Al-7175 chemical composition.

Element	Content
Cr	0.18 - 0.28
Cu	1.2 - 2.0
Fe	0.2
Mg	2.1 - 2.9
Mn	0.1
Si	0.15
Zn	5.1 - 6.1
Ti	0.1
Al	Balance

Table 2: Al-7175 mechanical properties.

Property	Value
Yield strength (MPa)	435
Density (kg/m^3)	2800
Elastic modulus (GPa)	72
Brinell hardness (HB)	135
Elongation (%)	13
Poisson's ratio	0.33

Table 3: Chemical composition of SiC.

Element	%
Si	0.3
SiO_2	5
Fe	0.08
Al	0.1
C	0.3

Table 4: Mechanical properties of SiC.

Property	Value
Density (g/cm^3)	3.1
Elastic modulus (GPa)	410
Poisson 's ratio	0.14
Compressive strength (MPa)	3900
Hardness (kg/mm^2)	2800

Table 5: Chemical composition of B_4C.

Element	%
B	80.0
C	18.1
Ca	0.3
Fe	1.0
Si	0.5
F	0.025
Cl	0.075

Table 6: Properties of B_4C.

Property	Value
Density (g/cm^3)	2.52
Elastic modulus (GPa)	450 - 470
Posson's ratio	0.18
Ultimate tensile strength (MPa)	500
Hardness (kg/mm^2)	2900 - 3580

Stirrer

In the manufacturing process of MMCs, achieving a homogeneous mixture of ceramic particles (e.g., SiC) within the liquid metal is vital. To ensure uniform distribution, a stirrer is utilized, designed to withstand high temperatures while preserving the composite's integrity. This stirrer comprises a stainless-steel rod connected to a nuclear number 6 fan. Powered by a 1/2 H.P. AC motor, the stirrer rotates at a rapid 400 rates. When adding the ceramic particles, it is inserted about one-third of its height into the vessel. Additionally, external mediums can be employed for mixing by connecting them to the chamber through the top at any point. This meticulous mixing process theater is a crucial part in enhancing its properties with performance for its resulting MMCs.

Casting on molten aluminum

Upon mold preparation, the molten metal was poured into the mold cavity from a vessel and left to solidify. Figure 5 presents after casting. After the casting process was finished, the product was separated from the mold.

Figure 5: After casting.

Machining

Machining refers to different progression along with raw substance is systematically removed to achieve a preferred concluding silhouette with dimension. These processes, involving restricted substance exclusion, fall under the category of subtractive manufacturing, distinguishing them from additive manufacturing methods, which involve controlled material addition. The term "controlled" in the definition typically implies the use of machine tools, power tools, or hand tools. Machining is a key part of manufacturing many metal products, but it is also applicable to materials like wood, plastic, ceramics, and composites. Individuals specialized in machining are known as mechanical engineers, and the places where machining is carried out are referred to as machine shops. Nowadays, much of modern machining is accomplished through Computer Numerical Control, using computers to control the movement and operation of cutting machines, plants, and tools. Figure 6 presents during machining. Figure 7 presents after machining.

Density test

The composites' density was determined using its Archimedean technique, involving tiny members slash beginning its compound trial. The experimental density was obtained by measuring the weight of the specimen in air and then in water.

Figure 6: During machining.

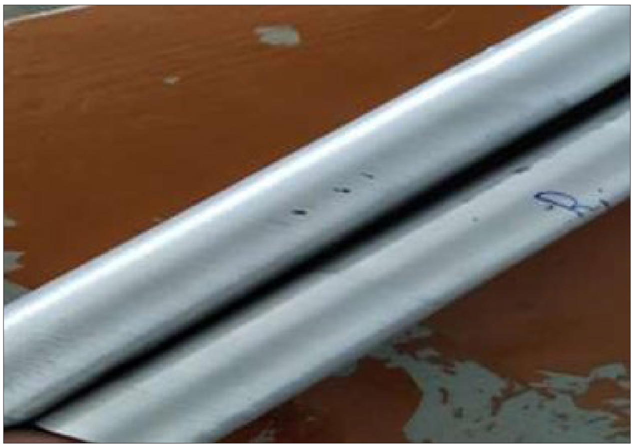

Figure 7: After machining.

The theoretical density was calculated using the mixture rule based on the weight fraction of the component. Density represents the mass-to-volume ratio of a material. This measurement is accomplished by comparing the weight of the specimen in air to the weight loss experienced when submerged in water.

Tensile test

An essential investigation within the fields of physical engineering including technology, and tensile evaluation, commonly referred to as stress examination, involves putting the specimen under a regulated amount of stress up to the point when it breaks. Direct measurements of parameters such as tension resilience, strength, shattering endurance, greatest expansion, along reduction in area are taken during the test. In addition, we may determine other significant characteristics, including Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics, based on these data.

Compression test

A compression test is a type of examination where a material undergoes opposing forces that press it inward from opposite sides or result in compression, crushing, squeezing, or flattening. This test is designed to evaluate the material's capacity to resist and react to compression pressures in order to determine its suitability for use. During the test, the sample is often sandwiched between two plates that are designed to equally distribute the force that is being applied throughout the whole surface area of the sample's opposing sides. The plates are then brought closer together by universal testing machine (UTM) in order to flatten the sample. When subjected to compression, the sample will shorten in the direction that the applied pressures are directed while lengthening in the opposite direction. Essentially, a compression test is the opposite of the more commonly conducted tensile test.

Vickers hardness test

The hardness of a material can be evaluated through Brinell, Rockwell, and Vickers hardness tests. Vickers hardness test employs diamond indentation to measure hardness. The measurement of the depth of penetration of an indent under a certain load, in comparison to the indentation caused by a preload, is how the hardness of a material is determined. different loads or indenters are applied to the different scales, each of which is indicated by a single letter. Like other hardness testing techniques, it measures a material's plastic deformation resistance from a standard source. The Vickers test is one of the widest hardness tests and works on all metals. The test yields the Vickers Pyramid Number or Diamond Pyramid Hardness. Hardness can be translated to pascals; however, it is not pressure albeit they use the same units. Hardness is calculated by the load delivered across the indentation's surface area, not the force's perpendicular area, unlike pressure. Vickers Micro Hardness Tester (LECOAT700 Micro hardness Tester) was used to measure the hardness of the Al-7175 alloy and composites. Each specimen, with dimensions of 20 x 10 mm, was prepared by grinding and polishing to achieve a flat, smooth surface. The testing involved applying a 100 g load for 10 s on the specimen using a square-based diamond indent, and hardness readings were recorded following standard procedures.

Impact test

The testing method known as impact testing is used to evaluate the toughness, impact strength, and notch sensitivity of engineered materials. The Charpy impact test, also known as the Charpy V-notch test, is a tried-and-true technique for determining the quality of materials in the field of material science. This standardized high strain rate test measures the notch toughness of a material by determining the amount of energy that is absorbed by the material as it fractures. The Charpy impact test is widely used in a variety of different sectors due to the fact that it is simple to both prepare and carry out, as well as the fact that it is both cost-effective and produces results rapidly. The apparatus comprises a swinging pendulum with an arm and head. The standard specimen used in the test measures 50 x 10 x 10 mm and acts as a simple supported beam. The swinging head impacts the opposite side of the specimen's notch. The pendulum is released from a height of 1.457 m or at an angle of 1400. The swinging hammer weighs 20.932 kg or exerts a force of 250 N. The specimen is precisely struck at its center, i.e., 27.5 mm. Additionally, the machine is equipped with a pedal-operated brake to halt the hammer's motion after striking the specimen.

Microstructure test

Microstructural analysis utilizes optical or scanning electron microscopes to magnify material characteristics. Dimensions and proportions of features are assessed and compared to established acceptance standards. This process aids in understanding the material's quality and performance, ensuring its suitability for specific applications. Microstructural estimation encompasses a wide spectrum of analyses, spanning from basic assessments of parameters like grain size or coating thickness to more complex examinations of porosity, pore structure, multi-component systems, and the investigation of degradation or failure mechanisms.

Microstructure refers to the fine-scale arrangement of a material, visible under a microscope at magnifications of 25 x or higher. It significantly impacts various physical properties like strength, toughness, ductility, hardness, corrosion resistance, and high/low temperature behavior, as well as wear resistance. To conduct the testing, a computer aided microscope will be employed.

These compacted pellets obtained from the previous step underwent a thermal treatment procedure in a tubular furnace under an inert atmosphere of 99.99% pure argon gas. The pellets were heated to 600 °C and kept there for 2 h. The powder samples were compressed, and then subjected to heat treatment to assure densification of materials for further study and characterization, the density within the sintering specimens is evaluated and then published.

Results and Discussion

Density test

The Archimedean approach was used to estimate the density of the composites; this procedure included cutting the sample of the composite up into little pieces. The experimental density was obtained by measuring the weight of the specimen in appearance more over subsequently into dampen. Overall estimated concentration was established by applying the mixing rule to the weight fraction of each component in order to obtain the result. Density represents the mass-to-volume ratio of a material. This measurement is accomplished by comparing the weight of the specimen in air to the weight loss experienced when submerged in water. Figure 8 presents density specimens. Table 7 present density varying with SiC and B_4C.

Tensile test

An essential investigation throughout the fields of materials research including technology, tension examination, addi-

Table 7: Density varying with SiC and B_4C.

Composition	Density (gm/cc)
Pure	2.587
98.5 Al + 0.5% B_4C + 1%SiC	2.492
97.5 Al + 0.5% B_4C + 1%SiC	2.478
96.5 Al + 0.5% B_4C + 1%SiC	2.451
95.5 Al + 0.5% B_4C + 1%SiC	2.440

Figure 8: Density specimens.

tionally referred to simply stress examination, involves putting a specimen under a regulated amount of stress up to the point when it breaks. Precise measurements of parameters such as terminal elastic endurance, breakdown endurance, ultimate expansion, and decrease in area are taken during the test. In addition, we may calculate other essential qualities, which include the Young's modulus, Poisson's percentage, yield capacity, and other strain-hardening characteristics, based on these data. The tensile test, performed at room temperature using a UTM, is a prevalent technique to assess strength and ductility under static load conditions. This test involves loading a standard specimen clamped at both ends and measuring its elongation as the load is incrementally increased. Figure 9 presents tensile pieces after machining. Figure 10 presents tensile test specimen after testing. Table 8 presents tensile strength.

Compression test

In contrast to tensile strength, which is the capacity of a material or structure to endure stresses that lead to extension, compression strength refers to the ability of a material or structure to withstand loads that lead to a reduction in its size. To put it another way, compressive strength is the resistance to compression, while tensile strength is the resistance to tension. UTM is commonly employed for conducting compression tests. Figure 11 presents compression pieces before testing.

Figure 9: Tensile pieces after machining.

Figure 10: Tensile test specimen after testing.

Table 8: Tensile strength.

Composition			Ultimate tensile strength (N/mm^2)	Elongation (%)	Breaking stress (N/mm^2)	Yield stress (N/mm^2)
Al (%)	B_4C (%)	SiC (%)				
100	-	-	425	7.34	368	301
98.5	0.5	1	434	8.10	382	312
97.5	0.5	2	456	8.34	398	324
96.5	0.5	3	460	8.56	404	336
95.5	0.5	4	472	8.90	416	338

Figure 11: Compression pieces before testing.

Figure 12 presents compression pieces after testing. Table 9 presents compressive strength.

Hardness test

Vickers Micro Hardness Tester (LECOAT700 Micro

Figure 12: Compression pieces after testing.

Table 9: Compressive strength.

Composition	Compression strength (N/mm^2)
Pure	312
98.5 Al + 0.5% B_4C + 1% SiC	324
97.5 Al + 0.5% B_4C + 2% SiC	334
96.5 Al + 0.5% B_4C + 3% SiC	338
95.5 Al + 0.5% B_4C + 4% SiC	340

hardness Tester) was used to measure the hardness of the Al-7175 alloy and composites. Each specimen, with dimensions of 20 x 10 mm, was prepared by grinding and polishing to achieve a flat, smooth surface. The testing involved applying a 100 g load for 10 s on the specimen using a square-based diamond indent, and hardness readings were recorded following standard procedures. Figure 13 presents hardness test specimen after testing. Table 10 presents Vicker's hardness.

Figure 13: Hardness test specimen after testing.

Table 10: Vicker's hardness.

Composition	Hardness
Pure	124
98.5 Al + 0.5% B_4C + 1% SiC	125
97.5 Al + 0.5% B_4C + 2% SiC	127
96.5 Al + 0.5% B_4C + 3% SiC	129
95.5 Al + 0.5% B_4C + 4% SiC	134

Impact test

The apparatus comprises a swinging pendulum with an arm and head. The standard specimen used in the test measures 50 x 10 x 10 mm and acts as a simple supported beam. The swinging head impacts the opposite side of the specimen's notch. The pendulum is released from a height of 1.457 m or at an angle of 1400. The swinging hammer weighs 20.932 kg or exerts a force of 250 N. The specimen is precisely struck at its center, i.e., 27.5 mm. Figure 14 presents the test specimen before testing. Figure 15 presents the test specimen after testing. Table 11 presents Charpy impact test.

Figure 14: Test specimen before testing.

Figure 15: Test specimen after testing.

Microstructure test

Figure 16 presents pure Al-7175. Figure 17 presents 98.5 Al + 0.5% B_4C + 1% SiC. Figure 18 presents 97.5 Al + 0.5% B_4C + 2% SiC. Figure 19 presents 96.5 Al + 0.5% B_4C + 3% SiC. Figure 20 presents 95.5 Al + 0.5% B_4C + 4% SiC.

Conclusions

The swirl transmit process is a process that creates aluminum mixed combinations using an aluminum matrix that was strengthened by B_4C and SiC. When making composite materials, a total of three distinct percentage proportions for additives typically used within order to get the desired popu-

Table 11: Charpy impact test.

Reinforcement	Area of the notch (mm^2)	Initial energy (J)	Final energy (J)	Net energy (J)
Pure	100	300	52	252
98.5 Al + 0.5% B_4C + 1% SiC	100	300	50	254
97.5 Al + 0.5% B_4C + 1%SiC	100	300	48	256
96.5 Al + 0.5% B_4C + 1%SiC	100	300	46	257
95.5 Al + 0.5% B_4C + 1%SiC	100	300	45	258

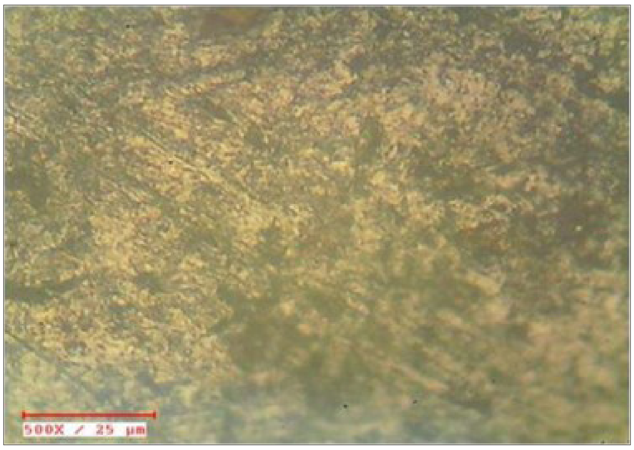

Figure 16: Pure Al-7175.

Figure 17: 98.5 Al + 0.5% B$_4$C + 1% SiC.

Figure 18: 97.5 Al + 0.5% B$_4$C + 2% SiC.

lation density, its microstructure, tensile test, and compression test results, as well as hardness measurement. According to the findings of the micro structural investigations, the SiC particles in the Al-7175 MMCs are distributed in a manner that is quite homogeneous, however its B$_4$C granules exhibit the distribution that is considerably less uniform.

The tensile strength has increased as the amount of SiC and B$_4$C reinforcements have improved.

Figure 19: 96.5 Al + 0.5% B$_4$C + 3% SiC.

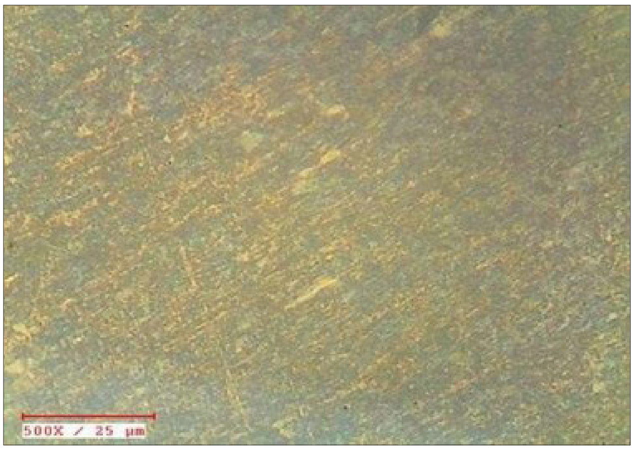

Figure 20: 95.5 Al + 0.5% B$_4$C + 4% SiC.

The compression strength, impact strength, with stiffness have all increased as the amount of SiC and B$_4$C reinforcements has increased.

When the amount of SiC and B$_4$C additions within this composite increased, this the material dropped.

Based upon these results of the microscopic investigation, it was determined whether its SiC as well as B$_4$C nanoparticles in the Al-7175 had successfully mixed correctly, therefore its combination had fewer faults.

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None.

Conflict of Interest

None.

References

1. Seshappa A, Prasad BA. 2022. Swirl cast with wire cut electric discharge machining for investigational purposes on Al-7075/Al$_2$O$_3$&SiC. *Mater Today Proc* 68: 2258-2264. https://doi.org/10.1016/j.matpr.2022.08.482
2. Seshappa A, Prasad BA. 2022. Experimental investigation on Al-7075 of GCI & fly ash by swirl cast with wire cut electronic discharge machining. *AIP Conf Proc* 2648(1): 030027. https://doi.org/10.1063/5.0114418

3. Kumar A, Singh RC, Chaudhary R. 2020. Recent progress in production of metal matrix composites by stir casting process: an overview. *Mater Today Proc* 21: 1453-1457. https://doi.org/10.1016/j.matpr.2019.10.079
4. Chandra D, Chauhan NR, Rajesha S. 2020. Hardness and toughness evaluation of developed Al metal matrix composite using stir casting method. *Mater Today Proc* 25: 872-876. https://doi.org/10.1016/j.matpr.2019.12.026
5. Subramani N, Haridass R, Pramodh S, Anand AP, Manikandan N. 2021. Mechanical strength analysis of Al6061&Al2024 based metal matrix composite prepared through stir casting method. *Mater Today Proc* 47: 4513-4517. https://doi.org/10.1016/j.matpr.2021.05.417
6. Kumar SA, Vignesh JH, Joshua SP. 2021. Investigating the effect of porosity on aluminium 7075 alloy reinforced with silicon nitride (Si_3N_4) metal matrix composites through STIR casting process. *Mater Today Proc* 39: 414-419. https://doi.org/10.1016/j.matpr.2020.07.690
7. Kumar A, Lal S, Kumar S. 2013. Fabrication and characterization of A359/Al_2O_3 metal matrix composite using electromagnetic stir casting method. *J Mater Res Technol* 2(3): 250-254. https://doi.org/10.1016/j.jmrt.2013.03.015
8. Ashok N, Shanmughasundaram P. 2017. Influence of particle size on the mechanical properties of Al8011-SiC composites- Taguchi approach. *Int J Chem Tech Res* 10(5): 293-300.
9. Patel M, Pardhi B, Pal M, Singh MK. 2019. SiC particulate reinforced aluminium metal matrix composite. *Adv J Grad Res* 5(1): 8-15. https://doi.org/10.21467/ajgr.5.1.8-15
10. Shyn CS, Rajesh R, Anand M. 2021. Review of aluminium 6061 metal matrix composites fabricated using stir casting method and applications. *AIP Conf Proc* 2317(1): 030027. https://doi.org/10.1063/5.0036169
11. Sunar T, Cetin M. 2021. Manufacturing of B_4C particle reinforced A360 aluminium cellular composite materials by the integration of stir casting and space holder methods. *J Compos Mater* 55(25): 3763-3773. https://doi.org/10.1177/00219983211022825
12. Muhammad F, Jalal S. 2021. A comparative study of the impact of the stirrer design in the stir casting route to produce metal matrix composites. *Adv Mater Sci Eng* 2021: 4311743. https://doi.org/10.1155/2021/4311743