A Review on Fabrication and Characterization of Aluminum based Metal Matrix Composites using Stir Casting

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Abstract

The need to reduce energy consumption and pollution in an industry is currently the most crucial demand of an industry, and necessity is the mother of research (invention). One method for achieving this would be to improve efficiency. It is necessary to enhance the material's characteristics, such as strength, toughness, stiffness to weight ratio, good formability, good corrosion resistance, and high mach inability. The structural, aerospace, and automotive industries all extensively use these composite materials. MMCs are made of a metallic base material called matrix that has been strengthened with either soft or hard ceramic reinforcement. By adding multiple types of reinforcements with various properties to the matrix alloy, hybrid MMCs are created. For instance, SiC and graphite could be used as hard and soft ceramic reinforcement, respectively. The review of the fabrication and characterization of a hybrid metal matrix, as well as a summary of recent advancements relating to the use of aluminium in the manufacturing process, are the main topics of this research paper.

Keywords: Metal matrix composite, Stir casting method, Hybrid metal matrix composite, SiC, Surface roughness

1. Introduction

If a composite material is a substance made up of two or more constituent materials. It is also referred to as a composition material or, more commonly, just as composite. These constituent materials are combined to create a material with characteristics distinct from the constituent parts, despite having distinctly different chemical or physical properties. Composites are distinct from mixtures and solid solutions because the individual components are distinct and remain separate within the final structure.

Composites are significant materials that are now widely used in many fields of commercial mechanical engineering, including but not limited to the aerospace industry. Applications include internal combustion engines, machine parts, thermal management, and electronic packaging, as well as the structural elements of cars, trains, and planes, as well as mechanical parts like brakes, drive shafts, flywheels, tanks, and pressure vessels, as well as biomedical equipment.

For engineering applications, it is necessary to use materials that are stronger, lighter, and more readily available. The materials must have low density, high strength, good toughness, low cost, and good chemical resistance.

1.1. Metal Matrix Composite (MMCs)

The superior qualities of metal matrix composites (MMCs) compared to most conventional materials are currently the subject of research. The scientific community has done a lot of research on two types of reinforcement: alumina and silicon carbide. In order to improve the final behaviour of AMCs and to avoid some disadvantages of utilising ceramics as reinforcement for aluminium alloys, the introduction of new reinforcements such intermetallics to aluminium alloys is still being studied. The two main barriers to the use of such materials at the moment are their high cost and chemical reactions at reinforcement/matrix interfaces during material production and service at high temperatures.

Metal matrix composites are usually made up of aluminum to give it enough strength as it is less dense than iron, and hence is preferred in the aerospace industry. Continuous carbon, silicon carbide, or ceramic fibres are embedded in a metallic matrix to create this substance.

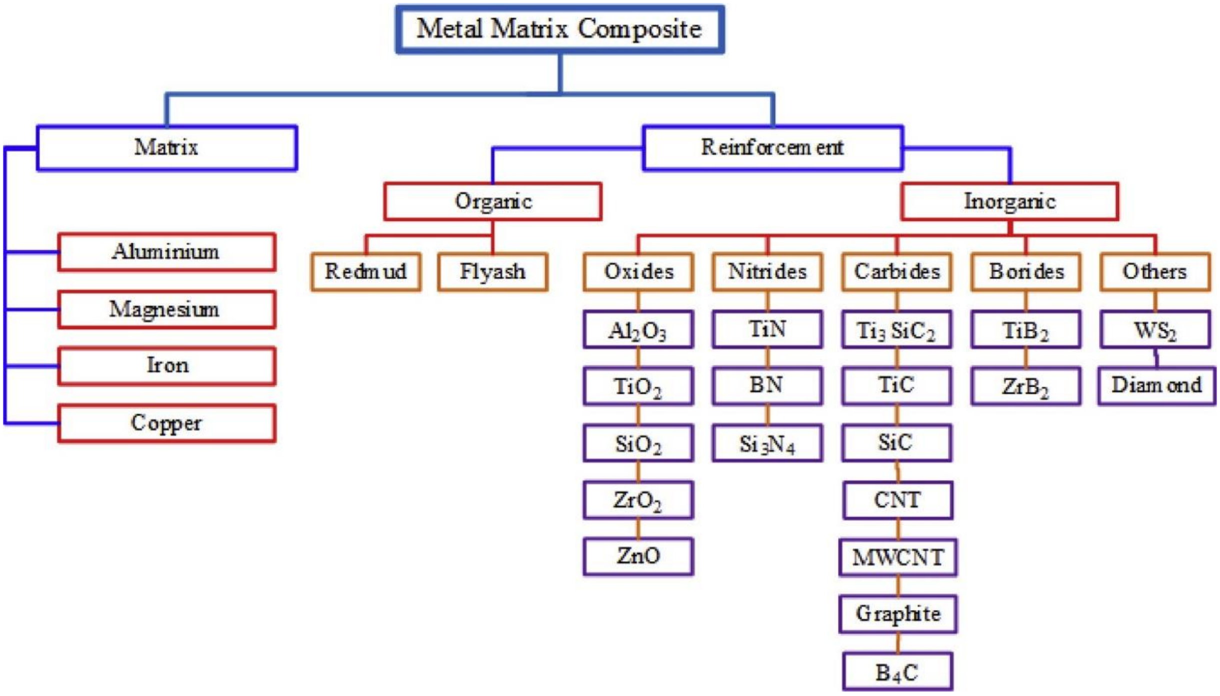

Fig. 1. Various matrix and reinforcement materials used for the production of MMCs. [29]

Aluminum matrix composites are the most prevalent type of metal matrix composites. Major benefits of aluminium matrix composites include higher wear resistance, lower density, and strong corrosion resistance in addition to increased specific strength, specific stiffness, and elevated temperature strength.

The reinforcements may take the form of particles, fibre, layers, or even interpenetrating materials. Composites can be divided into fibre reinforced, laminar, flake, filled, and particle reinforced composites depending on the type of reinforcement utilised. Because they are more widely available, less expensive, and easier to spread in the matrix, particle reinforced composites are the main focus of this review. Based on the goals and applications of the composite, reinforcement materials are chosen. Applications where weight reduction is a top goal are now possible thanks to the strengthening of light metals. One of the most popular MMCs, Al reinforced with SiC, Al2O3, or B4C, produces better mechanical qualities at comparatively cheaper production costs.In the process of creating composite materials, interfacial bonding is a major source of worry. It is challenging to obtain the desired qualities from the constructed composites if the matrix and reinforcement components are not properly matched. The several matrix and reinforcing materials that can be employed to create MMCs are depicted in Fig. 2.

1.1.1. MMCs Applications

- Composite materials are frequently used in the aerospace sector to build the structures of both military and commercial aircraft and spacecraft.

- Composites offer notable advancements in corrosion response and structural response.

- Building of structures like the Kodak pavilion for an exhibition, bridges, lighthouses, hydraulic structures, storage tanks, and door and window parts.

- Stabilization of damaged structures.

- Production of fishing boats, yachts, and life boats.

Fig. 2. Short fiber particulate reinforced aluminum matrix composite used as a cylinder liner in the Honda Prelude. [27]

2. Processing of Metal Matrix Composites

2.1. Processing of Metal Matrix Composites in Stir casting

Stir casting of metal matrix composites was invented in 1968 by S. Ray, who mixed molten aluminium alloys containing ceramic powders to introduce alumina particles into the melt. An illustration shows a schematic of the setup for the stir casting technique used to prepare composites. In a stir casting method, mechanical stirring is used to disperse the reinforcing phases, which are typically in powder form, throughout the molten aluminium. A crucial component of this procedure is mechanical stirring in the furnace. The molten alloy that is produced with ceramic particles can subsequently be utilised for sand casting, die casting, or permanent mould casting. [30]

The capacity of this two-step processing technique to dissolve the gas layer surrounding the particle surface is primarily responsible for its success. The thin layer of gas that is typically absorbed on the surface of particles prevents wetting between the particles and the molten metal. Because the high melt viscosity generates a more abrasive action on the particle surface than traditional stirring does, mixing the particles while they are semi-solid allows for a more effective breakdown of the gas layer. As a result, the subsequent mixing in a totally liquid condition is more successful after the gas layer is broken. Using a suitable stirring system, such as mechanical, ultrasonic, electromagnetic, or centrifugal force stirring, along with typical metal processing techniques is possible with stir casting. Stir casting's potential to be used in large-scale production is one of its main benefits. Stir casting is the most affordable way of creating established metal matrix composites. Stir casting is currently the most widely used commercial process for making aluminum-based composites as a result. [30]

The setup for the Stir Casting Method is show in fig. 3. In stir casting, the molten metal matrix is stirred using a stirrer. The material used to make the stirrer typically has a higher melting point than the matrix temperature. Graphite stirrers are typically used in stir casting. The stirrer primarily consists of two components: a cylindrical rod and an impeller. The rod's other end is attached to the motor shaft, and its other end is connected to the impeller. The stirrer is typically kept vertical and rotates at different speeds thanks to a motor. Afterward, the molten metal is poured into a die for casting. Stir casting can be used to create composites with reinforcement volume fractions up to 30%. The segregation of reinforcement particles as a result of different process variables and material properties that lead to the non-homogeneous metal distribution is a significant issue with stir casting. The different process variables include things like the degree to which metal particles are wet, relative density, settling velocity, etc. The speed of the stirrer, its angle, the presence of vortices, and other factors all have an impact on how the particles are distributed within the molten metal matrix. This method involves heating the matrix metal above its liquid temperature in order to completely melt it. It is in a semi-solid state once it has cooled to a temperature between the liquid and solidus states. The molten matrix is then supplemented with the previously heated reinforcement particles, which are then heated once more to a fully liquid state to ensure thorough mixing.

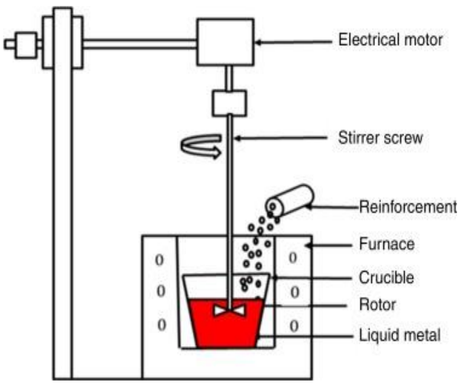

Fig.3. Stir casting Setup. [29]

3. Literature Review

S.Arivukkarasan et al in is paper by Public was If only Aluminum LM6 could be reinforced with Silicon Carbide. In this manner, a strong and lightweight composite material would be created. Stir casting was used to create aluminium matrix composites with weight fractions of titanium dioxide and silicon carbide of 3:11, 7:9, and 5:5. The test of the mechanical properties was completed satisfactorily! Aluminum LM6 86%, Titanium dioxide 3%, and Silicon Carbide 11% all had significantly higher tensile, yield, compression, and hardness values. For the Aluminium LM6 90%, Titanium dioxide 5%, and Silicon Carbide 5%, the impact strength and percentage elongation were improved, whereas other properties were noticeably decreased. The microstructure of the composite of aluminium LM6, titanium dioxide, and silicon carbide has been observed to show homogenous distribution and excellent binding of titanium dioxide, at 3%, and silicon carbide, at 11%, with the aluminium LM6, at 86%, matrix, and noticeably less binding with uniform distribution of aluminium LM6, titanium dioxide, and silicon carbide, at 90%, 5%, and at 3%, respectively. [1]

Kamaal Haider et al. In demonstrated in their study the SiC and Al2O3 filled Al6061 alloy composites were discovered to be more efficient at supplying desirable properties in the castings. The hardness and strength of composites increased with increased ceramic particles content, according to experiments on SiC & Al_2O_3 filled Al6061 alloy composites. Better hardness and strength of composites and lower wear rates are attributed to finer grain sizes. [2]

Yadav Anshul et al. In investigated Due to the high density SiC reinforcements, the density of hybrid composite for S3 hybrid composite (12% SiC) was highest, whereas S2 hybrid composite (12% B_4C) had the lowest density due to low-density B_4C reinforcements. Due to an increase in void close to the location of the SiC reinforcement, the S3 hybrid composite (12% SiC) and S4 hybrid composite (9% SiC) exhibit the maximum porosity. The manufactured hybrid composites had porosities that ranged from 1.4 to 3.4%. The porosity and weight percentage of SiC/B_4C of the composites affected the hardness value. [3]

Siddharth Srivastava et al. Presented a paper on “Characterization of Aluminium Hybrid Metal Matrix Composites” and using the two-step stir casting procedure, an aluminium hybrid metal matrix composite was created. Along with tungsten carbide (WC), alumina (Al_2O_3), and rice husk ash in constant weight percentages of 2%, 3%, and 2%, respectively, silicon carbide was added to the AMMC in various weight percentages (5%, 10%, 15%, and 20%). Microstructural analysis and mechanical properties such tensile strength, hardness, density, impact strength, and flexural strength were carried out. [4]

S Ram Kumar et al. In evaluated the aluminium metal matrix composite is created utilising the stir casting method with various reinforcement compositions, including alumina and silicon carbide at weight percentages of 2.5% and 5%, respectively. As the weight percentage of silicon carbide increases, the composites' tensile strength rises. Due of the lack of reinforcing elements, sample 1 (Al 6061) absorbs less energy than the other samples. (Fig.4.) In comparison to the other two samples, sample 2 (Al6061 with 5% SiC and 2.5% Al_2O_3) has a greater Hardness rating. With regard to mechanical qualities, sample 2 (Al6061 with 5% SiC and 2.5% Al2O3) is superior to the other two specimens. [5]

	Tensile strength (MPa)	Yield stress (MPa)	Elongation in %
Al6061 (100%)	154.52	133.08	5.28
Al6061(92.5%), SiC(5%), Al2O3(2.5%)	194.46	167.43	4.36
Al6061(92.5%), SiC(2.5%), Al2O3(5%)	129.03	110.26	4.48

Fig. 4. Comparison of Mechanical Properties of Metal matrix composites. [5]

Ashish Srivastava et al. In investigated, It is shown that HMMCs produced via FSP are straightforward and exhibit great surface hardness and homogeneity. The majority of studies have so employed this strategy. yet results in lower wear resistance. Additionally, SiC and graphite are shown to be the most popular refractory materials. While graphite is used to soften and even wear rate is lowered, SiC is utilised to harden and increase mechanical qualities while simultaneously increasing wear rate. These MMCs can be processed using powder metallurgy (P/M), however getting a homogeneous distribution of graphite and SiC particles requires a fair amount of mixing time. [6]

Balamurugan Chinnasamy et al. In demonstrated in their study it has been discovered that the crucible casting method has been effective in incorporating silicon nitrate and eggshell (Si_3N_4 and Es) into the Al6082 matrix alloy. In comparison to conventional materials, composite materials, particularly those made of eggshell, magnesium, silicon nitrate, and aluminium 6082, have reached exceptional mechanical properties. It has a high toughness and can be utilised for a variety of industrial applications. As a result of the inquiry, the tensile, hardness, and compressive strengths of the Al6082 metal matrix have been analysed. In comparison to a pure alloy of Al6082, Ratio 2 (Al6082 + $Si3N_4$ 2% + Es 5% + Mg 1%) has been found to have greater tensile, hardness, and compressive strength. [7]

P. K. Farayibi et al. in is paper by Public This study has effectively evaluated the mechanical characteristics of Al-4043/SiC composites with different Ni-coated SiC reinforcing fractions. The eutectic Al-SiC microstructure of the composites was identified, together with SiC solid solution precipitates and SiC particles evenly dispersed throughout the Al matrix. It was discovered that the density of the composites increased linearly as the percentage of SiC reinforcement increased. With increasing SiC reinforcement percentage, it was discovered that the tensile strength, yield strength, and elastic modulus all increased. The highest values were achieved for composites with 25 weight percent SiC and were 350 MPa, 254 MPa, and 13.4 GPa, respectively.The composite with the most reinforcing had the lowest elongation, 10%, nevertheless. The composites' hardness, compressive strength, and impact energy all considerably rise as SiC content increases from 25 weight percent to 76 HB, 184 MPa, and 48 J, respectively. The greatest SiC reinforcement Al-4043/SiC composites were found to have an eleven-fold increase in wear resistance over the monolithic Al-4043 alloy.This study has effectively evaluated the mechanical characteristics of Al-4043/SiC composites with different Ni-coated SiC reinforcing fractions. The eutectic Al-SiC microstructure of the composites was identified, together with SiC solid solution precipitates and SiC particles evenly dispersed throughout the Al matrix. It was discovered that the density of the composites increased linearly as the percentage of SiC reinforcement increased. With increasing SiC reinforcement percentage, it was discovered that the tensile strength, yield strength, and elastic modulus all increased. The highest values were achieved for composites with 25 weight percent SiC and were 350 MPa, 254 MPa, and 13.4 GPa, respectively.The composite with the most reinforcing had the lowest elongation, 10%, nevertheless. The composites' hardness, compressive strength, and impact energy all considerably rise as SiC content increases from 25 weight percent to 76 HB, 184 MPa, and 48 J, respectively. The greatest SiC reinforcement Al-4043/SiC composites were found to have an eleven-fold increase in wear resistance over the monolithic Al-4043 alloy. [8]

Raj Kumar et al. In demonstrated in their study the wear rate of hybrid metal matrix composites and hybrid nano metal matrix composites for all applied loads, the weight fraction of micron- and nano-sized reinforced particles was increased to 1.8% and 0.6%, respectively. The hybrid metal matrix composites have a decreased wear rate at concentrations of Ni and Cr nanoparticles as low as 0.6 weight percent and Ni and Cr micron-sized particles as high as 1.8 weight percent. It was shown that raising the typical load caused an increase in wear rate. HNMMC and HMMC wear rates were reduced by 76% and 37.1%, respectively, at 10N. In comparison to monolithic Al6061 alloy and Al6061/1.8Ni/1.8Cr hybrid metal matrix composites, Al6061/0.6Ninp/0.6Crnp hybrid nano metal matrix composites have better tribological properties.Therefore, nano hybrid metal matrix composites have a better chance of enhancing mechanical behaviour. [9]

Johny James.S et al. In evaluated SiC and TiB_2 are present in the metal matrix and are distributed there, according to micro structural investigation. According to the results of the hardness measurement, adding reinforcements has an impact on the hardness value, however adding TiB_2 up to 5% results in porosity, which has an impact on the hardness value. Wear study has shown that TiB_2 particles improve the hybrid aluminium metal matrix's wear resistance characteristics. The machining study has revealed that TiB_2 reinforcement accounts for 38.86% of the surface roughness, making it the most important element. The value of surface roughness is increased by the addition of TiB_2 reinforcement. The following ideal machining settings are tabulated using Taguchi analysis to provide the best surface roughness: cutting speed of 120 m/min, feed rate of 0.3 mm/rev, depth of cut of 0.5 mm, and no TiB_2 reinforcement. [10]

Dr. S. Madhusudhan et al. In evaluated the stir casting procedure, rice husk ash and fly ash fragments were successfully integrated into the alloy Al 356.2. Al356.2/RHA/FA composites get harder as the rice husk ash percentage rises. With an increase in rice husk ash content, the ultimate tensile strength rises. As Fly Ash levels rise, the percentage of elongation rises as well. As the percentage of rice husk ash rises, so does the compressive strength. As the percentage of rice husk ash rises, so does the impact strength. In comparison to pure alloy, all hybrid examples demonstrated a higher improvement in mechanical properties. By using the stir casting procedure, rice husk ash and fly ash fragments were successfully integrated into the alloy Al 356.2. Al356.2/RHA/FA composites get harder as the rice husk ash percentage rises. With an increase in rice husk ash content, the ultimate tensile strength rises. As Fly Ash levels rise, the percentage of elongation rises as well. As the percentage of rice husk ash rises, so does the compressive strength. As the percentage of rice husk ash rises, so does the impact strength. In comparison to pure alloy, all hybrid examples demonstrated a higher improvement in mechanical properties. [11]

Pardeep Saini et al. In demonstrated in their study SEM and OM have seen a consistent SiC particle distribution throughout the underlying Al-4032 matrix material for AMCs with up to 6% reinforcement. Localized reinforcement coagulation (creating adverse effects on homogeneity) has been seen at 8% weight fraction, indicating that the manufacture of the AMC is only suitable up to 6% reinforcement. At 8% reinforcement, the porosity is at its maximum. In general, the UTS and micro hardness of the AMC improve when SiC particles (up to 6% by weight) are added to the matrix. The characteristics start to deteriorate at greater weight fractions, or 8%, as a result of the reinforcement coagulating and weak interfacial bonding. As the SiC fraction increases with a decrease in the ductility of the Al-4032 matrix matter, elongation has been observed to be reduced. At 6% reinforcement, the minimum elongation is reached. The composites' impact toughness seems to be higher than the Al-4032 matrix's. At 4%SiC, the impact toughness reaches its maximum. Beyond this composition, there is a trend toward lessening impact hardness. [12]

M.Vamsi Krishna et al. In investigated in this study has been shown that the weight fractions have a significant impact on the mechanical properties of composites, such as tensile strength. The maximum tensile strength reported is 192.45 MPa at 15 weight percent SiC/Gr, according to research on the tensile strength of SiC & SiC/Gr reinforced hybrid particulate aluminium composites with various weight fractions. When compared to single reinforcement, the mechanical behaviour of SiC/Gr reinforced hybrid composites performed better. Studying the density of SiC and SiC/Gr reinforced hybrid particle aluminium composites with various weight fractions revealed that the density rises with SiC and falls with SiC/Gr hybrid particulates, making these SiC/Gr hybrid composites excellent light weight engineering materials. As per microstructure investigations, the matrix contains a consistent dispersion of reinforcing particles. [13]

K.R.Padmavathi et al. In evaluated the fabrication of hybrid Aluminium-SiC-MWCNT reinforced metal matrix Nano composites is discovered to be appropriate for the stir casting technique. SiC and MWCNT reinforcement of aluminium results in greater resistance to dry abrasive wear. With an increase in the percentage of MWCNT, the particular wear rate falls for all applied load values. The composites become harder as the hybrid ratio rises. This research serves as a foundation. To assess how SiC and MWCNT nanoparticles affect the wear characteristics of the hybrid composites, a thorough study is needed. [14]

N. Balaji et al. in demonstrated in their study in comparison to base Al alloy 6061, stir produced Al alloy 6061 with Al_2O_3 and TiC reinforced composites clearly outperformed it in terms of hardness value, according to the data. Al_2O_3 and TiC particles dispersed in an aluminium matrix increase the material's tensile strength. When turning aluminium HMMC, the response surface methodology was used to analyse the rate of material removal and the surface roughness. The analysis above led to the following findings. With increasing speed, feed, and depth of cut—in particular, increasing depth of cut will increase the chip thickness—the material removal rate increases from 0.48 Cm^3/min to 3.60 Cm^3/min. By reducing feed as well as depth of cut from 0.297 mm/rev, 0.45 mm to 0.1 mm/rev, 0.3 mm correspondingly, surface roughness lowers from 0.181 m to 0.038 m. These findings hold true for the mixture of AA606185p/Al_2O_3 10p/TiC_5p. Pure cast aluminium 6061 displays a surface roughness value of 0.031 m for the same speed, feed, and cut depth. When AA6061 and AA606185p/Al_2O_3 10p/TiC_5p are put side by side, the latter exhibits the best surface roughness value. The main cause is that as the volume % of Al_2O_3 and Tic increases, the work piece's hardness increases and surface roughness decreases. Additionally, it was found that as the depth of cut increased, so did the surface roughness values. It can be because increasing cut depth will result in more vibrations and cutting force, which will increase surface roughness. For assessing material removal rate and surface roughness in turning aluminium HMMC and AA6061, response surface approach is used. R2 > 0.95 indicates that the fitted value is extremely near to the experimental value. [15]

Shashi Prakash Dwived et al. In evaluated Fly-ash is a thermal power plant waste that pollutes the area around thermal power plant companies with both soil and air. It can be used successfully to fabricate composites. In order to create a hybrid composite material, which included fly ash as a secondary reinforcement material and Al_2O_3 as a primary reinforcement material, AA 6061 aluminium alloy was employed as the matrix material. The results showed that the tensile strength and hardness of the composite were increased by the addition of Al_2O_3 and Fly-ash to the AA 6061 alloy. The composite made of AA 6061+0% Fly-ash + 15% Al_2O_3 had a maximum hardness of 94 BHN. After heat treatment, a composite made of AA6061 + 7.5% Fly-ash + 7.5% Al_2O_3 was found to have a maximum tensile strength of 175 MPa. With the addition of ceramic particles, the AA6061 matrix material's toughness and ductility were lowered. The minimum toughness for sample number 8 (AA6061+0% Fly-ash + 15% Al_2O_3) was determined to be 6.5 Joule/m3. [16]

Nagender kumar chandla et al. In demonstrated in their study the carbide, oxides, nitrides, and agro-industrial reinforcements were successfully incorporated into Al-6061 MMC through the stir route of casting process, including SiC, B_4C, TiC, WC, TiB_2, Al_2O_3, TiO_2, ZrO_2, MoS_2, Fe_2O_3, Gr, FA, RM, CNT, and MWCNT in single, dual, and multiple reinforcements. The mechanical, tribological, and physical performance of Al-6061 composites were significantly improved by the accumulation of these reinforcements in particle form. The incorporation of particle reinforcements slightly improved the mechanical characteristics of

Al-6061 MMC. Al_2O_3, SiC, WC, and Fe_2O_3 among other reinforcements considerably increased the UTS, UCS, and hardness of cast Al-6061 MMC. Glass fibre, FA, and RM were additional reinforcements that helped the composites be stronger. However, when reinforcement weight percentage increased, the ductility and impact strength of reinforced composites declined. Al-6061 MMC's tribological characteristics, including as SWR, VWR, WR, WL, and COF, were greatly enhanced by the inclusion of solid reinforcements. The SWR and COF of Al-6061 MMC were greatly enhanced by the Gr, SiC, B_4C, and Al_2O_3 particulates. But because of its self-lubricating qualities and ability to produce a scratch-resistant layer on the surface of as-cast composites, Gr was thought to be the ideal reinforcement for tribological properties, improving the WR and COF of Al- 6061 MMC. Photomicrographs of the Al-6061 MMC's microstructural behaviour showed that, up to a certain level of reinforcement, uniform interfacial bonding and homogeneous distribution within the matrix were seen; however, many authors also reported the presence of some voids, clusters of particles, agglomerations, and cracks at higher weight fractions. However, the wettability and bonding between the solid matrix and particle reinforcements were improved by the inclusion of Mg and K_2TiF_6. Physical characterization revealed that the theoretical and experimental density of the Al-6061 alloy increased with higher concentrations of SiC, Al_2O_3, and Fe_2O_3 and reduced with higher concentrations of BA, B_4C, and CSA. Porosity% shown a direct correlation with the weight% of reinforcements in the most investigated feature. To minimise the density of Al-6061 composites with less porosity, light-weight B_4C, Gr, FA, BA, and CSA reinforcements were thought to be the most helpful reinforcement. [17]

J. Chandradass et al. Presented a paper on "Effect of silicon carbide and silicon carbide/alumina reinforced aluminium alloy (AA6061) metal matrix composite" Due to proper mechanical stirring action and homogeneous particle distribution, The presence of hard silicon carbide and aluminium oxide particles improved the properties of materials and wear characteristics of the aluminium (AA6061) alloy hybrid composite due to proper mechanical stirring action and homogeneous particle distribution. Tensile strength and hardness values of AA6061/7 wt% SiCp/3 wt% Al_2O_3 alloy are 27% and 25% higher, respectively, than those of unreinforced AA6061 alloy. According to the optical micrograph, silicon carbide and aluminium oxide particles are distributed uniformly in the hybrid AA6061 alloy matrix composite. The use of silicon carbide and aluminium oxide improved wear resistance, with the minimum wear rate being 2.5312x105mm3/Nm for a 40 N load and constant sliding speed. [18]

Adnan Adib Ahamed et al. In demonstrated According to the research, RHA may be successfully mixed into a pure aluminium matrix for the creation of composites. Additionally, this can address the issue of RHA storage and disposal as well as the use of agricultural waste. Stir casting was used to make composites by adding up to 9% by weight RHA to aluminium. The addition of magnesium boosted the RHA's retention in the composite by improving the RHA's wettability with aluminium melt. In comparison to the unreinforced state, the inclusion of RHA and magnesium increases the hardness of the composites from 22 BHN to 33 BHN. With a rise in RHA content and a decrease in density, the ultimate tensile strength and yield strength have both increased, allowing for the application of materials that are lighter in weight but stronger. [19]

S. Nallusamy et al. In investigated the metal matrix composites' hardness test revealed that Al-6061/20wt% SiC has a greater hardness value than Al-6061/10wt% SiC. By increasing the weight percentage of SiC from 10 to 20%, the hardness value in hybrid composites rises from 40 to 52.5, and in every composition, the value was higher than base alloy. SEM analysis revealed the presence of transverse and surface defects, as well as moderate and severe wear on the composite's worn surfaces and wear structure. It was discovered that by having access to SiC, which acts as a barrier to displacement movement, we might boost the wear resistance relative to the base alloy. The load of 10 N and 20 N, the sliding speed of 500 rpm, and the sliding distance of 1750 m all have a role in the wear rate. Additionally, a direct correlation between the wear rate and the increase in sliding distance was observed. The load of 10 N and 20 N, the sliding speed of 500 rpm, and the sliding distance of 1750 m all have a role in the wear rate. Additionally, a direct correlation between the wear rate and the increase in sliding distance was observed. [20]

Gaurav Mahajan et al. In demonstrated in their study in the microstructure, hexagonal-shaped crystals of TiB_2 and dendritic SiC are seen. The reinforcement is distributed uniformly throughout the microstructure, with occasional cluster formation. SiC and TiB_2 add a significant amount of hardness value to the Al6061 matrix. Al/10 SiCp exhibits a 38% increase in hardness, whereas Al/10SiCp/5TiB_2 exhibits a 35.7% increase in hardness iii. SiC and TiB_2 reduce the matrix material's wear rate and coefficient of friction. Due to dependence on different parameters, such as wettability and bonding between matrix and reinforcement, the hardness and wear values drop up to a specific point and then remain unaltered. The wear resistance of the composite may be lowered by excessive Al_3Ti flakes production. [21]

Ashok Kr. Mishra1 et al. In evaluated For Al - 6061/ 10% SiC metal matrix composites, applied load contributes 85.5% to coefficient of friction, while sliding distance contributes 13.4%. While the sliding distance contributes 13.4%. The most influential factor on wear rate is sliding distance (62.5%), followed by sliding speed (37.5%) and applied load (1.25%). The contribution of applied force is 87.2%, sliding distance is 9.7%, and sliding speed is 7.1% for Al - 6061/ 15% SiC metal matrix composites. The most influential factor on wear rate is applied load (57.2%), followed by sliding distance (7.1%), sliding speed (7.1%), and coefficient of friction (7.1%). By creating a protective layer between the pin and counterface, SiC inclusion (10% & 15%) boosts the wear resistance of composite materials. We expect that the sliding distance & applied load will have the biggest impact on wear rate in both composites based on the aforementioned conclusion. The only factor that significantly affects the coefficient of friction in both composites is the applied load, which is similar in both cases. The wear rate and coefficient of friction of Al - 6061/ (10% & 15%) SiC MMCs for intermediate conditions were reasonably predicted using the regression equation created for the (10% & 15% SiC MMCs) current model. The results of a confirmation experiment and a comparison of experimental figures revealed that the coefficient of friction and error associated with dry sliding wear varied, respectively, in both composites, from 3.17% to 9.256% and 4.69% to 11.23%. Thus, the Taguchi approach of experiment design proved successful in predicting the tribological behaviour of composites. [22]

Ashish Srivastava et al. In evaluated Conclusion: Base alloy is clearly inferior than aluminium alloy with reinforcing. With its exceptional tensile strength, impact strength, wear resistance, hardness, and corrosion resistance, among other qualities, it enhances the mechanical properties. When compared to other materials, the fatigue properties of cast aluminium alloy also show better results, however occasionally porosity may produce less than ideal outcomes. Additionally, it is established that the base metal's electrical and thermal properties are enhanced when reinforcement is added. [23]

G.Anil Kumar et al. In investigated This research discusses the many reinforcement combinations employed in the synthesis of hybrid AMMCs and how they affect their performance. The application of the proper manufacturing techniques, depending on the choice of reinforcement, can efficiently construct AMMCs. Because reinforcement particles enhance mechanical qualities such as tensile strength, impact strength, wear resistance, hardness, and corrosion resistance, aluminium alloy with reinforcement is always preferable to base alloy. Among the different reinforcement particles, such as TiC, TiB_2, B_4C, SiC, Al_2O_3, and Gr. etc., it was discovered that B_4C has a greater hardness quality than the other reinforcements. [24]

Sunday aribo et al. demonstrated in their study in is known that the silicon carbide PAMC exhibits good mechanical characteristics at high temperatures. This material has high temperature capabilities, based on the stability and minor improvement in the yield strength, ultimate tensile strength, hardness, and ductility at higher temperatures. The impact strength is the sole characteristic that decreases as temperature rises. From the aforementioned, silicon carbide PAMC is suitable for high temperature applications in addition to its high specific strength and high specific modulus. [25]

4. Conclusion

After studying composites, we came to the conclusion that different fabrication techniques, which differ from metal to metal and depending on the alloy's physical state, can be employed to create composites. Since many researchers have utilised the stir casting process for their study, it has been discovered to be very cost-effective and advantageous for the production of composites. It may also be enhanced with ultrasonic assistance to improve the mixing of reinforcement in the melt. Stirring duration and speed are crucial factors that determine the composition of composite. The mechanical qualities of a composite depend on these factors, and by applying them optimally, we can enhance a variety of mechanical attributes like tensile strength, hardness, density, and microstructure.

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