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## Synthesis of Metal Matrix Composites through Stir Casting Process – a Review

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Metal is the one of the important material in engineering materials because of their high strength to weight ratio. However the pure metals cannot be used as engineering materials due to their ductile property. So, to improve their mechanical properties, some of the high strength materials (not metals) were added as reinforcement to improve the mechanical properties of pure metals and the newly developed material is called as metal matrix composites. At present, Aluminium, Copper, Magnesium, Titanium and Iron have been used as matrix materials and materials like TiC, SiC, B<sub>4</sub>C, WC, Cr<sub>3</sub>C, TiO<sub>2</sub>, ZrO<sub>2</sub>, Gr, MoS<sub>2</sub> and Si<sub>3</sub>N<sub>4</sub> have been used as reinforcements. There are many processing techniques to fabricate metal matrix composites namely stir casting, ultra-sonic assisted casting, compo-casting, rheo casting, powder metallurgy technique, etc,. Among these, stir casting process is the most suitable and economical method to fabricate the metal matrix composites. In this article, an effort has been made to review the work of various researchers to fabricate metal matrix composites through stir casting process.

*Keywords:* metal matrix composites, synthesis, stir casting.

## 1. Introduction

Composite materials are the mixture of two or more materials in which one is the matrix material and the other one is reinforcement material. The matrix material will be continuous and the reinforcement material will be discontinuous like particulates, whiskers, fibres, etc. The composite materials are classified into metal matrix composites (MMC), polymer matrix composites (PMC) and ceramic matrix composites (CMC). In these three composites, metal matrix materials play an important role in engineering materials due to its weight to strength ratio. Metal matrix composites possess better mechanical properties, tribological properties and good machinability. Based on this criteria metal matrix composites demand has been increased. Mostly the matrix material used is pure metal like aluminium, copper, magnesium. Since the pure material will not meet the required mechanical and tribological properties, the reinforcement materials are dispersed homogeneously without atomic level interaction in the matrix material to enhance the properties of pure material. When the MMC's are fabricated through stir casting process the bonding between the matrix material and reinforcements will be good it results in substantial improvements in the properties. Conventionally, MMCs have been formed by some fabrication techniques namely powder metallurgy, preform infiltration, spray deposition and mechanical alloying. Among these techniques, desirable properties can be achieved through stir casting process. Between numerous categories of matrix materials for composites, Aluminium and its alloys are the one of the most preferred metal for fabricating MMC. The simplest and furthestmost commercially used method is known as stir casting technique. MMC are most attractive engineering materials for their wide range of applications due to its high strength to weight ratio [1]. Stir casting route is essentially used for manufacturing of additives reinforced metal matrix composite (MMC). Fabrication of aluminum alloy centered casting composite by stir casting is one of the supreme cost-effective approaches of processing MMCs [2]. The leading purpose of the metal matrix composite fabrication is to attain high wear resistance, less in weight, and high specific strength in order to decrease the costs of technological applications and fuel consumption. Nowadays, the application of metal matrix composites (MMC's) has increased in several areas of industry because of their superior mechanical and physical properties. MMC's have the prospective to exchange conservative materials in various fields of application such as automobile, aeronautical and aerospace, as well as in others progressive industries because of its own properties [3]. Metal matrix materials have appeared as the essential class of progressive materials giving engineers the chance to tailor the material properties rendering to their requirements. Metal matrix composites have evidenced their reputation to conventional alloys in high strength and stiffness application in production industries like auto-mobile, aerospace and mineral processing. Metal matrix materials diverge from the predictable engineering materials from the perspective of similarity. Particulate metal matrix composites are generally fabricated by melt incorporation and stir casting method. Composites fabricated through stir casting method will possess good mechanical properties and creates them worthy materials for many engineering applications [4]. In stir casting methods, the wettability of the particulate particles by molten metal is developed by relating high pressures during casting [5].

## 2. Aluminium metal matrix composites

M. Ravichandran et al. [6] synthesized Al-TiO<sub>2</sub> composites through stir casting route. The compositions such as Al and Al-5% TiO<sub>2</sub> were chosen. The stir casting process was conducted at a stirring speed of 300-500 rpm for a period of 5 minutes. The mechanical properties such as tensile strength and hardness tests were carried out. The microstructure examination was carried out by using scanning electron microscope. The experimental results confirmed that while adding TiO<sub>2</sub> to the pure Al, the tensile strength and hardness was increased. From the SEM image it was understood proper distribution has taken place between the Al and TiO<sub>2</sub> composites.

T. Rajmohan et al. [7] investigated the mechanical and wear behavior of hybrid aluminium matrix composites fabricated through stir casting method. The matrix material chosen here was Al 356 alloy and the ceramic materials used were Mica and SiC. The hybrid composites were synthesized through stir casting route. The chemical elements present in the hybrid composites were predicted by using EDX analysis. The matrix material Al 356 alloy was first poured into the silica crucible and it was liquefied in the electric furnace. In the next stage Mica and SiC, warmed to a temperature of around 620°C, and then the ceramics were added to the molten metal at about 750°C and stirred constantly. The time taken for stirring was 5-7 minutes and the stirring speed was 500 rpm. During stirring magnesium was added in little amount to increase the wetting. The molten metal with particulates was dispensed into a permanent metallic mould. The density of the composites was found by using Archimedean principle. The density results revealed that the densities of mica strengthened composites are better than those of ceramic strengthened composites. The hardness results showed that Al/10%SiC-3%mica composite is higher when compared with Al/10%SiC-6%mica. Wear loss was determined by using central composite face centered second order design. The optimization tool used here was Response Surface Methodology (RSM). The experimental ANOVA results revealed that load is the major parameter, which affect the wear loss of composites trailed by mass fraction of mica. The results showed that tensile strength is extreme for Al/10%SiC-3%Mica composites.

Shivaprakash Y. M. et al. [8] investigated the dry sliding wear characteristics of AA2024 matrix material reinforced with fly ash. The metal matrix composites were fabricated through stir casting route. The different compositions were AA2024+2.5% fly ash, AA2024+5% fly ash, AA2024+7.5% fly ash, AA2024+10% ly ash and AA2024+15% fly ash by weight. The dry sliding wear behavior of the stir cast composites were determined by using pin-on-disc machine. AA2024 blocks were charged into graphite crucible furnace and melted. The blocks were melted at a temperature range of 850°C. Then 10gms of dry hexachloroethane tablet is added to degas the total melt. The moisture content present in the fly ash particles were removed by preheating them at a temperature of about 400°C for a time period of 1 hour. Fly ash particles were preheated and added at the vortex of molten matrix by varying the weight %. The speed of the stirrer was retained at 350-400 rpm for a time period of 10 minutes. To expand the wettability of fly ash particles with the melt 0.5% of magnesium were added. During the accumulation of the elements temperature was preserved in between 800-850°C. The slurry was poured at the

temperature of 850°C in the grey cast mould which is preheated to 300°C. Finally various weight % of aluminium-fly ash composites ranging from 2.5 to 15 % were manufactured. The samples were solidified in air for two hours. The SEM images clearly show the distribution of various weight % of fly ash particles in the matrix. The wear tests were accompanied as per ASTM G-99 standards. The time taken for single test was 6 hours. The samples were made as cylindrical pin with dimensions of 8 mm diameter and 27 mm length. The load was designated in the assortment of 10, 25 and 35 N with adaptable speed of 200, 300 and 400 rpm. Totally eight set of samples were tested. Every single set have nine samples of a specific type of composition. The experimental result showed that co-efficient of friction was reduced when the percentage of fly ash was increased in the matrix.

N. Nanda Kumar et al. [9] Premeditated the mechanical behavior of Aluminium based hybrid composites. In this investigation two different types of hybrid composites have been fabricated. The first hybrid combination was AA6061-SiC-Gr and the second hybrid combination was AA6061-Al<sub>2</sub>O<sub>3</sub>-Gr. Both hybrid combinations were manufactured through Stir Casting Method. The matrix material AA6061 was initially poured into the 2.5kg capacity crucible. By using the shaping machine the AA6061 was broken into fine scraps. The metal scraps were dispensed into the furnace. The temperature maintained was around 600oC. The particulates were warmed to a temperature of 500°C and finally it was added to semi liquid aluminium alloy in the furnace. Aluminum matrix composite was again reheated to touches the wide-ranging liquid state. Stirring was done by using a mechanical stirrer and the stirrer speed was 150 rpm. At 800°C temperature hybrid composite material becomes exclusively liquid state. Finally the melted aluminium hybrid metal matrix composite was transferred into the permanent moulds. From the SEM image it was evident that, the dispersal of reinforcing particulates in both the composites was equally even. The ultimate tensile strength was increased when the reinforcements graphite and SiC was added with AA6061. In the mean while addition of 17wt% Al<sub>2</sub>O<sub>3</sub> also tensile strength increased.

Ghanaraja S et al. [10] investigated the mechanical properties of hot extruded Al (Mg)-TiO<sub>2</sub> composites. The matrix material chosen was Al 1100-Mg alloy and reinforcement chosen was TiO<sub>2</sub>. The different weight % of TiO<sub>2</sub> powders was namely 3, 6, 9 and 12. By using clay graphite crucible available inside the muffle furnace pure Al 1100 of around 600gm was melted and superheated at a temperature of 900°C. The surface of the melt was cleaned by skimming afore adding the reinforcements. The required quantity of TiO<sub>2</sub> powders were added into molten Al 1100 at a dispensation temperature of 900°C. The oxide particles addition was well-ordered at an estimated range of 6-8g/min. To distribute the TiO<sub>2</sub> reinforcements into the melt coated flat blade stirrer was used. The stirrer speed was fixed at 300rpm. The speed of the stirrer was measured by using non-contact type sensor. The temperature of the slurry was retained within ±100°C while stirring. Later the addition of TiO<sub>2</sub> magnesium lump of 2 wt% was enveloped by aluminium foil and charged into the melt particle slurry. The bottom of the crucible was removed after completed the above steps by using the lever to discharge molten slurry into riven kind graphite coated and preheated steel mould everlasting of three cavities with 12 mm diameter and one cavity of 36mm diameter and cavity length 80mm was provided in the mould. Entire cast composites were exposed for hot extrusion. Hot extrusion was

carried out to reduce the porosity content in the cast composites and grain refinement was achieved. Before extrusion all the composites were heated in a furnace at the temperature range of 500°C for a time retro of 90 min to disperse the specimen temperature over the volume. Solid lubricant powder was used as lubricant with a range of 1:3. It was mixed with solid and semi-solid lubricant. To reduce the friction during the extrusion process the mixture was applied over the inner surface of the die. The extruded composites range from 35mm to 10mm diameter with an extrusion ratio of 12.25. To predict the presence of reinforced particles in the matrix metallography study was carried out by using SEM. XRD analysis was also carried out to predict the purity of TiO<sub>2</sub> and the level of purity was confirmed. The mechanical properties such as tensile strength and hardness were improved significantly while increasing the reinforcement. Greater hardness and tensile strength was achieved for 12 wt % of TiO<sub>2</sub>.

MadevaNagaral V. et al. [11] Developed and studied the mechanical performance of Al6061/Al<sub>2</sub>O<sub>3</sub>/Graphite strengthened hybrid Aluminium metal matrix composites. The Al<sub>2</sub>O<sub>3</sub> reinforcement was taken as 6 wt % and Gr reinforcement wt % was extensive from 2, 4 and 6. The matrix material Al6061 was dispensed into the crucible. The reinforcement particulates were preheated before dispensed into the melt at a temperature of 200°C. The preheated reinforcements Al<sub>2</sub>O<sub>3</sub> and graphite were discharged into the molten alloy. The molten alloy was mechanical stirred for a retro of 10min afore and later introduced the reinforcement particles with the help of zirconia-coated steel impeller. Before dipped the stirrer into the melt the stirrer was preheated by placed it nearly to a distance of 2/3 height of the molten metal from the bottommost and it was rotated at a speed of 400 rpm. The molten hybrid composites was drizzled into stable cast iron moulds at an embraced discharge temperature of 750°C. The hybrid composites were gotten in the cylinder shape of diameter 14 mm and length 120mm. The better hardness value was achieved for Al6061 alloy+6% of Al<sub>2</sub>O<sub>3</sub> when compared with the Gr reinforced composites. The yield stress was significantly increased while increasing the reinforcement percentage. The maximum yield stress was attained at Al6061 alloy+6% of Al<sub>2</sub>O<sub>3</sub>+6% Graphite. The ultimate tensile strength value also considerably increased whereas reinforcement percentage was increased. The highest tensile strength achieved for Al6061 alloy+6%Al<sub>2</sub>O<sub>3</sub>+6% Graphite. From the experimental work it was concluded that while increasing the reinforcement percentage strength will be increased. Mohsen Hajizamani et al. [12] Synthesized and studied the mechanical properties of A356 alloy reinforced with Al<sub>2</sub>O<sub>3</sub>-10% Vol. ZrO<sub>2</sub> nanoparticles. In these investigation Al<sub>2</sub>O<sub>3</sub>-10% Vol. ZrO<sub>2</sub> nanoparticles with 80 nm has been used. Resistance furnaces, furnished with a stirring arrangement were used to prepare samples. 3 g Keryolit was added to the molten metal after melted the aluminium blocks. The stirring speed was maintained frequently at 420 rpm and the time taken for stirring was 14mins. During stirring Al<sub>2</sub>O<sub>3</sub>- 10% Vol. ZrO<sub>2</sub> nanoparticles were enfolded in aluminum foils finally added to the molten metal. The temperature maintained during the casting process was 850°C. Microstructural study was carried out. The results showed that Al<sub>2</sub>O<sub>3</sub>-10% Vol. ZrO<sub>2</sub> nanoparticles were not properly mixed with the matrix material. Agglomeration was occurred because of poor wettability. While increasing the reinforcement contents density was decreased in the meanwhile porosity was increased. The tensile test revealed that yield and ultimate

tensile strength (UTS) increases with increase in Volume % of ZrO<sub>2</sub>. The compressive strength was increased gradually when increasing the reinforcements from 0 to 2%. When increasing the reinforcement from 1 wt.% Al<sub>2</sub>O<sub>3</sub>-10% Vol. ZrO<sub>2</sub> hardness value was increased after increased the weight percentage 1.5 and 2% hardness value was decreased this is due to non-uniform distribution of reinforcement particles with the matrix material.

T. Rajmohan et al. [13] investigated the mechanical properties of hybrid MMC. In this study Al6061 was matrix material and TiO<sub>2</sub> particles of size 25 microns and graphite particles of size 45 microns were used as the reinforcement materials. The compositions chosen here was Al+5%TiO<sub>2</sub>+3%Gr, Al+10% TiO<sub>2</sub>+3%Gr, Al+15%TiO<sub>2</sub>+3 %Gr. Before melting Al6061 alloy was preheated initially at a temperature of 450°C for a time period of 2hrs. To increase the wetting behavior by eliminating the engrossed hydroxide and other gases in TiO<sub>2</sub> and Gr it was preheated initially at a temperature of 1000°C for a time period of 1hr 30mins. The composite slurry was then warmed to a fully molten state. The mechanical stirring was carried out for a time period of 20 mins at a speed of 200 rpm. The composite slurry was finally poured in permanent metallic mould. Microstructure examination was revealed that reinforcement particles were distributed uniformly with the matrix material. Energy dispersive spectroscopy analysis showed the presence of Al6061/TiO<sub>2</sub>+Gr. The hardness of Al+5%TiO<sub>2</sub>+3%Gr were 55 BHN, Al+10%TiO<sub>2</sub>+3%Gr were 58 BHN and Al+15%TiO<sub>2</sub>+3 %Gr were 62 BHN. This is due to brittle nature of reinforcement particles. The ultimate tensile strength of Al+5%TiO<sub>2</sub>+3%Gr were 110N/mm<sup>2</sup>, Al+10%TiO<sub>2</sub>+3%Gr were 113 N/mm<sup>2</sup> and Al+15%TiO<sub>2</sub>+3 %Gr were 118N/mm<sup>2</sup>. This is due homogenous distribution of TiO<sub>2</sub> and Gr reinforcement particles with the Al matrix.

G. G. Sozhamannan et al. [14] fabricated aluminium matrix composites using stir casting technique. In his research the matrix material chosen was Al-11Si-Mg alloy and the reinforcement was SiC at an average size of 40 micrometer. The specimens had been prepared by varying the temperature level of the crucible i.e 700°C, 750°C, 800°C, 850°C, 900°C. The percentage of reinforcement added to the matrix is 10% by volume in all the five specimens. The reinforcement SiC was pre heated to 1000°C for two hours and then added to the molten matrix material. The speed of the stirrer was maintained at 450 rpm for all the four specimens. To avoid the oxide formation above the molten melt, argon gas was passed near the crucible. After the stirring process, the mixture is allowed to solidify in the steel die which is preheated to 350°C. In micro structure analysis, the specimens prepared at 750°C and 800°C has a homogeneous mixture. Whereas the specimen prepared at 700°C, 850°C and 900°C the particles agglomerated due to the viscosity change of Aluminum matrix. It shows that the viscosity of Al matrix decreases with increase in temperature. The tension test result proves the ultimate strength increases up to 800°C and starts to decrease gradually when the processing temperature increases. The hardness value increases with increase in processing temperature.

K. K. Alaneme et al. [15] synthesized and investigated the mechanical properties of aluminium matrix composites reinforced with alumina particles by two step stir casting process. The matrix material used in this research was aluminium 6063 alloy reinforced with Al<sub>2</sub>O<sub>3</sub> 6%, 9%, 15% and 18% by volume. The size of the alumina particles used in this research were 28 m. The AA6063 ignots were melted in a gas

fired crucible furnace above its liquidous temperature i.e. 750°C. Then it is allowed to become semi solid state at the temperature of 600°C. The alumina particles are preheated to 250°C to increase the wettability of the reinforcement with the matrix material. Then the preheated alumina was added to the semi-solid aluminium matrix and stirred manually. Then the mixture was superheated to 720°C and stirred with electric motor. The stirring speed of the stirrer was 300rpm maintained for 10 minutes for the uniform distribution of reinforcement in the matrix. The porosity found in the specimen Al6063+9%Al<sub>2</sub>O<sub>3</sub> is 1.79% and increases suddenly on further addition of reinforcement. The mechanical properties hardness, tensile and yield strength increases with increase in reinforcement. Whereas strain and fracture toughness values decreases gradually with increase in alumina percentage in the matrix material.

M. D. Antony et al. [16] investigated the dispersion of silicon carbide (SiC) and boron carbide (B<sub>4</sub>C) in the aluminium 6061 matrix. The hybrid composite were fabricated through stir casting process. Four samples has been synthesized by varying the weight percentage of SiC and B<sub>4</sub>C. The composition of the specimen were 90%Al6061+5%SiC+5%B<sub>4</sub>C, 90%Al6061+6.5%SiC%+3.5%B<sub>4</sub>C and 90%Al6061+8%SiC%+2%B<sub>4</sub>C. Al6061 was charged in electric furnace and melted at the temperature of 850°C. The reinforcement particulates were pre heated at the temperature of 840°C for 3 hours to make their surface oxidized. At the semi-solid state, the preheated reinforcements had been dispersed in to the matrix. The slurry was mixed manually and the slurry was heated above the liquidous temperature of the Al6063 alloy and automatic stirring was started for 10 min at 600 rpm. After the solidification, the samples had been prepared for scanning electron microscopy and optical microscopy. The samples had been mechanical polished with 1μm alumina-powder suspended in distilled water. Then polished with 0.5μm diamond paste to get mirror like finish and etching has been done with Kellar's agent. From SEM and optical microscopy analysis, it has been seen that the reinforcement has been homogeneously dispersed in the matrix. The particulate clusters has been seen when the processing temperature increases in the specimen.

Shubham Mathur et al. [17] fabricated the aluminum-copper-silicon carbide hybrid composites by varying the pouring temperatures through stir casting process. Initially, aluminium balanced with 4% copper melted in a graphite furnace. The reinforcement 5% SiC was preheated to 1100°C to remove surface oxides. Then the reinforcement is added to the matrix and stirred for 3 minutes at 600 rpm. Three composites were fabricated by varying the pouring temperatures 700°C, 725°C and 750°C and poured into the sand mould. After the successful fabrication of composites, mechanical properties hardness, impact strength and ultimate tensile strength were determined. The test results indicate that the composite made at 725°C pouring temperature has best optimum value on mechanical properties. The tensile and impact strength increases with increase in grit size of the SiC particles.

Siddabathula Madhusudan et al. [18] investigated the mechanical properties of aluminum matrix reinforced with copper particulates. The different composite was fabricated by varying the weight percentage of copper

5% and 15%. Pure aluminium ingots were charged into electrical furnace at the temperature 720°C. Copper powders were added at the vortex of aluminum melt which is thoroughly dried in muffle furnace at the temperature of 250°C. The strength

of the specimen is low due to the lean reinforcement of copper. The strain failure decreases with the presence of reinforcement in the matrix. Agglomeration occurs due to increase in reinforcement.

ShivrajKoti et al. [19] studied the microstructure and tensile properties of Aluminium 7475 alloy reinforced with boron carbide (B4C). Three specimens were fabricated using stir casting technique, one specimen without reinforcement and the other two by varying the weight percentage of B4C 2% and 4%. AA7475 was melted in a graphite crucible furnace at the temperature of 718°C. B4C at the size of 70-80  $\mu\text{m}$  was preheated at 250°C to avoid oxide formation and increase the wettability of the reinforcement with the matrix. The preheated B4C were added to the molten alloy and stirred continuously for 15 minutes at the temperature of 750°C. Then the slurry is poured into the preheated die. Microstructure analysis shows the uniform dispersion of B4C particulates in the AA7475 alloy. The hardness of the composites increased gradually by adding the reinforcement compared to the base alloy properties. The yield strength also increases by adding the B4C particulates in to the aluminium alloy matrix.

Rajeshkumar Gangaram Bhandare et al. [20] synthesized a hybrid aluminium composite reinforced with silicon carbide, alumina and graphite in Al6061 alloy matrix using stir casting technique. The composites were prepared by varying the process parameters stirring speed, blade angle and number of blades using design of experiments. The aim of the research is to find at which parameter the dispersion of reinforcement is uniform in the matrix. In this research the temperature maintained for stirring is 630°C to increase the wettability between the reinforcement and matrix. The reinforcement was preheated to 500°C to remove oxides or any other gases present in it. The study shows that the reinforcement should be added at the semisolid stage to increase the wettability of the reinforcement with matrix. For homogeneous mixture, the blade angle should be 45 or 60 and the number blades in the stirrer should be 4. The mould should be preheated to reduce the porosity of the composite.

Raghavendra N. et al. [21] investigated the tribological behavior of Al7075 alloy hybrid composite reinforced with alumina and silicon carbide. The composites have been prepared by varying the weight percent of alumina 3%, 6%, 9% & 12% and Silicon carbide 3% by weight is added to the all composites. Al7075 were charged into graphite crucible in electric furnace at the temperature of 750°C. The reinforcement had been added to the molten alloy in semi-solid stage and mechanically stirred. Then the slurry was poured in the mould and cast composites were taken. The composites had been prepared for microstructure analysis with diamond paste and Kellers reagent. The specimens were machined to test their wear and hardness properties. From the hardness test results, the hardness had been gradually increased by increasing the weight percentage of alumina particles. Pin-on-disc wear test had been carried out by varying the sliding speed and load to study the wear properties of the composites. The wear rate decreases when the weight percentage of alumina increased. Co-efficient of friction, noise and vibration had been reduced by the addition of SiC particulates.

Sharanya Nair et al. [22] Prepared and studied the microstructure of aluminum metal matrix composite fabricated through stir casting method. Aluminium 6061 alloy was used as matrix material reinforced with Silicon carbide (SiC) particles.

Scanning Electron Microscopy had been taken to study the dispersion of SiC in Al6061 matrix. The alloy was charged in graphite crucible and melted at 650°C. 10% by weight of SiC in the 100 mesh size was added to the molten metal. To reduce the porosity and increase the wettability 1% magnesium had been added in to the slurry. The slurry was mixed mechanically by graphite stirrer for 10 minutes at 250rpm. Then the slurry had been poured into the mould and allowed to solidify. From SEM images, it was clear that the reinforcement dispersed uniformly in the matrix material. Addition of magnesium resulted in less porosity and increased the wettability of the reinforcement with matrix.

### 3. Magnesium matrix composites

C. Y. H. Lim et al. [23] investigated the wear behavior of magnesium base metal matrix composites (MMCs) reinforced with silicon carbide particulates (SiCp) during dry sliding. The composites exhibit lightly superior wear resistance under the lower load, but the effects of the SiC particulate reinforcement on wear resistance are not as conclusive under higher load. During SEM analysis, it was observed that the melt wear becomes the dominant wear mechanism, causing gross deformation of the magnesium matrix at the contacting interface. The useful range of Mg/SiCp composites appears to be limited to loads and speeds below 30 N and 5.0 m/s respectively.

S. Jayalakshmi et al. [24] investigated the tensile behaviour of AM100 magnesium alloy and its composites at different temperatures. The nature and distribution of precipitates influenced the inherent brittle nature of AM100 alloy and it dominates the tensile behaviour. At higher temperatures, the strength was attributed to the load carrying capacity of the fibers. The strength reductions mainly due to averaging and softening of the matrix alloy, which indicates the addition to matrix flow properties.

X. J. Wang et al. [25] conducted a study on the novel stir casting assisted by ultrasonic treatment processing of micro-SiC particles reinforced magnesium matrix composites. The ultrasonic treatment significantly improved the mechanical properties of the composites fabricated by different parameters compared with traditional stir casting. Addition of SiC particles results in refinement of the grain size. Grain sizes of composites decreased with the increases of particle contents. The ultimate tensile strength, yield strength and elastic modulus were significantly enhanced as the particle contents increased.

A. Kandil [26] synthesized and studied the microstructure and mechanical properties of AZ91 magnesium matrix reinforced with SiC particulates. The composites were synthesized by varying the volume fraction SiC particulates. SiC particles were preheated at a temperature of 1100°C for 2 hours to avoid oxidation. Matrix material was melted in a graphite crucible at 725°C in inert atmosphere. The preheated SiC particulates were added at the vortex of the melt. The melt was stirred for 1 minute and poured at 700°C. Scanning Electron Microscopy and Energy Dispersion X-ray analysis were done to study the interface and particulate dispersion between matrix and reinforcement.

The hardness value increases with increase in addition of SiC particulates. The % of elongation decreases with increase in volume fraction of SiC particulates.

Hu Lianxi et al. [27] fabricated SiCw/ZK51A magnesium matrix composite by a modified two step stir casting technique. The new fabrication technique revealed that it was increasing the modulus and mechanical strength significantly as compared with the unreinforced matrix alloy. There was no interfacial reaction in the SiC ZK51A composite, attesting that SiC whiskers are very stable reinforcements for magnesium matrix composites.

T. Rzychoń et al. [28] fabricated and investigated the mechanical properties of magnesium matrix composites reinforced with SiC particles. WE43 (Mg - 4% wt. Y - 3% wt. RE - 0.4% wt. Zr) magnesium matrix composites reinforced with 0.3%, 2%, 5% and 10% SiC at an average size of 45  $\mu\text{m}$ . The magnesium alloy is charged in mild steel furnace and preheated at 4500C and argon gas is passed over the alloy to remove the surface oxides. Then the furnace temperature had been raised to 720°C for the time period of 20 minutes to achieve homogeneous melting of alloy. SiC were preheated at 200°C and added to the molten alloy. The slurry was stirred with stainless steel stirrer for 10 minutes and the stirrer speed was maintained at 150rpm. Finally the slurry had been poured into the graphite mould at 720°C to get a cast of 4 cm diameter. Microstructural studies had been carried out using Scanning Electron microscopy and light microscopy. Microstructural studies show that uniform distribution of the reinforcement in the matrix and less amount of porosity at the interface of matrix and reinforcement. By increasing the volume percentage of SiC, the hardness value of the composite increases. Ultimate strength and elongation % had been decreased with the increase of reinforcement.

#### 4. Copper metal matrix composites

Jitendra Kumar et al. [29] developed and investigated the tribological behavior of copper metal matrix reinforced with graphite. The composition of the specimens were 95%Cu+5 wt. % Gr, 90%Cu+10 wt. %Gr and 85%Cu+15 wt. %Gr. The composites were fabricated through stir casting technique. The microscopy shows that reinforcement material had been dispersed uniformly in the matrix in all composites synthesized by stir casting technique. The tests had been carried out in pin-on-disc tribometer. High volumetric losses resulted by increasing the load and sliding distances. From the synthesized composites, 15% Gr possess superior wear resisting property than the 5% Gr and 10% Gr composites. By adding the graphite, the impact strength reduces gradually. This is due to the ductile nature of the graphite.

Kenneth Kanayo Alaneme et al. [30] fabricated copper matrix reinforced with steel machining chips through stir casting technique and investigated the mechanical, wear and corrosion properties of the composites. Three specimens were prepared by varying the weight percentage 5, 7.5 and 10 steel chips. The size of the steel chips was 105 m. The steel chips were preheated at a temperature of 250°C to avoid dampness and to increase the wettability of the reinforcement with matrix. Copper was melted in a gas fired crucible furnace at the temperature of 1150°C. The molten copper was cooled to 920°C and the reinforcement was added at semi solid state. The mixture was stirred manually for min. Then the semi-solid mixture was heated

to 1200°C and mechanically stirred for 7 min at 300rpm. Then the composites were cold rolled to 10.2 mm diameter from 12mm in diameter through the rolling dies. The wear behavior of the specimen was tested in Table abrasion machine. Corrosion behavior of the samples was investigated in 0.3 M H<sub>2</sub>SO<sub>4</sub> and 3.5 wt% NaCl solutions at room temperature (25°C) using an AutoLab potentiostat. The mechanical properties and wear properties were improved due to the addition of steel chips reinforcement. The corrosion resistance were improved in 0.3 M H<sub>2</sub>SO<sub>4</sub> than in NaCl solution.

## 5. Conclusion

Stircasting is the one of the best and economical method for the fabrication of metal matrix composites. In Stir casting process, the dispersion of reinforcement particles is uniform throughout the matrix material. Inorder to increase the wettability of the reinforcement with matrix material, maximum 1% of magnesium can be added in the molten matrix and also the addition of reinforcement at the semisolid stage of the molten matrix not at the liquid state of the matrix. The slurry can be stirred for about 10 to 15 minutes at 300 to 500 rpm to obtain a homogeneous mixture of the reinforcement in the matrix. The mould can preheated to 250°C to 350°C to reduce the porosity in the composites which results in increase in density of the composites. Agglomeration of reinforcement may take place if the addition of reinforcement is above 15% in the matrix which reduces the mechanical and tribological properties of the composites.

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