Behavior of Aluminium Matrix Composites Produced By Stir Casting Technique – A Review

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Abstract- *The process of Stir Casting had been in existence for a very long time and this particular process is the core for the fabrication of aluminum matrix composites. This study aims at bringing together all the eminent works in this particular area and comparing and evaluating their results to form an overall picture as to what the necessary conditions and proceedings for the fabrication of aluminum matrix are. During the study it was observed that a shorter stirring period was necessary for the incorporated ceramic to achieve its metal or ceramic bonding at the interface. Moreover, the mechanical and microstructural characteristics at different stirring period at different temperatures were also studied and the most efficient conditions for each of these processes have been analyzed and studied.*

Keywords- Composites,Aluminum,Stir Casting.

I. INTRODUCTION

For decades, Stir Casting was employed as the conventional process for the production of discontinuous, reinforced and metal matrix composite. The strength of this material can be improved by reinforcing with hard ceramic particles like SiC, Al_2O_3 etc. which in turn help enhance the wear resistance and strength to wear ratio.

Stir casting is an economical process, for the fabrication of aluminum matrix composites. There are many parameters in this process, which affect the final microstructure and mechanical properties of the composites .From microstructural characteristics, it was concluded that a shorter stirring period is required for ceramic incorporation to achieve metal or ceramic bonding at the interface. A higher stirring temperature of 850°C also leads to improved ceramic incorporation. In some cases; shrinkage, porosity and intensive formation of Al_4C_3 at the metal or ceramic interface are also observed. Moreover, the mechanical properties of the composites were evaluated, and their relation with the corresponding microstructure and processing parameters of the composites are discussed.

A. Aluminum

Aluminum is a remarkable metal with low density and has the ability to resist corrosion through the phenomenon called “passivation” and its alloys are vital to many industries like aerospace, transportation, building et-cetera. Aluminum is relatively soft, lightweight and ductile. Aluminum has many Composites and some of them are discussed here.

B. Aluminum Matrix Composites (AMCs)

Nowadays, Aluminum alloys are preferred over conventional metals and alloys in many industries like; Automobile, due to the various mechanical and advance properties like wear resistance. Aluminum Matrix Composite(AMCs), which is reinforced with micro and Nano sized Al_2O_3 are widely used for high performance applications like Aerospace and Military because of their improved properties.

Cast aluminum matrix particles reinforced with composites have higher specific strength, specific modulus and good wear resistance as compared to unreinforced alloys .When fly-ash was considered as a reinforcing element, it was observed that the high electrical resistivity, low thermal conductivity and low density of fly-ash was helpful for making a light weight insulating composites. Theparticulate composite can be prepared by injecting the reinforcing particles into liquid matrix by the method of casting. Casting is preferred as a less expensive and more suitable method for mass production. Among the entire liquid state production routes, stir casting is the simplest and cheapest one. The only problem associated with this process is the non-uniform distribution of the particulate due to poor wettability and gravity regulated segregation.

C. Metal Matrix Composites (MMC)

A composite material is actually a material consisting of two or more physically or chemically distinct phases. The composite has superior characteristics than those of each of the individual components [1].

Usually the reinforcing component is distributed in the continuous or matrix component. When the matrix is a metal, the composite is termed as metal-matrix composite (MMC). In MMCs, the reinforcement usually takes the form of particles, whiskers, short fibers, or continuous fibers.

The Metal matrix composites (MMCs) possess significantly improved properties including high specific strength, specific modulus, damping capacity and good wear resistance compared to Un-reinforced alloys [2]. Nowadays, composites containing low density and low cost reinforcements are mostly preferred. Among the various discontinuous dispersions used, fly ash is one of the most inexpensive and low density reinforcement available in large quantities as solid waste by-product during combustion of coal in thermal power plants. Hence, composites with fly ashes reinforcement are likely to overcome the cost barrier for wide spread applications in automotive and small engine applications thereby, reducing the cost of aluminum products.

Conventional monolithic materials have many limitations in achieving good combination of strength, stiffness, toughness and density. To overcome these shortcomings and to meet the ever increasing demand of modern day technology, composites are the most promising material ofrecent interest.

The application of Metal Matrix Composites (MMCs) as structural engineering materials has received increasing attention in recent years [3]. The high strength and toughness at elevated temperatures coupled with low-density makes them suitable for use in applications where conventional engineering materials, such as steel are used. Moreover, MMCs exhibit significantly higher stiffness and mechanical strength compared to matrix alloys, but often suffer from lower ductility and inferior fracture toughness. MMCs have the ability to withstand higher tensile and compressive stresses by the transfer and distribution of an applied load from the ductile matrix to the reinforcement material .This load transfer is only possible due to the existence of a bond between the reinforcement elements and the matrix material.Therefore, appropriate selection of reinforcement material and its properties coupled with a good fabrication method will significantly influence the resulting MMC.

Since the early 1960, there had been a demand for new and improved engineering materials. With the advancement of modern technology and interest in the areas like aerospace and auto-motive industries had forced a rapid development of metal matrix composites. Moreover, a high demand on the material for better overall performance has led to extensive research and development efforts in the composites fields. Among the composites field, the aluminum based metal matrix composite materials are widely used to meet the emerging need for the innovations in materials processing which in turn had enabled achieving an enhancement in stiffness, realization of high strength to weight ratio, an improvement in wear resistance and maintaining strength at elevated temperatures.

Aluminum based metal matrix composites have been one of the key research areas in materials processing field in the last few decades where most of the research work were dealing with aluminum matrix and SiC reinforcements that was required in the light weight combination of high strength and high stiffness materials [4].This is because, aluminum being lighter weighted is the first requirement in most of the industries. In addition, it provides impressive strength improvement and the thermal expansion coefficient of Al matrix composites which in turn can be adjusted by using silicon carbide, carbon and boron carbides. As a result, these materials are now being rapidly utilized in industries than traditionally used metals, and these have become the forefront of research and development activity in the many related areas.

D.Aluminum Metal Matrix Composites (AMMCs)

In the recent years, Aluminum metal matrix composites (AMMCs) have gained significant attention primarily due to their lightweight, low coefficient of thermal expansion (CTE), good machinability, and improved mechanical properties, such as 0.2 % yield stress (YS), ultimate tensile stress (UTS), and hardness [5]. Owing to these advantages, they are widely used in aerospace (e.g., airframe components), automobile (e.g., engine pistons), and electronic (e.g., integrated circuit mounting frame components) industries.

Stir casting (vortex technique) is generally accepted commercially as a low-cost method for the fabrication of AMMCs. Its advantages include its simplicity, flexibility, and it’s applicable to large scale production. This process is the most economical among all the available routes for AMMCs production, and thus it allows large-sized components to be fabricated. However, the following considerations for achieving AMMC via stir casting are to be considered:

(i) No adverse chemical reaction between the reinforcement material and matrix alloy.
(ii) No or very low porosity content in the cast AMMCs.
(iii) Wettability between the two main phases and
(iv) A uniform distribution of the reinforcement material. Also, factors like wettability and reactivity determine the quality of the bonding between the constituents

and thereby greatly affecting the final properties of the composite materials.

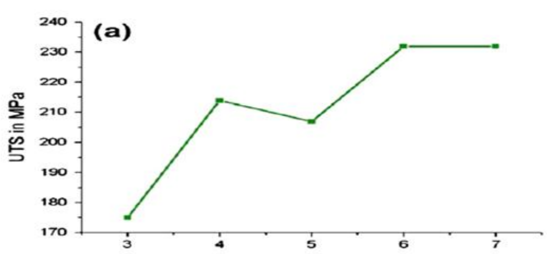
Micron-sized SiC particles were used as reinforcement of pure aluminum to fabricate cast aluminum matrix composite, and Mg where 1wt% was added to improve the wettability and thereby incorporating the fractions of ceramic particles and thus improving the quality of the fabricated composites. Therefore, reaction at matrix or ceramic interface, porosity, ceramic incorporation, and agglomeration of particles were evaluated. Moreover, the mechanical properties of the composites were also investigated, and their relation with the corresponding microstructures and processing parameters were also studied.

II. MATERIALS AND METHODS

A. Titanium

S. Gopalakrishnan et-al explored methods to produce Metal Matrix Composite (MMC) in a cost efficient way to improve specific strength, high temperature and wear resistance applications [6]. In this particular study, particles of Al-TiC castings with different volume fraction of TiC were produced in an Argon atmosphere by an enhanced stir casting method .It was found that, the Specific strength of the composite had increased with higher percentage of TiC addition. Also, the analysis revealed the improved Specific strength as well as the wear resistance of the above mentioned material.

During the experiment, tensile strength and ductility were estimated and the observed data is been plotted in the graph below:

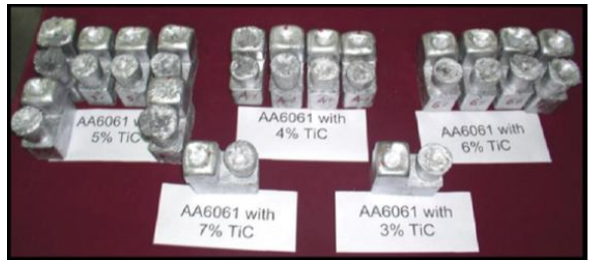


Effect of TiC addition on the mechanical properties of AMC. (a) Tensile strength

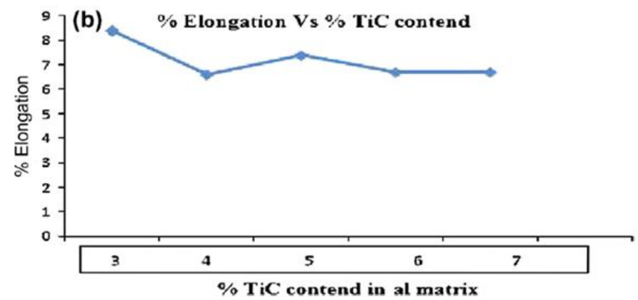
Each trial in the experiment were repeated thrice and the average value of volume wear loss after each interval of time was considered for analysis of wear behavior. The wear rate was calculated using the formula

$$W= V / \rho D$$

Where ρ is the density of the material, V is the weight loss and D is the sliding distance. Specific wear rate W = w/L, where L is the applied load. The worn surfaces of the specimens were examined under an optical microscope to understand the wear pattern of AMC.



AMC castings produced with different percentage of TiC addition.



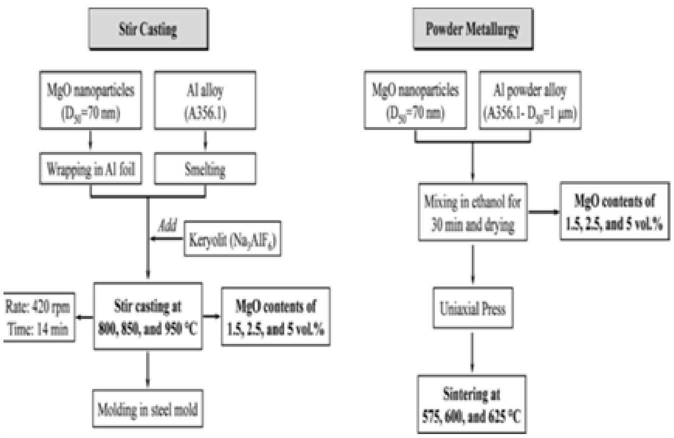
Effect of TiC addition on the mechanical properties of AMC. (b) Ductility.

S. Suresh et-al found that the composites have many applications in aerospace, automotive and structural components [7]. The experiment is conducted using various weight fraction of TiB_2, keeping other parameters constant. The wear mechanism of the material is analyzed using microscopic examination. It was found that the addition of TiB_2 improves the wear resistance of aluminum composites. Results were also found on mechanical properties like tensile strength, wear resistance and hardness caused by the percentage of TiB_2 present in the samples.

B. Magnesium

Hossein Abdizadeh et-al, fabricated Al-Nano MgO composites using A356 Aluminum alloy and MgO nanoparticles (1.5, 2.5 and 5% vol. %) has been fabricated using Stir casting and powder metallurgy (PM) methods [8]. During the experiment, it was analyzed that Powder metallurgy samples showed more porosity portions compared to the casting samples which results in higher density values of casting composites.

Moreover, it was found that the highest hardness value for sintering and casting samples were obtained at 850 and 625°C respectively, in 5 vol% of MgO. The compressive strength values of casting composites were higher than sintered samples which were majorly due to the more homogeneity of Al matrix and better wettability of MgO nanoparticles in casting method. Also, it was found that casting method represented more homogeneous data values of mechanical properties compared to the method of powdermetallurg.



Flowchart representation of stir casting and powder metallurgy methods for fabrication of Al–MgO Nano composite

In general, it can be said that the results depicted dominant properties of stir casting compared to powder metallurgy, which is quite simple, cheap and an efficient method for the production of Al – MgO nanoparticles.

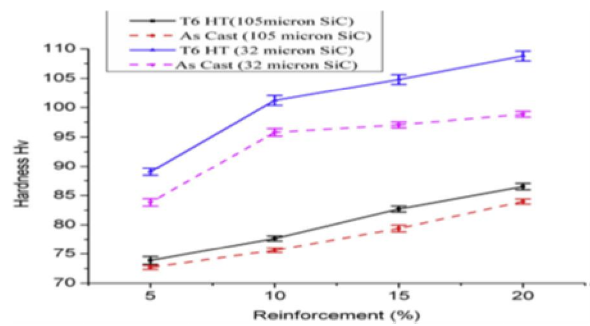
C. Zinc

Kenneth Kanayo Alaneme et-al discuss on the microstructure and mechanical properties of Zn -27Al [9]. They were able to produce different composites of Zn -27Al of varied weight ratios using stir casting process. Different tests including Hardness test, tensile property evaluation, fracture toughness determination and microstructural examination were used to characterize the composites produced.

The results showed that the microstructures of the composites are similar, which consists of the dendritic structure of the Zn -27Al alloy matrix with fine dispersion of the reinforced particles. As the weight percentage of RHA in the reinforcement increases, the hardness of the composite decreases. Moreover, the tensile strength and yield strength decreases slightly with the increase in the weight ratio of RHA in the composites with a maximum of 8.5% and 9.6% reductions respectively for 40% RHA in the hybrid reinforcement .In the case of fracture toughness of the composites, it increases with the increase in the weight percentage of RHA with as much as 20% increase for 40% RHA in the hybrid reinforcement.

D. Silicon Carbide

S. Aravindan et-al, discuss about the fabrication of Magnesium alloy composites with silicon carbide particle by two step stir casting process [10]. They noted the particle size and volume fraction of SiC particles on physical and mechanical properties and were evaluated under cast and heat treated (T6) conditions .The result was compared under standard theoretical models and was found that the mechanical properties of composites increased with increasing SiC particles and decreased with increasing particle size.



Hardness of magnesium alloy (AZ91D) composite.

The composites of the alloy reinforced with finer SiCp exhibits superior properties while the coarse SiCp exhibits better properties when compared with unreinforced magnesium alloy (AZ91).

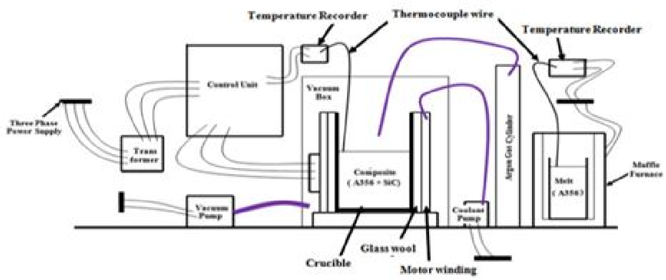
Palash Poddar et-al synthesized elemental Mg and Mg-alloy (AZ91D) composites reinforced with 15 vol% silicon carbide (SiC) particulates by stir casting method [11]. Many properties like, particle distribution , hardness and mechanical properties and also heat treated conditions were analyzed .It was found that , the composites show uniform distribution of SiC particulates and that the grain size decreases with the presence of SiC particulates and also as particle size decreases . The alloy composite, AZ91D show an increase in hardness and modulus when compared to monolithic alloys. It was also found that, the ultimate tensile strength and ductility of the composite material was reduced when compared to unreinforced alloy .Moreover, it was found that porosity can be made minimum with a melt holding and stirring at a temperature of 680°C.

X.J.Wang et-al, discuss the uniaxial deformation behavior of a 10 vol% Sic particulate reinforced AZ91 magnesium matrix composite fabricated by stir casting [12] .The experiment was conducted between the temperature range of : 250 to 400°C . As temperature increases, peak stresses and flow stresses decreases. As temperature decreases, the extent of dynamic recrystallization (DRX) becomes less. An analysis conducted on the effective stress dependence on stress rate and temperature gives a stress exponent of n=5 and an activation energy of Q= 99 kJ /Kg. The conclusion states that the deformation mechanism of the composite during hot compression is controlled by the dislocation climb.

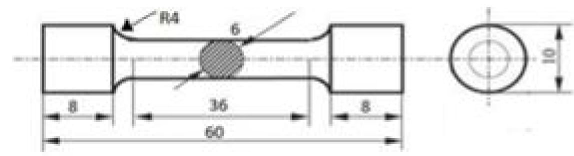
X.J .Wang et-al fabricated 5, 10 and 15 volume percentage of SiCp / Mg, Zn, Ca composites [13].The composites particle distribution was uniform throughout except the boundaries in micro-scale level .The second phase was affected by the size of SiCp as so was their distribution in the matrix . Many large phases were seen on the particle surface .The large particle size were hardly observed as the particle content was increased up to 10%. The second phase consist of fine flakes in 10% and 15% composites , unlike the alloy and 5% composites in which the second phases were large .The mechanical properties of the composite were significantly influenced by the effect of SiCp.

Afshin Matin et-al, worked on the microstructure and room temperature mechanical properties of pure magnesium and cast AZ80 Nano composites [14]. For this different weight percent of SiC reinforced Nano particles were added homogenously into the matrix by the method of stir casting and was found that the Sic Nano particles can significantly reduce the grain size of magnesium matrix .It was found that, by increasing the SiC content, tensile strength and ductility values increased. But there was an optimum Sic content beyond which the strength and formability of the material decreased , which was later found that was caused by the agglomeration of SiC particles in the microstructure of the composites .The study on work hardening behavior of the materials was analyzed by compressive stress strain curves .
Long Jiang Zhang et-al, invested the tensile properties of Nano-SiCp /Al2014 composites at elevated temperatures and found that, the Nano SiCp can improve the tensile strength at 493 K of Al2014 alloy without the need of sacrificing ductility.The strength of the matrix was also found to be superior [15].

Shashi Prakash Dwivedi et-al, conducted an experiment on A356 / SiC metal matrix composites with different reinforcement weight percentage [16]. Different tests like tensile test, hardness test impact test and fatigue tests were carried out at the samples and the following results were obtained. The microstructure study, exposed uniform distribution and porosity. Least porosity value was obtained for 5% reinforcement. Adding of SiC particles led to the improvement in tensile strength, hardness and toughness. Later in the experiment, it was found that: The best mechanical properties were obtained when the percentage of reinforcement was increased in the electromagnetic stir-casting.



Schematic view of electromagnetic stir casting set-up



Dimension for the testing of tensile strength specimen

J. Jabeen Moses et-al, Aluminum alloy is reinforced with various amounts of SiC particles. For this, the matrix alloy is melted in a furnace and stirred to form a vortex [17]. To this, SiC particles are added and the composites melt was solidified to a permanent mold.Further the matrix is studied using optical and scanning electron microscope. The results showed that, the SiC particles are distributed uniformly In the Aluminum matrix and SiC particle clusters are seen in a few places. The SiCp is bonded to the aluminum matrix. Micro hardness and Ultimate tensile strength of the AMCs were improved by the reinforcement of SiC particles. Fracture morphology was also studied.

Tony.Thomas.A et-al conducted an experiment whose objective was to create Aluminum alloy (LM6) – Sic particles reinforced MMC with the aid of stir casting [18]. They find immense application in automotive and aeronautical manufacturing of components. The significance of stirrer and feeder are found by testing the specimen.

E. Aluminum

Rupindar Singh et-al attempted to improve the dry sliding wear properties of aluminum matrix composite (AMC) consisting of Al -6063 matrix and SiC reinforcement prepared through vacuum molding assisted stir casting (VMASC), which has various industrial applications [19]. The study mainly include ; parameters of stir casting namely , particle size of solute SiC , proportion of SiC , vacuum pressure and sand grain size ; to find out their effect on wear properties of AMC .

Pin-on-disc type tribo-setup.

"Pin on disk type tribiological tester "was used to examine the wear .The result concluded that dry sliding wear, sand grain size, vacuum pressure, particle size and proportion of Sic have contributed immensely.In fact their percentages are: 5.95, 10.14, 10.71 and 73.2 respectively.The result was further counter verified with microstructural analysis.

R.Ravi et-al says that the Aluminum matrix is strengthened when it is reinforced with hard ceramic particles like SiC, Al_2O_3 etc., which results in enhanced wear resistance and improved strength to weight ratio [20]. Based on the reinforcement, the AMC's are fabricated by different methods .The experimental results show that: the Mechanical characterization was done and tensile strength and hardness had increased with the weight percentage of B_4C particles.

B.N.Sharada et-al, says that the Aluminum alloys are preferred over conventional metals and alloys in automobile industries due to their various mechanical and wear resistive properties [21]. In their experiment, they attempts to produce an Aluminum hybrid metal matrix composite (LM25+ Activated carbon +Mica) over conventional composite (LM25+Activatedcarbon) and (LM25+Mica) .Various tests like Brinnel Hardness test and Abrasive belt wear testing machine were performed. Also various other tests like wear debris and worn surfaces were carried out using Light optical Microscope (LOM).

After their analysis, they found that: Aluminum alloy metal matrix hybrid can be synthesized by stir casting and for that; stirrer design, alloy pouring temperature, particle pre-heating temperature, size and amount are the important parameters in the process. They also found that: hybrid reinforcement increased the hardness and resistance than single reinforcement.

Subhranshu Chatterjee et-al, prepared reinforced aluminum composite by a simple liquid metal stir casting route [22].They performed X –ray diffraction technique to identify the types of aluminide particles were present in the cast composites.With the aid of energy dispersive spectroscopy compositional variation of the samples were estimated.Different heat treatment schedules and deformation conditions were studied.The micromechanical behavior was assessed and so was micro hardness and Nano indentation. To estimate the mechanical properties and determine the mode of failure of samples, tensile test and fractographic analysis were performed. Further the mechanical properties and microstructure of the composite were correlated and discussed.

Fei Chen et-al, employed a new technique which involved mechanical stirring of the aluminum (salt) interface which was developed to fabricate the TiB2 particulate reinforced with aluminum based in situ composites which have improved particle distribution [23].The stirring intensity, stirring duration and stirring start time was optimized to the mechanical and microstructural properties. The result revealed that the 1st and the last 15 minutes of the 60 minute holding was the most crucial for a fine composite.The SR-CT results says that the composites fabricated by the present technique yielded uniformly distributed Al matrix. Also, the composites not only did have higher yield strength and ultimate tensile strength, but also have superior ductility with respect to the composites fabricated by the conventional process. Also the composites in the present work are 260% and 180% higher than those of the matrix. As a result, it was revealed that the composites thus fabricated, follow ductile fracture mechanism in spite of the presence of stiff reinforcements.

Qiyao Hu et-al fabricated a novel hybrid composite of (B4C + Al3Ti) / Al by two step stir casting process , where it's produced by subsequently adding Ti powders and B4C particles , which is followed by gravity solidification [24] . This mixture showed much more uniform particle distribution than the free composite. The composite also yielded hardness, tensile strength and elongation of 52HB, 129MPa and 13.6% respectively.

K.Umanath et-al reinforced aluminum alloy metal matrix composite with 5 to 25%vol. fraction is obtained by the method of stir casting [25]. By using pin-on-disc wear testing method, the wear behavior of the hybrid composite and of the unreinforced alloy were investigated. The results showed that, the Silicon carbide and Aluminum Oxide particulates are regularly distributed in the metal matrix. Moreover, the wear surface of the hybrid composite is much rougher than that of the non-reinforced alloy.

H.R.Ezatpour et-al developed a mixing method in which injection of the particles into the melt by inert gas and casting was used [26]. This is prepared with the aid of AMC reinforced with Al_2O_3 particles.The microstructure observations revealed a uniform distribution of particles in the matrix. It was also found that, the porosity of the composite increases with the increase of mass fraction of Al_2O_3, stirring speed and was found to be decreased by the method of extrusion process. Moreover properties like Hardness, yield and tensile strength of the composites increased with the increase in particle mass function.

Ahmed M.E and Sabbagh I et-al, prepared Al 6061 and Al 7108 SiCp (Al-PMMC) by stir casting with SiCp of size 8 and 15 µm and volume fraction (vf) of 0-20% respectively [27].The composites were then subjected to successive hot rolling at 450°C. Tensile test was later conducted on these particles. Different tensile properties include: Ultimate tensile strength (UTS), Young's modulus and elongation were determined. The result of the experiment is that: Successive heat rolling will result in decreasing casting defects such as void and SiCp agglomeration in composites and so enhanced mechanical properties were achieved. Ultimate tensile strength of 6061 and 7108 composites were achieved to be 240 and 390% respectively. Annealing helped improve elongation percentage by more than three times and the effect of T6 treatment on the composite tensile behavior werediscussed.

Hamid Reza Ezatpour et-al says that Al 6061 reinforced with hard particles possesses higher strength, stiffness and wear and creep resistance in a wide temperature range, which in turn can be used for automotive components and aircrafts and aircraft structures [28]. They investigated the effects of adding Nano alumina particles to Al 6061 alloy and extrusion process on the mechanical and microstructural properties of composites. After conducting the experiment on microstructure, they found that: The injection of powders in the form of Al/ Al_2O_3 and application of extrusion process led to the fabrication of nanoparticles with reasonable distribution of Al_2O_3 in the matrix alloy with low agglomeration and low porosity.They also found that, the extruded samples show strength and ductility values much higher than those of as-cast samples. Also, both as-cast and extruded samples with increased amount of Al_2O_3 nanoparticles, yield strength and tensile strength increased but elongation decreased.

Pankaj Charan Jena et-al prepared a sample of AMMC with modified stir casting method and was used for crack analysis .Since AMMC is more susceptibility for crack failure, a finite element method (FEM) was used for crack analysis [29]. The different frequency of the beam were analyzed to know the behavior of AMMC as beam structures. The final results proved that, it can be used as a structural material in different applications.

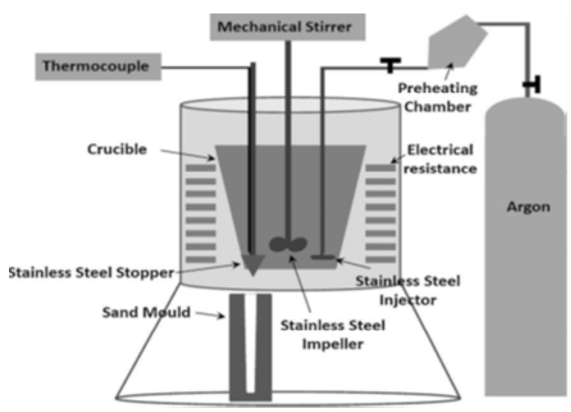
V.Balaji et-al focused his work on the manufacturing of Aluminum metal matrix composite (AMMC) material using stir casting process [30].Various tests were conducted on AMMC material to find many properties like, Tensile strength and hardness and was found that , there is an increase in strength and hardness by 10% when compared to A16061. The density of the composite was found to be better than the base matrix. Moreover it was found that, the Metal matrix system have uniform distribution of Sic particles when subjected to Micro structural analysis. The matrix Al7075 – Sic has potential applications in aircraft and space industries as they have higher strength of weight ratio, high wear resistance and creep resistance.

Bharat V et-al. attempted to synthesize Metal matrix composite using 6061 Al as matrix material reinforced with ceramic Al_2O_3 particulates using liquid metallurgy in stir casting technique [31]. For this, reinforced particles are preheated to a temperature of 200°C which is further dispersed in steps of three into the vortex of molten Al6061, which further helps to improve wettability and distribution. Homogenous distribution of particle is further ensured by taking specimens from the central portion of the casting. The extent of improvement was determined by performing hardness and tensile properties of the composite before and after adding Al_2O_3 particulates. The results showed that fairly uniform distribution was obtained and, hardness and tensile properties are higher in the composites when compared to matrix. Reinforcement proves to improve both hardness and tensile strength.

Abshek Kumar et-al discussed on a new approach of fabricating cast Al matrix composites using electromagnetic stir casting method, which is proved to be efficient enough. It was concluded that, the hardness of cast composite increases linearly with increasing the weight fraction of Al_2O_3 [32]. It was also found that hardness of MMC is much higher than unreinforced metal matrix. Also it was found that, as the weight fraction of Al_2O_3 increases, tensile strength of cast composites increases. Moreover, microstructure observation suggest that electromagnetic stirring action produces cast MMC with smaller grain size and facilitates higher particulate matrix interface bonding .

S.A.Sajjadi et-al, tried to improve the wettability and reinforcement within the particles of AMC [33]. For this, they devised a new method which comprises of 3 novel steps of mixing, which include; heat treatment of micro and Nano

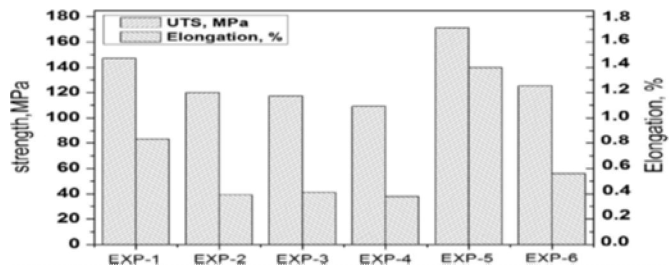
Al_2O_3 particles, injection of heat treated particles within the molten A356 aluminum alloy by inert argon gas and stirring the melt at different speeds. Different parameters like injection process, heat treatment, reinforced particle size, micro structure and mechanical properties were investigated. Scanning electron microscope (SEM) was used to analyze matrix grain size, morphology and distribution of Al_2O_3nanoparticles and Optical microscope (OM) and energy dispersive spectroscopy (EDS) and X-ray diffraction (XRD) were also used.The results showed that, the use of heat treated particles, injection of particles and stirring system improved wettability and distribution of nanoparticles within the matrix.Also, as weight percentage of Al_2O_3particles increased, the amount of hardness, compressive strength and porosity increased.



Schematic of designed equipment.

F. Ultrasonic Treatment Processing

X.J Wang et-al talks about a novel stir casting method assisted by ultrasonic treatment processing and found that there exists an optimal time for ultrasonic treatment, which is both two short and too long for the treatment resulted in homogeneous particle distribution [34].Further, they could prove that: liquid stirring was necessary, which could in turn further improve particle distribution.The composites mechanical properties further indicated that ultrasonic treatment evidently improved the mechanical properties compared with traditional stir casting techniques.Also, with the increase in particle content, grain size of composites decreases.Further it was concluded that the ultimate tensile strength, yield strength and elastic modulus were enhanced as the particle contents increased.



The tensile properties of the composites fabricated under different methods.

III. CONCLUSION

This review aims to portrait the different properties and characteristics of Metal Matrix Composites (MMC) and specifically Stir Casting as a whole. The recent reviews suggest that clustering of reinforcement particles, wettability of reinforcement (SiC) in molten Aluminum are one of the many concerns in the production of composites through stir casting. Moreover, it was also revealed that the Mechanical properties of stir cast composites dependupon many factors like fabrication techniques, volume fraction, size and shape of reinforcement particles. Also it was evident that the addition of reinforcement up to a particular level increases the mechanicalproperties but thereby decreasing the fracture toughness of the composites. Processing variables such as holding temperature, stirring speed, size of the impellers have a direct relation to the composites as they have an impact on mechanical properties.

REFERENCES

[1] Dinesh Pargunde, Prof. Dhanraj Tambuskar, Swapnil S. Kulkarni,“Fabrication of Metal matrix composite by Stir Casting Method”,International Journal of Advanced Engineering Research and Studies - Int. J. Adv. Engg. Res. Studies / II/ IV/July-Sept, 2013.

[2] Sudipt Kumar, J. Ananda Theerthan, “Production and Characterization of Aluminum Fly ash composite using stir casting method”, Department of Metallurgical & Materials Engineering National Institute of Technology Rourkela (2008).

[3] Jasmi Hashim, “The production of Metal Matrix Composite using stir casting technique”,School of Mechanical and Manufacturing Engineering Dublin City University Ireland (1999).

[4] G. G. Sozhamannan, S. Balasivanandha Prabu, V. S. K. Venkatagalapathy, “Effect of Processing Paramters on Metal Matrix Composites: Stir Casting Process”, Journal of Surface Engineered Materials and Advanced Technology, 2, 11-15, (2012).

[5] Shahin Soltani, Rasoul Azari Khosroshahi, Reza Taherzadeh Mousavian, Zheng-Yi Jiang, Alireza Fadavi

Boostani, Dermot Brabazon, “Stir casting process for manufacture of Al–SiC composites”.

[6] Gopalakrishnan. S, N. Murugan,“ Production and wear characterization of AA 6061 matrix titanium carbide particulate reinforced composite by enhanced stir casting method” ,SciVerse Science Direct - Composites: Part B 43 302–308(2012).

[7] Suresha N .S. Shenbaga Vinayaga Moorthi, “Process development in stir casting and investigation on microstructures and wear behavior of TiB2 on Al6061 MMC”, Procedia Engineering 64.1183 – 1190 (2013).

[8] Hossein Abdizadeh, Reza Ebrahimifard, Mohammad Amin Baghchesara, “Investigation of microstructure and mechanical properties of Nano MgO reinforced Al composites manufactured by stir casting and powder metallurgy methods: A comparative study”, Science Direct Composites: Part B 56.217–221(2014).

[9] Kenneth Kanayo Alaneme, Olusola Joseph Ajayi, “Microstructure and mechanical behaviour of stir-cast Zn–27Al based composites reinforced with rice husk ash, silicon carbide, and graphite”, Journal of King Saud University –Engineering Sciences, (2015).

[10] Aravindan S, P.V. Rao, K. Ponappa, “Evaluation of physical and mechanical properties of AZ91D/SiC composites by two step stir casting process”, Science Direct -Journal of Magnesium and Alloys 3 (2015).

[11] Palash Poddar, V.C. Srivastava, P.K. De, K.L. Sahoo, “Processing and mechanical properties of SiC reinforced cast magnesium matrix composites by stir casting process”, Materials Science and Engineering A 460–461 (2007).

[12] Wang X.J, X.S. Hu, K.Wu, K.K. Deng ,W.M. Gan, C.Y.Wang, M.Y.Zheng, “ Hot deformation behaviour of SiCp/AZ91 magnesium matrix composite fabricated by stir casting”, Materials Science and Engineering A 492 (2008).

[13] Wang X.J, K.B. Nie, X.J. Sa, X.S. Hu, K. Wu, M.Y. Zheng (2012), “ Microstructure and mechanical properties of SiCp/Mg Zn Ca composites fabricated by stir casting”, Materials Science and Engineering A 534 (2012).

[14] Afshin Matin, Faramarz Fereshteh Saniee, Hamid Reza Abedi, “Microstructure and mechanical properties of Mg/SiC and AZ80/SiC Nano-composites fabricated through stir casting method”, S0921-5093(14)01418-X:http://dx.doi.org/10.1016/j.msea.11.050,(2014).

[15] Long-Jiang Zhang, FengQiun, Jin-GuoWang, Qi-ChuanJiang, “High strength and good ductility at elevated temperature of Nano-SiCp/Al2014compositesfabricatedbysemi-solid stir casting combined with hot extrusion”, Materials Science&EngineeringA626.338–341 (2015).

[16] Shashi Prakash Dwivedi, Satpal Sharma, Raghvendra Kumar Mishra, “Microstructure and Mechanical Properties of A356/SiC Composites Fabricated by Electromagnetic Stir Casting”, Procedia Materials Science 6.1524 – 1532 (2014).

[17] Jebeen Moses J , I. Dinaharan, S.Joseph Sekhar, “Characterization of silicon carbide particulate reinforced AA6061 aluminum alloy composites produced via stir casting”, Procedia Materials Science 5.106.112(2014).

[18] Tony Thomas A, Parameshwaran R, Muthukrishnan A, Arvind Kumaran .M, “Development of Feeding and Stirring Mechanism for Stir Casting of Aluminum Matrix Composites”, Procedia Materials Science 5.1182 – 1191(2014).

[19] Rupinder Singh, Gagandeep Singh, “Investigations of Al–SiC AMC prepared by vacuum molding assisted stir casting”, Science Direct - Journal of Manufacturing Processes 19.142–147 (2015).

[20] Afshin Matin, Faramarz Fereshteh Saniee, Hamid Reza Abedi, “Microstructure and mechanical properties of Mg/SiC and AZ80/SiC Nano-composites fabricated through stir casting method”, S0921-5093(14)01418-X: http://dx.doi.org/10.1016/j.msea.11.050, (2015).

[21] Sarada B.N, P.L.Srinivasa Murthy, G.Ugrasen, “Hardness and wear characteristics of Hybrid Aluminium Metal Matrix Composites produced by stir casting technique”, Materials Today: Proceedings 2.2878 – 2885 (2015).

[22] SubhranshuChatterjee, ArijitSinha, DebdulalDas, SumitGhosh, AmitavaBasumallick, “Microstructure and mechanicalproperties of Al/Fe- aluminide in-situ composite prepared by reactive stir casting route”, Materials Science&EngineeringA578.6–13 (2013).

[23] Fei Chen, ZongningChen, Feng Mao, TongminWang, ZhiqiangCao, “TiB2 reinforced aluminium based in situ composites fabricated by stir casting”, Materials Science&EngineeringA625.357–368(2015).

[24] QiyaoHu, Haidong Zhao, Jilong Ge,“Microstructure and mechanical properties of (B4C+Al_3Ti)/Al Hybrid composites fabricated by a two-step stir-casting-process”, S09215093(15)305049:http://dx.doi.org/10.1016/j.msea.10.041(2015).

[25] Umanatha K, S.T.Selvamani, K.PalanikumarK and D.Niranjanavarma, “Metal to Metal Worn Surface of AA6061 Hybrid Composites Casted by Stir Casting Method”, Procedia Engineering 97.703 – 712 (2014).

[26] Ezatpour H. R, M. Torabi –Parizi , S.A. Sajjadi (2013), “Microstructure and mechanical properties of Extruded Al/Al2O3 composites fabricated by stir-casting process”, Trans. Nonferrous Met. Soc. China 2.1262−1268(2013).

[27] Ahmed M. El-Sabbagha, Mohamed Solimanb, Mohamed A. Tahaa, Heinz Palkowskib, “Effect of rolling and heat treatment on tensile behavior of wrought Al-SiCp

composites prepared by stir-casting", Science Direct Journal of Materials Processing Technology 213.1669–1681 (2013).

[28] Hamid Reza Ezatpour , Sayed Abolkarim Sajjadi , Mohsen Haddad Sabzevar , Yizhong Huang,"Investigation of microstructure and mechanical properties of Al6061-nanocomposite fabricated by stir casting", Materials and Design 55.921–928 (2014).

[29] Pankaj Charan Jenaa, Dayal R Parhi, G. Pohit, B.P. Samal, "Crack Assessment by FEM of AMMC Beam Produced by Modified Stir Casting Method", Materials Today: Proceedings 2.2267 – 2276 (2015).

[30] Balaji .V, N.Sateesh, M.Manzoor Hussain, "Manufacture of Aluminium Metal Matrix Composite (Al7075-SiC) by Stir Casting Technique", Materials Today: Proceedings 2.3403 – 3408 (2015).

[31] Bharath V, Madev Nagaral, V Auradi and S. A. Kori, " Preparation of 6061Al-Al2O3 MMC's by Stir Casting and Evaluation of Mechanical and Wear Properties", Procedia Materials Science 61658 – 1667 (2014).

[32] Abhishek Kumar, Shyam Lal, Sudhir Kumar, "Fabrication and characterization of A359/Al2O3 metal matrix composite using electromagnetic stir casting method", 2(3):250–254(2013).

[33] Long-Jiang Zhang,FengQiu,Jin-GuoWang, Qi-ChuanJiang, "High strength and good ductility at elevated temperature of Nano-SiCp/Al2014compositesfabricatedbysemi-solid. Stir casting combined with hot extrusion", Materials Science&EngineeringA626.338–341 (2015).

[34] Wang X.J, N.Z. Wang L.Y. Wang X.S. Hua , K. Wua, Y.Q. Wang, Y.D. Huang, "Processing, microstructure and mechanical properties of micro-SiC particles reinforced magnesium matrix composites fabricated by stir casting assisted by ultrasonic treatment processing", Science Direct- Materials and Design 57.638–645 (2014).