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Analysis of Mechanical Properties of Aluminium Based Metal Matrix Composites Reinforced with SIC and Alumina: A Review

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Abstract-In the present work, literature related with suitable fabrication of aluminium as a base matrix and particles as a reinforcement is studied. From literature survey it is find out that Al356 Aluminium alloy has wide scope in all engineering applications and Alumina and Silica as a reinforcements gives excellent modifications in overall mechanical properties when utilized with base metal. An attempt has made for the estimation of suitable Combination of base matrix i.e Al356 and reinforcements particles i.e Al_2O_3 and SiC. The ratio between the base matrix and the reinforcements are such that composite gives upgraded mechanical properties than base metal and this is best find out by charge equation. The best method for the fabrication of AMMC's is also found out.

Keywords-*Al356 Aluminium alloy, Alumina, Silica, mechanical properties, AMMC's, fabrication method.*

I. INTRODUCTION

The development of Al based metal matrix composites is attracting a lot of interest from materials engineers in developing countries. This interest spans from the low cost of aluminium based alloys in comparison with other potential metal matrices and the wide spectrum of properties it offers which includes: high specific strength and stiffness, improved high temperature properties, controlled thermal expansion coefficient, improved wear and abrasion resistance among others.

A composite material can be characterized as a combination of a matrix and a reinforcement, which when joined gives properties better than the properties of the individual parts.

The matrix, normally a form of resin, keeps the reinforcement in the desired orientation. It shields the reinforcements from chemical and nature attack, and it bonds the reinforcement so that connected loads can be viably transferred.[1-5]. Composite materials have unique place in assembling industry in view of their properties, for example, high strength and stiffness, wear resistance, thermal and mechanical fatique and creep resistance. Till date a substantial number of composites have been developed and effectively discovered their utilization for various applications. Metal network composite (MMCs) is a progression underway of composites[6]. Metal matrix composites, at present however producing a wide enthusiasm for research organization, are not as generally being used as their plastic counterpartrs. High strength, fracture toughness and stiffness are offered by metal matrix than those offered by their polymer partners. They can withstand raised temperature in destructive condition than polymer composites. Most metals and composites could be utilized as matrices and they require reinforcement materials which should be steady over a scope of temperature and non-reactive as well. However the managing viewpoint for the decision depends basically on the matrix material. Light metals frame the matrix for temperature application and the reinforcements notwithstanding the previously mentioned reasons are described by high module[7]. Here, in MMC network of metal or combination and some reinforcement material is utilized to create composite. Matrix is the base material in the composite. Among the different matrix materials accessible, aluminum and its compounds are generally utilized as a part of the creation of metal network composites. Different aluminum based composites with different support material have been accounted for by researchers. Reinforcement of aluminum compound by hard and soft reinforcements, for example, SiC, MgO, graphite, Si-rice husk, and numerous more is continue in research industry. Extensive variety of utilizations and requirement of metal matrix composites in industry for various applications put many researchers in finding a cost effective techniques for these composites[8]. There are distinctive strategies for creation of composites, depend on sort of material included and furthermore on kind of composite to be delivered. Casting is regularly utilized technique for production of MMC. Powder metallurgy is other generally utilized technique for creation of MMC. One of the problem in wide utilization of MMC in different applications is its plastic counterparts. But still, MMCs are preferred because of High strength, fracture toughness and stiffness are offered by metal matrixes than those offered by their polymer counterparts[9].Stir casting method is most preffered method for the manufacture of the composite. Stir casting set-up essentially comprises a furnance and a stirring assembly. As a rule, the solidification synthesis of metal network composite includes a melt of the selected base material taken after by the addition of a reinforcement material into the melt, acquiring a suitable dispersion. [10-15]

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II. LITERATURE SURVEY

Martin et al. (1996) takes Al2618 composite as base matrix and add 15% by volume of SiC in it by utilizing Stir Casting technique and examine wear resistance in the temperature between 20 to 200 °C and analyse that by reinforcement of the SiC particulates the wear resistance enhanced by a figure of two in the mild wear area, and the transition temperature was increased by approx. 50 °C. This increase transition temperature was a result of the holding of the mechanical properties of the composite at increased temperature [16].

Wilson and Alpas (1996) takes Al356 alloy as base matrix and add 20% by volume of Al_2O_3, SiC and graphite and examines high-temperature dry sliding wear resistance and notice, Gentle to extreme wear postponement was seen in the composites with the diffusion of Al_2O_3 and SiC. On the other hand Al356 composite hybrid containing SiC and graphite both in a gentle wear regime even at the most elevated temperature of 460°C. The nonappearance of extreme wear in this composite adds to the hindrance of comminution and break by graphite entrained in the surface tribolayer[17].

N. Chawla et al. [2003] Writers examined the Tensile Strength in irregularly reinforced aluminium samples. In their analysis writer changes the normal molecule measure (6-23 micrometer), Heat treatment is likewise given. The results of this paper is that there is inverse relation between the Tensile Strength and Particle Size of reinforcements but heat treatment increases the Tensile Strength.

S. Balasivanandha et al. [2006] In this study the Authors takes high silicon content aluminum alloy and reinforced this with 10% SiC, by varying different stirring speed and time certain samples are prepared. The microstructure of the reinforced composites was inspected by the optical and electron microscopes and then hardness test was performed. The Increment in stirring speed and time brought about better dispersion of particles. The hardness test shows that stirring speed and time have their impact on the hardness of the composite. The uniform hardness were accomplished at 600 rpm with 10 min stirring time. On the other hand after increase in beyond limits, their is decrement in properties observed.

Prabu et al. (2008) takes Al384 alloy and reinforced this with 10% SiC. Authors takes stirring speed and time as input parameters and observes the microstructure of the prepared samples. "Microstructure investigation shows that at low stirring speed i.e. at 500rpm and stirring time clustering was the predominant phenomenon but at increase stirring speed of 700rpm pores was observed in the prepare samples and mechanical properties of the composite decreases. The optimum properties observed at a speed of 600rpm with 10 min. At this speed and time uniform hardness and defect free structure were obtained[18].

Sudarshan and Surappa (2008) takes Al356 composite and reinforced this with 6 and 12 Vol.% fly ash debris particles by Stir Casting process and finds Mechanical properties of the samples and found that due to increase in reinforcements particles in the samples pores increases because of pickup of hydrogen from the air". The incremental in bulk hardness and micro hardness are also observed. The composite with 6% fly ash have higher compressive strength contrasted with 12% Vol. of fly ash strengthened composite. The reinforced Al356 fly ash metal matrix composite showed better properties than unreinforced composite at surrounding temperature [19].

Natarajan et al. (2009) takes Aluminum and reinforced this with 5% and 10% TiB_2 examined Wear at raised temperature and notices the "hardness and wear resistance of TiB_2 strengthened composite was higher than the unreinforced samples at all the experiment temperature and furthermore with the increase in quantity of TiB_2 the load taking capacity of the composite increases". The wear phenamenon of the composites changed from abrasive wear to oxidative wear with the increase of temperature. At higher temperature i.e. over 200^{o}C, extreme adhesive wear occurs, is because of crack propagation[20].

Manoj Singla et al. [2009] In this study Authors trying to create aluminum based silicon carbide particulate MMCs with a target to build up at an ordinary cost and efforts to acquire homogeneity in material. To accomplish these targets stir casting method has been used as fabrication technique and various properties of the samples has been measure. Aluminum (98.41% C.P) and SiC (320-grit) has been picked as matrix and strengthening material. Tests have been directed by varying weight of SiC (5%, 10%, 15%, 20%, 25%, and 30%), while keeping every single other parameter consistent. An expanding pattern of hardness and impact strength with increment of weight rate of SiC has been watched. The best outcomes (most extreme hardness 45.5 BHN and impact strength quality of 36 N-m.) have been gotten at 25% weight part of SiC.

Kumar et al. (2010) takes Al7075 and reinforced this with 15 - 25% SiC and explored Hardness, Rough wear conduct with various molecule sizes utilizing scientific model the examination of fluctuation (ANOVA) with utilizing the procedure of Powder metallurgy and watched "Hardness of the composite expanded with the SiC expansion and micrographs indicated uniform appropriation of the SiC particles". The abrasive clearly shows the expansion in wear resistance as SiC went about as a load supporting component. Composites with bigger particle size and high volume portion showed enhanced abrasive wear resistance when contrasted with different mixes[21].

Reddappa et al. (2011) takes Al-6061 and strengthed this with 2, 6, 10 and 15% beryl composites and then explored Hardness, Wear rate , Erosion coefficient with the changes in connected load utilizing using stir casting and "Increase in friction coefficient was seen because of the solid interlocking of the unpleasant surfaces in contact amid the underlying phases of sliding. Abrasive wear was prevailing in the steady state and the transfer film formed on surface lessened the wear rate". The expansion of load prompted leads to the increment of the wear rate. As the load expanded from lower to higher, the morphology of the well- used surface slowly transformed from the scratches to particular furrows and drop pits [22].

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Lakhvir et al. (2012) takes Al composite with 3, 6 and 9% Al_2O_3 particles examined Impact of input parameters i.e. molecule measure, wt% of strengthening element, stirring time, wt % and utilizing stir casting procedure and concludes "Increase in hardness, tensile strength and impact strength was seen with higher weight rate". All these mechanical properties showed an upward pattern with increment in weight %, stirring time and reduction in molecule size of the particles[23].

Anand Kumar et.al [2012] In this work base metal is taken as Aluminium and then it is reinforced with TiC, SiC, Al_2O_3, TiO_2, TiN etc for enhacement of the mechanical properties of the AMMCs. In-situ strategy for fabrication of the AMMCs is used over the Ex–situ technique. In the present examination, Al-Cu compound (arrangement of 2014 Aluminum composite) was utilized as a framework and strengthened with TiC utilizing As a part of situ process. The Metal matrix Composite (MMC) material, Al-.5%Cu/10%TiC shows higher yield strength, ultimate strength and hardness when contrasted with Al-4.5%Cu compound. Rate increment in yield and ultimate strength were accounted for to be around 15% and 24% separately though Vickers hardness expanded by around 35%. The higher values in hardness demonstrated that the TiC particles added to the increment of hardness ofAMMCs.

Daljeet Singh et al. [2012] In this work the alteration in the properties of aluminum by including a distinctive %age measure of "Sic" and "Al_2O_3" reinforcements are observed. It is concluded that as the weight %age of reinforcements increases the mechanical properties, for example, hardness, yield strength, ultimate strength likewise increments. On the other hand %age elongation decreases and the conduct of material changes from ductile to brittle. The outcomes affirmed that stir formed Al 1050 with SiC/Al_2O_3 reinforced composites is better than base Al 1050 in the correlation of tensile strength, impact strength and additionally Hardness. Scattering of SiC/Al_2O_3 particles in AMMCs enhances the hardness of the lattice material. It is also observed that %age elongation tends to diminish with expanding particles wt. rate, which affirms that silicon carbide and alumina particles increases brittleness. It is found that UTS and Yield strength begins increments with increment in weight rate of SiC and Al_2O_3 in the network. The Hardness increments after addition of SiC, Al_2O_3 particles in the matrix.

H. Izadi et.al [2013] In this paper it is watched that the increment in the micro scale hardness of Al–SiC composites produced by conventional powder metallurgy and sintering techniques observed. The material flow in the mixing zone amid FSP was successful in consistently distribution the SiC particles. In any case, when tests with 16% SiC (by volume) were prepared, there was remaining pores and absence of a union. An expansion in hardness of all specimens was seen after friction stir processing which was credited to the change in molecule appropriation and disposal of porosity.

Altinkok et al. (2013) takes Al alloy and strengthed this with 10% of Al_2O_3/SiC and observed micro hardness and Wear conduct at high temperatures with the utilization of stir casting process and discovered "distribution of hybrid inside the grid expanded the wear resistance". Fine Al_2O_3 particles were very much dispersed in the between particles separating of coarse SiC particles inside the grid which increments the hardness and diminished the wear rate. A fine MMCs coefficient of friction was lower than that of a coarse molecule estimate MMCs at surrounding temperature [24].

Show et al. (2014) takes Al635 and strengthening this with 4% (Al2O3+SiC) both together as reinforced particles and examined Wear behaviour at various loads utilizing stir casting technique and concludes "At lower load, the wear phenemenon includes adhesion and micro cutting abrasion". At higher loads abrasion wear including micro cutting and micro-ploughing with the oxide formation which was the primary cause of wear damage. Hybrid composite with (2 Vol% Al_2O_3+2 Vol% SiC) showed the best wear resistance because of massive clusters which opposed the abrasive activity [25].

Kumar and Sharma(2016) takes Al356 alloy as a base metal and reinforced this with different percentage of aluminium oxide i.e 5%, 10%, 15% and 20% by stir casting process and finds that addition of alumina particles in Al 356 alloy results in composite that have hardness greater than Al 356 alloy. Hardness of MMC increases with increase in percentage of alumina reinforcement.With increasing percentage of alumina amount of energy absorbed by MMC material increase. This increase has large value at 5-10 % alumina reinforcement. Study of tensile strength behaviour confirms that alumina reinforcement increases strength of Al 356 alloy. This increase in strength continues with increase in percentage of alumina in MMC. Microstructure study confirms formation of alumina particulate in Al 356 / Al2O3 MMC. This show feasibility of production technique[26].

III. IDENTIFICATION OF THE PROBLEM

From study of various works by different researchers it is observed still there is gap in the optimum fabrication & Characterization of metal matrix composites. Further research is needed to achieve objectives like:

- Suitable fabrication of various AMMC's.
- Improvement in mechanical properties like Tensile strength, Impact strength, Compressive strength, Shear strength & Hardness measurements of the prepared AMMCs.

In order to bridge this gap , it is decided to fabricate the aluminium based MMC's via stir casting method and then analyze their mechanical properties. Al356 is selected for present study. Work is planned for fabrication of Al356/Al2O3 and Al356/Sic composite with 10% reinforcement.

IV. OBECTIVES OF RESEARCH WORK

The objectives of research work are:

- To prepare the cost-effective AMMC material by taking Al356 with matrix ceramic particulate silicon carbide and alumina (aluminium oxide) as reinforced phase using stir casting technique.

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- To analyze the micro structural characteristics of the as cast AMMCs.
- Tensile strength, Impact strength, Compressive strength, Shear strength & Hardness measurements of the as prepared AMMCs.

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