Manufacturing of Aluminium Metal Matrix Composite By Stir Casting Technique.

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Abstract

Advancement of Aluminum Metal Network Composites (AMMCs) with enhanced tribological property has been one of the significant necessities in the field of material science and innovation. These days, Aluminum 7075 amalgam with Silicon Carbide (SiC) as fortification is supplanting the current segments that are made with Aluminum oxide support because of their higher wear opposition and creep obstruction applications. As we realize that in assembling segments gears assumes a fundamental job in transmitting power starting with one shaft then onto the next shaft, in this manner the present work focussed on the assembling of rigging with AMMC material utilizing mix throwing process. The different tests have been directed on AMMC material to know the different properties (Elasticity and hardness) and it was seen that there is an expansion in quality and hardness by 10 percent contrasted with Al6061. From Smaller scale structure examination directed on the material uncovers that uniform appropriation of SiC particles in the metal framework. The execution test was directed on the fabricated rigging to investigate wear opposition of the grid material. Blend throwing strategy utilized in the network arrangement is best conservative technique to create the grid. Al 7075-SiC network has been chosen for the make since it has potential applications in airplane and space businesses due to higher quality to weight proportion, highwear obstruction and creep opposition.

Keywords - *7075Al alloy; SiCp; Composite; Fabrication; AMMCs; Stir Casting; Micro analysis*

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1. Introduction –

Aluminium matrix composites have drawn immense interest for various applications in making aerospace and automobile components due to their light weight, high strength to weight ratio, high stiffness, lower cost and high dimensional stability. Particulate–reinforced Aluminum matrix composites (AMCs) are of particular interest due to their ease of fabrication, lower cost and isotropic properties.

Compared to other routes, Conventional stir casting is well established process for producing MMCs that are reinforced with micron size ceramic particles. Melt stirring process has some important advantages e.g., the wide selection of materials, better matrix–particle bonding, easier control of matrix structure, simple and inexpensive processing, flexibility, applicability to large quantity production and excellent productivity for near-net shaped components. However, there are some hurdles associated with stir casting of AMCs. Hashim et. al. has identified four technical difficulties in stir casting: difficulty of achieving a uniform distribution of the reinforcement material; wett ability between the two constituents, porosity in the cast structure and chemical reactions between the reinforcement material and the matrix alloy. Some recent studies have revealed that ultrasonic vibration is efficient in dispersing submicron and nano particles in the melt. In order to achieve a uniform dispersion and distribution of nano particles in aluminum matrix nano composites, G.I. Eskin et al., have used an innovative technique that combined solidification processes with ultrasonic cavitation based dispersion of particles in metal melts.

Several investigators have also found that the elastic modulus of Al-alloy increases by the dispersion of alumina and zircon particles in the alloy. Extensive studies have been made on evaluating the strength of discontinuously reinforced Al- alloys.It has been reported that SiC whisker and particle reinforcements in different alloy matrices improve the yield and ultimate tensile strength of the alloy up to 60 %, over the base alloy depending on the volume fraction of reinforcement, the type of matrix alloy and processing conditions

.Nrip Jit, et. al. have fabricated composites (A384.1)1-x [(SiC)p]x containing 0, 0.1, 0.15 and 0.2 percent SiC with particle size 0.220 μm by modified stir casting technique. The addition of SiC in A.384.1 Al Alloy was found to increase proof stress and ultimate tensile strength with respect to unreinforced Al Alloy. The compressive properties of the Al alloy and MMC 'revealed that the values of 0.2% proof stress and compressive strength increases with composition from x= 0 to x= 0.15 and decrease for x > 0.15. While moving from as cast to extruded condition, an increase in compressive strength and 0.2% proof stress was observed.

Ductility is one of the important aspects in the mechanical behaviour of composites. The tensile elongation decreases rapidly with the addition of reinforcing particles. To maximize ductility for a particular volume fraction, the composite should have(i) uniform particle distribution, (ii) finer particles (<10 μm), uniform particle size distribution, (iii) a high interfacial strength (iv)control of particle shape, (v) a ductile matrix and (vi) use of different free particles. Additionally, composite fabrication and processing will influence the degree of flexibility available to meet most of these above requirements.

The particulate reinforcements such as SiC, Al2O3 and aluminide are generally preferred to impart higher hardness. Umanath k. have fabricated Al 6061alloy based hybrid composites reinforced with mixtures of SiC and Al2O3 particles with 25 vol.% by stir casting method. Results revealed that micro hardness (HV) of the composite specimens increase with increasing volume percentage of particulate reinforcement. This may be attributed to the solid solution hardening of the matrix by the addition of reinforcements to the alloy.

The most important aspect of the microstructure of Al alloy and Al alloy composites is the distribution of the reinforcing particles in the matrix and the interface between the matrix and ceramic phase. These micro structural characteristics depend on the processing and fabrication routes. The interface between the matrix and reinforcement plays a crucial role in determining the
properties of metal matrix composites (MMCs).

2. Method of Stir Casting –

Stir casting is a liquid state process of composite materials fabrication, in which the reinforcement particles mixed with a molten metal matrix by means of mechanical stirring. Then the liquid composite material is cast by conventional casting methods and conventional metal forming technques. In last five decades the aluminium alloy based metal matrix composites are fabricated through stir casting method by reinforcing ceramic hard particles. Ali et al produced nano composites of A356/ (0 to 4.5 vol. %) SiCp/ 1 wt% Mg through stir casting route. The aluminium matrix alloy was melted to 750˚C and stirred at a speed 600rpm for 15 min by graphite impeller. From the SEM image shown in (Fig. 1), it is observed that the reinforcement particles were distributed uniformly in the A356 alloy matrix.

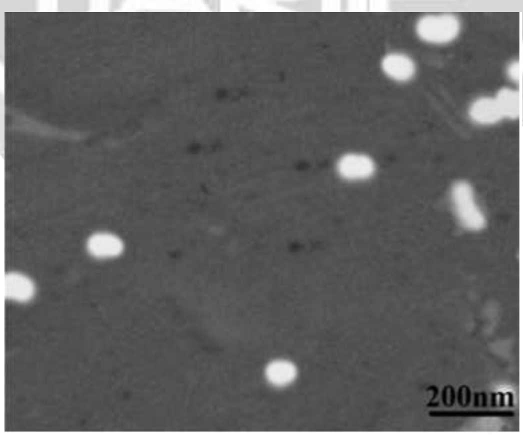

Fig. 1 SEM micrograph of 2.5 vol. % SiCp

3. Mechanical Properties Material –

The mechanical properties of composite materials mainly depend on type of reinforcement, shape, quantity of reinforcement and size etc. The researchers investigated mechanical properties of Aluminium based composite materials by reinforcing nano SiCp particles.

3.1. Tensile strength, ultimate strength and elongation

Omyma et al. evaluated the compressive strength of the composites of pure aluminium reinforced with SiCp particles of different sizes 70 nm, 10 μm, and 40 μm. The stress strain curves are shown in (Fig. 10) for compression tests of the pure aluminium alloy reinforced with 5wt. % and 10 wt. % of SiCp particles with different sizes. The 10 wt. % SiCp reinforced in aluminium composites shown better compressive strength compared to 5wt. % SiCp and pure aluminium samples. The aluminium metal matrix containing 70 nm SiCp particles have exceptional properties the samples of different sizes containing 10 wt. % SiCp has maximum compressive strength and among them 70 nm of size SiCp particles has maximum compressive strength of 601MPa. Jiang et al. studied the yield strength, ultimate strength and elongation of the rheoformed cylinder of material Al7075 alloy and Al7075/SiCp nano composites with and without T6 treatment. They were noted that the yield strength, ultimate tensile strength and elongation is better for Al7075/SiCp nano composite with T6 treatment as shown in Table.1. Without T6 treatment the nano composites were increased by 4.3% of yield strength and 6.25% of ultimate strength compared to base alloy but the elongation has decreased to 12.8 %. The T6 treated rheoformed components were increased by 11.4% of yield strength and 4% ultimate strength compared to the base alloy and the elongation decreased to 12.4%. The results of yield strength and ultimate strength of rheoformed and without T6 treated cylinder components reached closer to as extruded 7075 alloy

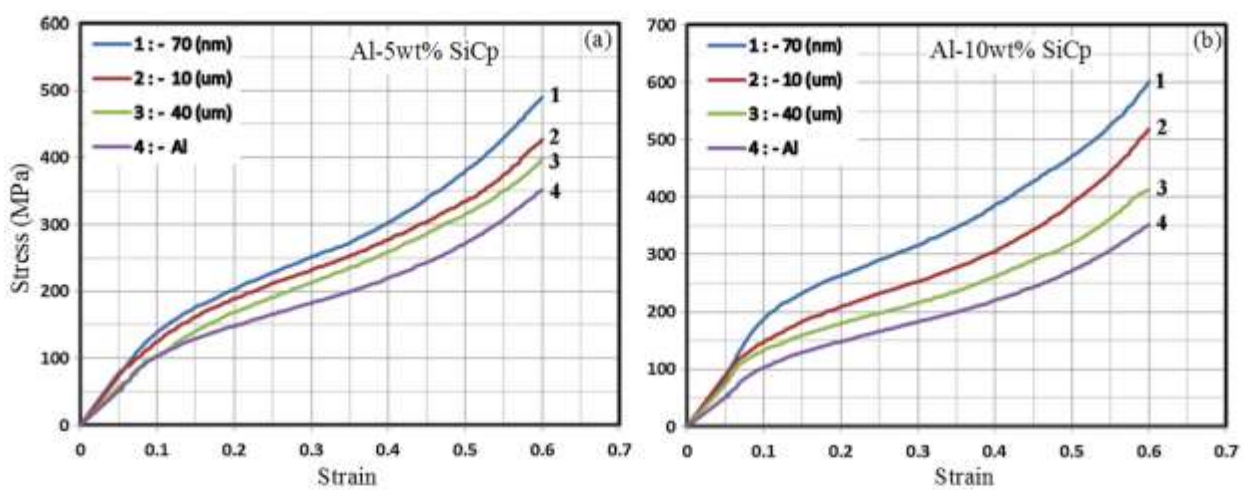

Fig. 2 The effect of SiCp size on the stress- strain behaviour of composites (a) Al-5wt% SiCp (b) Al-10wt%SiCp.

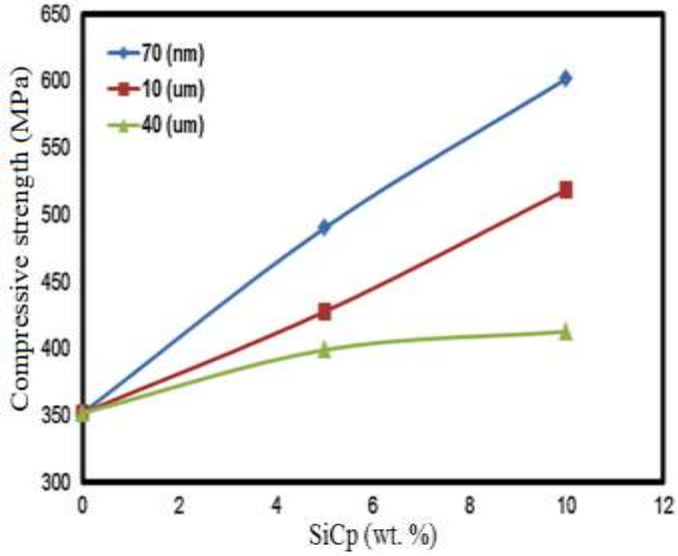

Fig. 3 The variation of the compressive strength of the composites as a function of SiCp wt. % and size

Sr. No.	Type of property	Al7075 alloy		Al7075/ nano SiCp	
		Without T6 Treatment	With T6 Treatment	Without T6 Treatment	With T6 Treatment
1	Yield strength (MPa)	253	342	264	381
2	Ultimate tensile strength (MPa)	336	460	357	478
3	Elongation (%)	8.6	9.7	7.5	8.5

Knowles et al.reported yield strength and ultimate strength with extruded and heat treated AA6061/SiCp nano composites with the addition of 10 and 15 wt% nano reinforcements. The strengths and elongation were increased in heat treated samples compared to extruded samples of same wt% of reinforcements. With 10 wt% of nano SiCp addition to the base alloy, the yield strength and ultimate strength increased from 131 to 192 MPa and 205 to 287 MPa respectively and elongation decreased from 16.5 to 15%. In heat treated samples the yield strength and ultimate strength increased from 226 to 281MPa and 342 to 424MPa respectively and elongation decreased from 20.5 to 17%. With 15 wt% of nano SiCp addition to the yield and ultimate strengths were increased from 131 to 229 MPa and 205 to 329 MPa respectively and elongation decreased from 16.5 to 14%, in heat treated samples the yield and ultimate tensile strengths were increased from 226 to 307 MPa and 342 to 449 MPa and the elongation decreased from 20.5 to 15.5%. Carreno et al. analyzed the yield strength and ultimate strength of AA2024/ SiCp nano composites and compared with annealed and T6 heat treated alloy samples from the literature. It is observed that there is a clear influence of the nano particle content on the yield strength behaviour up to 2.5 wt. %, the yield strength increased up to saturation value of 450 MPa and decreased with further increase in nano particles content. Due to difference of the thermal co-efficient of expansion in between matrix and the homogeneously dispersed nano SiCp particles, the high dislocation density is induced and particles work as the barriers for dislocation movement. The ultimate strength increased up to 684 MPa with increase of wt. % of the nano SiCp reinforcements. Ali et al. conducted experiments for yield strength, ultimate tensile strength and elongation on nano A356/ SiCp composites of varying wt % of SiCp nano reinforcement particles. Due to the difference of coefficient of thermal expansion between the matrix and ceramic particles, thermal residual stresses are generated and increased dislocations density upon rapid solidification process during manufacturing of composites. The non-shearable nano particles increase the strength level due to the interaction of dislocations with increase of particulate volume fraction. The tensile strength with volume fraction of 0.5, 1.5, 2.5, 3.5 and 4.5% of SiCp is 127 MPa, 134 MPa, 142 MPa, 145 MPa and 137 MPa respectively. The ultimate tensile strength with volume fraction of 0.5, 1.5, 2.5, 3.5 and 4.5% of SiCp is 220 MPa, 238 MPa, 257 MPa, 283 MPa and 240 MPa respectively. Both tensile and ultimate strengths are increased initially up to 3.5% and then decreased at 4.5%

4. Conclusion-

This paper presents the fabricating techniques and mechanical properties of Al-MMNCs reinforcing nano SiCp particles. The nano SiCp reinforced Al-MMNCs despite showing good mechanical properties over the unreinforced alloys. Microstructural evaluation showed the uniform distribution of nano SiCp in the metal matrix, as well as strong bonding between the particle and matrix at the interface. The porosity levels obtained in these composites are within acceptable limits. The most common technique used in the production of Al-MMNCs is powder metallurgy. The spark plasma sintering and ultrasonic assisted casting can be used for high sensitivity parts and which are more expensive processes.

5. References –

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