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Microstructure And Mechanical Properties Of Synthesized Aluminium Composite Using Stir Casting Process

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Abstract :Aluminium is one of the most common metals in the world and its use is increasing day by day in many industries mostly in space industry and automobile industry because of its light weight and high strength capabilities. Aluminium-based alloys have great potential for cost saving application due to their light weight combine with high specific strength and corrosion resistance, as well as good castability. This paper mainly emphasis with the fabrication of Aluminium composites with SiC particles and jute ash particles. Hardness and tensile properties of the prepared Aluminium composite were determined before and after addition of SiC and Jute Ash particulates to find the extent in improvement of properties. SEM images have shown the grain boundaries formation. Results shows that the tensile strength is maximum in case of composite with SiC with value of 123MPA when compared to unreinforced 6061Al matrix with strength of 64MPa.

Keywords:Metal matrix composite (MMC), Aluminiumalloy, Silicon carbide (SiC) and Jute ash.

1. INTRODUCTION

Aluminium in these days a most essential metal to be utilized in each industry and its utilization is expanding step by step because of its less weight. Aluminium composites are utilized in vehicle industry primarily in making Pistons, Engine Cylinders and Drum Brakes. These days aluminium is likewise broadly utilized in Aerospace industry because of its light weight and high wear safe properties. Aluminium is also been used in making the mobiles bodies so to reduce its total overweight.

There have been consistent endeavours to grow new assembling forms utilizing aluminium based compound materials, for example, car motor parts, wear opposition segments, and furthermore heavy applications. There are many procedures to create aluminium alloy, for example, gravity die casting, squeeze casting, hot forging, powder forging, stir casting processes. Among them, utilization of the stir casting process is sufficiently predominant to possess more than 90% of composites fabricating in the modern industry.

2.

This paper deals with the selection of better material for the process of more hardness and temperature resistance, in that aluminium hybrid composite are produced by Al6061 as matrix material with silicon carbide and jute ash as reinforcement in different composition. Different sample are produced by using stir casting methods. Tensile and microhardness test is conducted to evaluate the properties of aluminium composites which are compared with as-casted aluminium alloy.

2. LITERATURE REVIEW

Pazhouhanfar and Eghbali [1], Al6061 alloy was used as matrix material with chemical composition and TiB2 ceramic particles were used as reinforcement. Kumar and Birru [2], in this work Copper (4.5%)-Aluminium alloy matrix which was reinforced by bamboo(which was extruded from agro waste) leaf ash (BLA) at composition of 2%, 4% and 6%. The fortifying consequences for the bamboo strands containing different networks, for example, polystyrene, polyester and epoxy pitches have been widely contemplated. The light weight, economic value, high Strength and non-dangerous nature of bamboo fibres are among most engaging properties of this material which makes specialists to work toward composite research work. In present era an environmental danger has constrained numerous nations to pass laws focusing 95% recyclable materials in vehicles. The current period is the ideal opportunity for utilizing characteristic fibres, particularly bamboo fiber based composites in day by day lives. [1] The composite which was fabricated by stir casting method possessed superior properties due to an effective bonding between matrix and reinforcement particles. Kandpal et al. [3], he conducted various levels of weight % of Al2O3 particles reinforced into the matrix of

aluminium alloy 6061. Kaushik and Rao [4], the two body abrasive wear behaviour of stir cast Al6082–SiC–Gr hybrid composites was studied and compared with Al 6082–SiC composites and Al6082 alloy. Poovazhagan et al. [5], Nano particulates reinforced ceramic metal Nano composite materials have demonstrated gigantic potential in various fields of building because of their high strength to weight ratio, thermal stability and wear resistance. In the present examination, Nano particulate composites were manufactured utilizing the ultrasonic casting process fabricating Al6061 aluminium alloy strengthened with Nano silicon carbide (normal size 50nm) at weight levelsof 0, 0.5 and 1. Das et al. [6], The significant point of this present paper is to create MMC via activated charcoal powder (micron size) as a reinforcement into the metal matrix of titanium carbide to produce intermetallic of TiC in Al-Cu alloy matrix. Amouri et al. [7], In this research, using stir casting process the composites of A356-nano SiC (0.5 and 1.5wt%) and A356-5wt% of micro SiC

.Moses et al. [8], In this study Stir casting was used to produce Al6061/15%TiC (mass fraction) Aluminium matrix composites (AMCs). Ravi et al. [9], In this Study Aluminium Matrix Composites (AMCs) are the competent material in the industrial world. An effort has been made using stir casting method to fabricate Boron Carbide (B4C) of average particle size 25 µm with different weight percentages as a reinforcement into the Aluminium Matrix (Al6061). Koli et al. [10], In this paper, using ultrasonic assisted stir casting with nano Al2O3 particles with average size 40 nm and various weight percentages of 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0reinforced into Al alloy of Al6061and evaluating various mechanical properties has been investigated. Anshul et al. [11], This paper presents with the consequences of Friction Stir Processing on different alloys like Mg-4Y3Nd(WE43), Mg-$ZrSiO_4$-N_2O_3, Al-Si hypoeutectic A356 alloy, 5210 steel (WC-12% CO coated). Ravi et al. [12], In this paper these different effects and properties are concluded for reinforcing materials such as Silicon Carbide, Graphite, Fly ash, Rice husk ash and boron halide. It has been reported that there is an improvement in the properties of hybrid composites so formed on addition of these reinforcing materials to aluminium composites. Ravi et al. [13], In this paper, we are trying to develop Hybrid matrix composite (HMMC) reinforced with natural fibres which include Rice Husk Ash (RHA), Ground Nut Ash (GSA), and other reinforcement like SiC, Graphite. The results obtained from this study will help us to decide that in what proportion of the various reinforcement should be mixed. Vaibhav et al. [14], The main moto of this paper review is to determine the optimum machining parameters in CNC turning of HMMC using different algorithms and techniques. Namrata et al. [15],

This paper tells the current status of in-situ AMMCs fabrication through FSP technique. The main aim of this Paper is to review and summarize various systems of in-situ AMMCs fabrication such as Al- Transition metals (TM), Al-Metal oxides (MO), and Al-Salt reaction systems, at various operating conditions and FSP parameters and their effects on resultant microstructure and final properties.

From the above literature review, it is observed that in Synthesis of Casted composites, stirred rotational speed (rpm), temperature range have both good and bad effects. It is also observed that mostly the reinforcement taken are metallic powders and much research is done on SiC. Machine parameters considered during Stir Casting are Stirred rotational speed (rpm), temperature range, stirring time, preheating temperature out of these, Stirrer speedand temperature range have major effect during Stir Casting.

3. EXPERIMENTAL PROCEDURE

The machine setup of stir casting essentially contains an electric furnace and a mechanical operating stirrer. The electric furnace is of maximum capacity 3kg. The maximum working temperature of the furnace is 1000ºC. The rating of current passing of furnace is single phase is 230V AC, 50Hz. The aluminium alloy (Al6061) is made in the form of small constituents from the bigger rod using shaping machine which weighs about 2.25 kg. The small aluminium constituents are poured into the furnace and heated to a temperature just slight above its liquidus temperature to convert it into the form of semi liquid state (around 650ºC). The mixing of aluminium alloy is done manually for uniformity. Then the reinforcement powder which was heated earlier to a temperature of 500°C is added to semi liquid aluminium alloy in the furnace. Again reheating of the aluminum matrix composite is done until it reaches complete liquid state. Meanwhile argon gas is introduced into the furnace through a provision in it for few minutes. During this reheating process stirring is continuously done through a mechanical stirrer which rotates at a speed ofapprox 150 rpm. The aluminium composite material melts completely to liquid state at the temperature of about 800°C as the melting point of aluminium is about 700ºC. Thus the completely molten aluminium metal matrix composite is poured into the prepared permanent mouldsand subjected to compaction to produce the required specimen. The stir Casting machine setup is shown in Fig. 1.

Fig. 1: Stir Casting Setup

A. Silicon Carbide (SiC)

SiC which is also called as carborundum , is a compound of silicon and carbon with chemical formula ofname SiCas

shown in Fig.2. It happens in nature as the most rare mineral. SiC powder has been mass-produced since 1893 and can be used as an abrasive. Grains of silicon carbide are bonded together by method of sintering to become very hard ceramics materials whichare mostly used in applications which requires high endurance, such as car brakes, car clutches and ceramic plates in bulletproof vests. SiC with high surface area can be produced from SiO_2 contained in plant material.

Fig. 2: SiC Powder

B. Jute Ash

Among various natural fibers, jute is widely used natural fiber because of its advantages like easy availability, low density, less production cost and good mechanical properties. For a composite material, its mechanical behaviour depends on many factors such as fiber content, orientation, types, length etc.

Jute ash is prepared with the exterior part of the coconut cover known as jute. The jute was first made dried in the sun rays for 7 days. Dried part is burnt using Camphor balls and jute ash is prepared as shown in Fig.3. The jute ash is then made fine in ball milling.

Fig. 3: Dried jute burning

C. Process Parameters

Based on the literature review and number of trials performed, following parameters were considered during Stir Casting to obtain the matrix without any formation of defects.

- Constant Rotational Speed of 200 rpm
- Temperature of range 650^oC to 750^oC
- Preheating of SiC for1-2 hours

For each composite, reinforcement particles were preheated to a temperature of 500^oC and then dispersed into the vortex of molten Al6061 alloy to improve wettability and distribution.

TABLE I: SAMPLE COMPOSITIONS

Sample	Al Alloy 6061(%)	Silicon Carbide(%)	Jute ash(%)
1	100	0	0
2	96.6	3.4	0
3	99.1	0	0.9
4	95.7	3.4	0.9

Table 1. shows the percentage composition that is taken for sample preparation. All the samples are shown in Fig.4.

Fig. 4: All samples

4. RESULTS

A. Tensile Test (UTM)

The dimensions of the specimens for the tensile test are which is carved through the Wire EDM process. Large dogbone-shaped tensile specimens with a gauge length of 33 mm, a gauge width of 6 mm and a gauge thickness of 6 mm were machined. All the tensile specimens are shown in Fig.5.

Fig. 5: All tensile specimen

It can be clearly seen from Fig.6. that tensile strength of Sample 2 which contains SiC particles (3.4%) by weight has the maximum value of 123Mpa and there isalso increase in Tensile strength for Sample 3 which contains Jute ash having value of 122MPa and there is reduction in tensile strength for sample 4 containing SiC and jute ash having value of 113Mpa but there is overall increase in strength in Sample 2, sample 3, sample 4 as compared to the Parent metal which sis sample1 having value of 63.9Mpa.

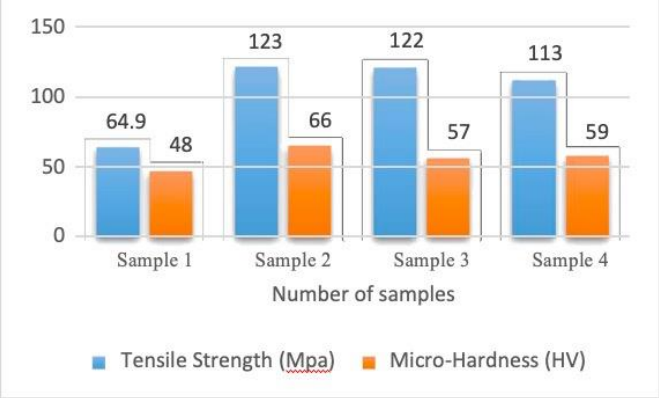

Fig. 6: Comparison of Tensile Strength (MPa) and Micro-Hardness(HV)

B. Micro-Hardness(HV)

The microhardness of the pure Al sample was measured along the middle-thickness of the processed casted zone with a 10-gram load for 10 seconds. Microhardness test result (shown in Fig.6.) gives us trend which depicts that microhardness of the composites increases because of the presence of the SiC particles and Jute ash particles. Highest microhardness is attained for sample 2 which contains SiC particles (3.4%) by weight.

C. Microstructure Characterization

Stir Casting Process resulted in successful fabrication of Al6061 metal matrix composite. Microstructural images of the stirred zone (SZ) of all four Al6061 alloy types which was examined by SEM.Grain boundaries can be clearly seen from the SEM images as depicted in the Fig.7. and Fig.8. Also jute ash particles and SiC particles can be seen in Fig.9. and Fig.10. which indicates the homogenous mixture of reinforcement in parent metal.

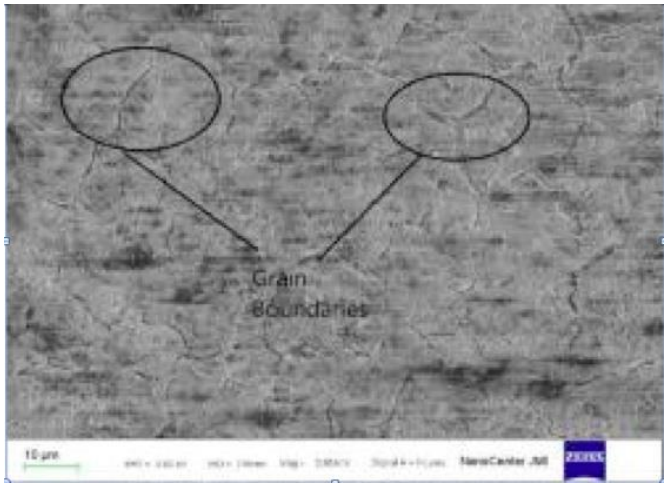

Fig. 7: SEM image at 10µm for sample 2

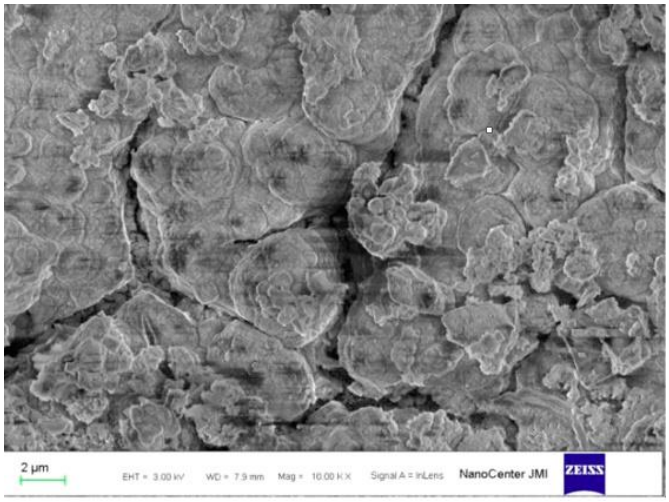

Fig. 8: SEM image at 2µm for sample 2

Fig. 9: SEM image at 10µm for sample 4

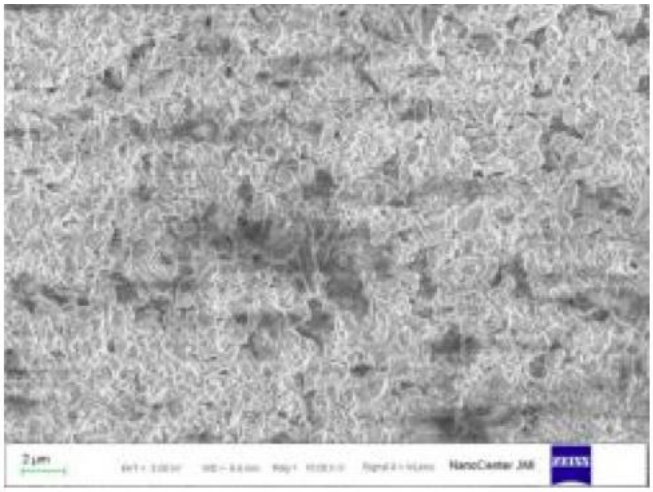

Fig. 10: SEM image at 2µm for sample 4

5. CONCLUSIONS

Aluminium 6061 (99% pure) with Silicon Carbide and Jute Ash Particle composite (approx. 50microns) was successfully synthesized using the Stir Casting process with minimum defects. Effect of reinforcement particle on the microstructure and microhardness properties of the surface composite produced was investigated by performing various tests on the sample.

- Casted Aluminium exhibited increased tensile strength upto 123MPa with SiC particle and increased tensile strength upto 122MPa with Jute Ash Particles whereas tensile strength increased to 113 MPa when fabricated with both SiC and Jute ash particles compared to 64.9 MPa for the parent metal.
- Grain boundaries can be clearly seen from the SEM images as depicted in the Fig.7. and Fig.8. Also jute ash particles and SiC particles can be seen in Fig.9. and Fig.10. which indicates the homogenous mixture of Reinforcement in Parent metal.
- Both Microhardness and Tensile strength increasing with the addition of Reinforcement in the parent metal.

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