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Investigation on Mechanical and Tribological Properties of 6061 Aluminium –SiC Alloy Fabricated by Stir Casting Method and Equal Channel Angular Extrusion: The Review

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Abstract - *With improvements in industrialization over the past few years, the utilization of composites has also drastically increased. Need for low cost, high performance and good quality materials have caused a shift in research from monolithic to composite materials, out of which Metal Matrix composites are advanced and latest materials that find application in diverse sectors. In the case of MMC's, aluminum matrix composite due to their high strength to weight ratio, low cost and high wear resistance they are widely manufactured and used in structural applications along with aerospace and automobile industry. Also, a simple and cost-efficient method for manufacturing of the composites is essential for expanding their application. In this study, the Aluminium 6061 is reinforced with SiC through the liquid metallurgical process and the properties are studied, followed by passing the specimen through Equal channel angular extrusion die. Comparisons are carried out for valid and reliable conclusions.*

Key Words: AMC, Reinforcement, Matrix, Stir casting, ECAP.

1.INTRODUCTION

With the development of science and technology, there is more demand for advanced engineering materials which is overlooked by the introduction of composite materials, as the use of conventional materials is limited due non-achievability of strength, stiffness, and density up to the desired value. Composite materials consist of two or more different materials that form regions large enough to be regarded as continua and which are usually firmly bonded together at the interface. Many natural and artificial materials are of this nature, such as reinforced rubber, filled polymers, mortar and concrete, alloys, porous and cracked media, aligned and chopped fiber composites, polycrystalline aggregates (metals), etc [1]. There are various definitions of composites which tend towards single intention. Jartiz, defined composites as multifunctional material systems that provide characteristics not obtainable from any discrete material[2]. Whereas Van Suchetclan explained composite materials as heterogeneous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale[3].

A composite[4] is also defined as a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fibers, particles, or flakes. The matrix phase materials are generally continuous. Various types of reinforcements include SiC, Al_2O_3, B_4C, TiC, TiB_2, graphite and various other ceramics. The types of composites include Polymer matrix composite, Metal matrix composite, and Ceramic matrix composite. Thus, the composite materials offer several advantages[5] discussed below:

- Composite materials have high specific stiffness.
- They provide capabilities for part integration.
- The specific strength of these materials is very high hence making lighter in comparison to other metal alloys. Due to this reason, it founds its application widely on aeroplanes and automobiles.
- The composite material provides high corrosion resistance.

2. SELECTION CRITERION FOR ALUMINIUM AS MATRIX AND SIC AS REINFORCEMENT

This study includes selection of Aluminium 6061 as the matrix and SiC as the reinforcement material hence forming metal matrix composite. Aluminium is very light material with specific weight of 2.71gm/cm^2 which allows its usage in wide applications such as automotive by reducing the dead weight and energy consumption while increasing load capacity. Even its strength can be improved by modifying the composition of its alloys. Its highly corrosion resistant property generates a protective

oxide coating on its surface. Aluminium is also an excellent heat and electricity conductor[6].The families of aluminium alloys are represented by 1XXX, 2XXX, 3XXX upto 8XXX. The first digit signifies the basic information about the principal alloying elements. The designation system gives information regarding the hardening of alloys belonging to a family. The 1XXX, 3XXX, 5XXX series are non heat treatable alloys; their strength is improved by alloying, whereas the 2XXX, 6XXX, 7XXX are heat treatable alloys which gain their strength by alloying but making use of precipitation hardening as a mechanism. Among several series of the aluminium alloys Al6061 and Al7075 are much explored. Al6061 is a highly corrosion resistant and exhibits moderate strength, thus its finds vast applications in the field of automotive, marine and aerospace[5].

SiC can be used as reinforcement in the form of particulates, whiskers or fibres to improve the properties of the composite. When embedded in metal matrix composites SiC certainly improves the overall strength of the composite along with the corrosion and wear resistance. Aluminium MNCs reinforced with SiC have about 20% improvement in yield strength, lower coefficient of thermal expansion, higher modulus of elasticity. Thus Silicon carbide finds its usefulness in variety of applications such as cutting tool, automobile parts, brake discs, bicycle frame[5].

3. STIR CASTING

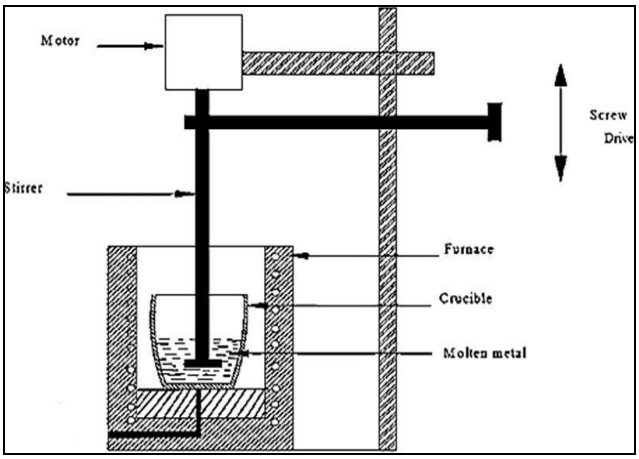

Fig-1: Stir casting experimental setup

The AMCs can be fabricated by various methods such as Stir casting, squeeze casting, spray deposition, liquid infiltration, powder metallurgy. From thr listed process the liquid method of processing is preferred much due to its simplicity and applicability to mass production. Stir casting is the widely used liquid method of processing to fabricate the AMCs[7]. Various researches were made for the stir casting process by varying parameters such as speed of rotation, percentage of reinforcements. Muhammad Hayat J et al. conducted the stir casting by making use of Al7000 as the matrix and Al2O3 as the reinforcements which was varied in terms of weight percentage. Swamy et al. prepared the aluminium 6061-graphite and Tungsten carbide composite by vortex method. The reinforcements were preheated followed by their addition into the molten aluminium maintained at around 500 degree celsisus and stirring was carried at speed of 500rpm. Aluminium-SiC-Graphite mixture was created by in-situ powder metallurgy where the weighed aluminium ingot were charged inclay bonded graphite crucible and variation was implemented in grain size of the reinforcements by S Mahdvi et al., Sharanya Nair et al. developed Al6061/SiC composite for 10% of SiC of 320 mesh size and studied on the distribution of the reinforced particles. K. Velavan et al. describes about the experimental setup used for stir casting with furnace capacity of 2.5kg wherein the aluminium in forms of scrap were and charged at 600 °C and were mixed manually to maintain uniformity followed by adding of preheated reinforcement and stirred at 150rpm. The observations concluded that process parameters such as Stirring rate, stirring temperature, reinforcement preheating, stirring time, preheating of mould is very important and must be taken care of during the conduction of the experiment.

4. ECAP

Equal channel angular pressing[12] is a processing method in which a metal is subjected to intense plastic straining through simple shear without any corresponding change in the cross sectional dimensions of the sample. This process is used to introduce ultrafine grain size into polycrystalline materials. Furukawa et al. described the working principle of the ECAP process.There are numerous well established methods for subjecting th metallic samples to an imposed strain, but ECAP is preferred as the cross section of the sample remains unchanged during straining.

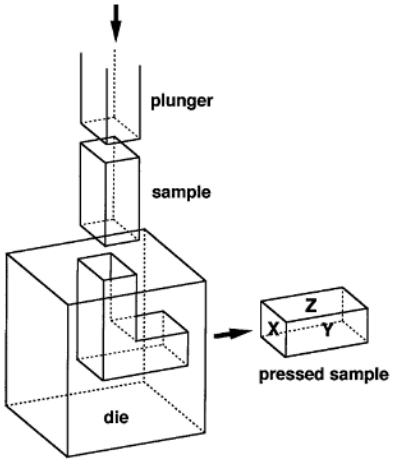

Fig-2: Equal channel angular pressing

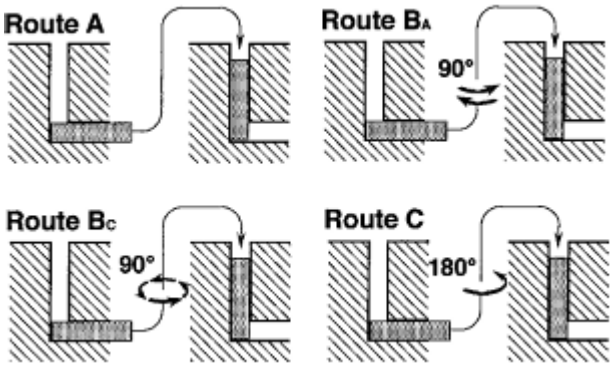

Fig-3: Different routes for pressing.

Fig 2 depicts the principle of ECAP process. The ECAP die contains two channels, equal in cross section, intersecting at an angle neat the centre of die. The test sample was machined to fit within these channels and pressed through die using plunger. In ECAP process there are four fundamental routes between each repetitive pressing[13]. These are route A- that the sample is repetitively pressed without any rotation, Route B_A- that the sample is rotated by 90 degree in alternative direction between each pass, Route B_C- that the sample is rotated in same sense by 90 degree and route C- that the sample is rotated by 180 degree between each pass. These routes create different slip systems during the press operation so that various microstructure and mechanical properties can be achieved.

Ramu et al. fabricated Al-SiC composite by stir casting with commercially pure aluminium as matrix and 5%,10% of SiC as reinforcements. The composites were made to undergo severe plastic deformation and after studying it was found that there was no change in particle distribution but it had led to refinement in the grain size of matrix material i.e. Al-5% SiC composite grain size had reduced from 8mico metre to 45 micro metre alon with the improvement in the mechanical properties. Horita et al. attempted to conduct ECAP on six different commercial Aluminium alloys i.e. 1100, 2024, 3004, 5083, 6061 and 7075 with a initial grain size of 30, 40, 15, 30, 50 and 30 micrometer respectively. The pressing was carried out in room temperature by using a solid die having channel angle of 90 degree. The applied load was measured through means of the load cell and the pressing was carried till 8 pass until the specimens had started to fail[15]. The grain refinement was noted under transmission electron microscopy along with the mechanical testings. Paydar et al. conducted the ECAP-forward extrusion for pure aluminium produced by powder metallurgy and pure ingot.annealing of the ingot sample was done around 200 °C and FE sample was produced with extrusion ratio of 10 at 200 °C and the composites were pressed through the designed die and tested for the changes occured.

5. CONCLUSIONS

- The properties of monolithic materials are enhanced after the addition of reinforcements.
- Addition of reinforcement SiC to alumina leads to improvement in hardness and wear resistance, thus increasing its applicability.
- Stir casting method can be successfully adopted for the fabrication of Aluminium matrix composites.
- With Equal channel angular extrusion desirable enhancement in material properties is achieved due to ultra-fine grain refinement.

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BIOGRAPHIES

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