Analysis of Aluminum 6061Composite Hybrid Material with Silicon Carbide, Graphite & Flyash Properties

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Abstract— Aluminium matrix composites (AMCs) have received considerable attention for military, automobile and aerospace application because of their low density, high stiffness and high strength. In this project Al 6061 reinforced with silicon carbide, graphite and fly ash. It is fabricated by conventional stir casting method. The addition of ceramic reinforcements (SiC, Graphite, Flyash) has raised the performance of the Al (6061) alloys. This aluminium matrix has good wear resistance, low weight and density. In this investigation mechanical properties have been conducted by varying mass fraction of SiC, Gr and fly ash with aluminium 6061. Conventional materials like steel, brass, aluminium etc., will fail without any indication. Now a day to overcome this problem, conventional material is replaced by aluminium composite materials. In this project microstructure study, hardness, impact and wear characteristics of SiC, Gr and fly ash particulate reinforced with Al6061 alloy composites have been reported.

Key words: Aluminium Alloys, Metal Matrix Composites, Silicon Carbide, Graphite, Fly Ash, Stir Casting Process

I. INTRODUCTION COMPOSITE MATERIALS

A composite material (also called a composition material or shortened to composite, which is the common name) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure.

The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials.

A. Characteristics of Composites

Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. The composite properties may be the volume reaction sum of the properties of constituents or the constituents may interact in a synergistic way resulting in improved or better properties. Apart from the nature of constituent materials, the geometry of reinforcement (shape, size and distribution) influences the properties of composites to a great extent interaction between the reinforcement and matrix composites as engineering materials.

B. Classification of Composites

Composite materials can be classified in the two different ways:

1) On the basis of Matrix Material
2) On the basis of matrix structure

C. Metal Matrix Composites

A typical composite material is a system of materials composing of two or more materials (mixed and bonded) on a macroscopic scale. Generally, a composite material is composed of reinforcement (fibres, particles, flakes, and/or fillers) embedded in a matrix (polymers, metals or ceramics).

The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix .when designed properly, the new combined material exhibits better strength than wood each individual material. Many of common materials (metals, hollows, doped ceramics and polymers mixed with additives) also have a small amount of dispersed phase in their structure however they are not consider as composite materials since their properties are similar to those of their base constituents.

Favorable properties of composites materials are,

- High stiffness
- High strength
- Low density
- High temperature
- Stability
- High electrical conductivity
- High thermal conductivity
- Corrosion resistance
- Improved wear resistance, etc.

Composites are multifunctional materials system that provides characteristics not obtainable any discrete material. They are cohesive structures made by physically combining two or more compactable materials, different in composition and characteristics and sometimes in form.

D. Method of Producing MMCs

Metal matrix composite materials can be produced by many different techniques. The focus of the selection of suitable process engineering is the desired kind, quantity and distribution of the reinforcement components (particles and fibres), the matrix alloy and the application. By altering the manufacturing method, the processing and the finishing, as well as by the form of the reinforcement components it is possible to obtain different characteristic profiles, although the same composition and amounts of the components are involved. Metal matrix composites can be made by liquid or solid state process.

E. Aluminium Based MMCs

Aluminium based composites are mostly used in automotive industries and aerospace application. This is due to its mechanical unique properties like greater strength, improved stiffness, reduced density, improved temperature properties and wear resistance. The key benefits of aluminium based MMCs composites in transportation sectors are low fuel consumption, less noise and lower airborne emission. The aluminium based MMCs very attractive for their isotropic mechanical properties and their lower costs.

F. Aluminium Metal Matrix Composites

MMC (Metal matrix composites) are generally the metals that reinforced with other metal, ceramic or organic compounds. They are made by dispersing the reinforcements in the metal matrix. Reinforcements of materials are usually done to improve the properties of the base metal, like strength, stiffness, conductivity, fatigue, impact etc. Aluminium and its alloys have attracted most attention as base metal in metal matrix composites because of its less weight, less density, ductility and toughness.

1) Aluminium MMCs are widely used in aircraft, aerospace, automobiles, marine and various other fields due to its excellent mechanical properties.
2) Aluminium metal matrix is getting strengthen by it is reinforced with hard ceramic particles Silicon carbide, aluminium oxide and boron carbide. Metal matrix reinforcement increases the tensile strength, hardness, density, wears resistance, thermal stability of Aluminium and its alloys
3) The particle distribution plays a vital role in the properties of the aluminium metal matrix composites (AMMC) and is improved by intensive shearing. Aluminium oxide reinforcement has good compressive strength and wears resistance. Boron Carbide is one of hardest Known elements and it has high wear and impact resistance and also has high elastic modulus and fracture toughness. The addition of Silicon Carbide (SiC) in Al matrix increases the hardness and high elastic modulus in the metal matrix composites.

Based on the stated potential benefits of MMC examine the various factors like

a) Effect of various reinforcement
b) Mechanical behaviour like strength, wear, fatigue behaviour, etc.
c) Processing methodology and its effects.
d) Application of the speciality AMC was discussed.

Metal matrix composites (MMCs), are same like all composites consist of at least two chemically and physically distinct phases, suitably distributed to provide properties not obtainable with either of the individual phases. Metal matrix composites as light metal matrix with reducing weight of composites. A metal matrix composite (MMC) combines into a single material a metallic base with a reinforcing constituent, which is usually non-metallic and is commonly a ceramic. By definition, MMCs are produced by means of processes other than conventional metal alloying.

Aluminium is the most competent material matrix for the metal matrix composites (MMCs). The Aluminium alloys are quite attractive due to their low density, their capability to be strengthened by precipitation, their good corrosion resistance, high thermal and electrical conductivity, high specific strength and their high damping capacity. Aluminium matrix composites (AMCs) have been widely studied since the 1920s and are now used in sporting goods, electronic packaging, armour, automotive industries and aerospace application. They offer a large variety of mechanical properties depending on the chemical composition of the Al-matrix. They are usually reinforced by Al2O3, Silicon carbide, carbon materials and some other ceramics.

II. LITERATURE REVIEW

i Wang, Qing-yu Shi, Peng Liu, Hong-ke Li, Ting Li (2008) states that a technique for joining aluminium alloys, by using friction stir welding(FSW). Preparing aluminiummetal matrix composites (MMCs) is just one of the important applications. The FSP (Mishra et al., 2000) is a plastic distortion way carried out the same approach as FSW (Li et al., 1999). Therefore, FSP was supposed to produce MMCs in this paper. Friction stir processing has been developed to produce upper surface modification of metallic materials in recent studies. The feasibility to make bulk dispersal SiC reinforced metal matrix composites (MMCs) were studied successfully in this paper.

J. Gandraa, R. Mirandaa, P. Vilac¸ ab,c, A. Velhinhod, J. PamiesTeixeiraa a UNIDEMI (2011) describes that Recently, much attention has been paid to friction stir processing (FSP), a solid state processing technique that uses the same physical principles as friction stir welding (FSW) as described by Mishra and Ma (2005). A non-consumable rotating tool with a probe and a shoulder is plunged into the surface and traversed along the path to be processed. An investigation was conducted in order to produce aluminium based functionally graded MMC reinforced by SiC ceramic particles with median size. AA5083 aluminium alloy plates in the H111 and partially annealed conditions were processed. Several strategies for reinforcement were investigated and its influence on the particle distribution and homogeneity was studied. A square shaped groove packed with reinforcement particles of SiC was studied and it was seen that it was more effective when the groove was placed under the probe.

Mehdi Zohoor a, M.K. BesharatiGivi b, P. Salami (2012) presented and studied that Nowadays; fabrication of metal matrix composites (MMCs) with high mechanical properties and modified microstructures has attracted many attentions. One of the methods to produce MMCs is friction stir processing (FSP) which is a novel modifying technique. In this investigation, production of AA5083 aluminum alloy with reinforced layers using copper particles via FSP was discussed. Micro structural characterization was performed through optical microscopy (OM) and scanning electron microscopy (SEM). Effects of rotational speed, FSP pass numbers and Cu particles' size were investigated on microstructure, particles distribution pattern and micro hardness.AA5083 aluminum alloy is a non-heat treatable Al–Mg based alloy with excellent corrosion resistance and weld ability combined with good strength and formability. Because of these advantages, this alloy is widely used for automobile and transportation industries.

Dolatkhah , P. Golbabaei, M.K. BesharatiGivi, F. Molaiekiya (2011) says that Friction stir processing (FSP) is a novel process for refinement of microstructure, improvement of material's mechanical properties and production of surface layer composites. In this investigation via friction stir processing, metal matrix composite (MMC) was fabricated on surface of 5052 aluminum sheets by means of 5 lm and 50 nm SiC particles. Influence of tool rotational speed, traverse speed, number of FSP passes, shift of rotational direction between passes and particle size was studied on distribution of SiC particles in metal matrix, microstructure, micro hardness and wear properties of specimens. Optimum of tool rotational and traverse speed for achieving desired powder dispersion in MMC was found. Results show that change of tool rotational direction between FSP passes, increase in number of passes and decrease of SiC particles size enhance hardness and wear properties.

A. Devaraju, A. Kumar, B. KotiveeracharіIn this paper they analyzed, the effect of reinforcement particles such as Silicon carbide (SiC), Graphite (Gr) and rotational speed on wear and mechanical properties of Aluminum alloy surface hybrid composites fabricated via Friction stir processing (FSP) was studied. Taguchi method was employedto optimize the rotational speed and volume percentage of reinforcement particles for improving the wear and mechanical properties of surface hybrid composites. The fabricated surface hybrid composites have been examined by optical microscope for dispersion of reinforcement particles and revealed that the reinforcement particles (i.e. SiC and Gr) are uniformly dispersed in the nugget zone. It is also observed that the microhardness at optimum condition is increased due to the presence and pining effect of hard SiC particles. The wear resistance of the surface hybrid composite is increased due to the mechanically mixed layer generated between the composite pin and steel disk surfaces which contained fractured SiC and Gr. The observed wear and mechanical properties have been correlated with microstructures and worn micrographs.

M. Azizieh, A.H. Kokabi, P. Abachi (2010) Friction stir processing (FSP) was used to fabricate AZ31/Al2O3 nano composites for surface applications. The effects of probe profile, rotational speed and the number of FSP passes on nano particle distribution and matrix microstructure were studied. The grain refinement of matrix and improved distribution of nano particles were obtained after each FSP pass. By increasing the rotational speed, as a result of greater heat input, grain size of the base alloy increased and simultaneously more shattering effect of rotation, cause a better nanoparticle distribution.

A. Shafiei-Zarghani, S.F. Kashani-Bozorg, A. Zarei- Hanzaki 2010 [6] A1050 porous aluminium is fabricated by the FSP route and the effect of the tool rotating rate on the porosity and morphology of the pores is investigated. To fabricate high-porosity porous aluminium with a uniform pore size distribution, a certain amount of stirring action is necessary; however, excessive stirring action is ineffective. A sufficiently uniform mixture is realized by traversing the FSP tool two times at a tool rotating rate exceeding 2200 rpm. The results indicate the minimum necessary amount of stirring action and will provide a guideline for improving productivity. Also, to improve the morphology of pores, optimizing the amount of Al2O3 is effective. Closed-cell porous aluminum with a porosity of about 80% was successfully fabricated by 2-pass FSP at 2200rpm with the addition of 7 mass% Al2O3, a holding temperature of 998K and a holding time of 10 min.

III. MATERIALS USED

A. Materials Selection

Selecting the right material for composite involves many factors, including the cost as well as the material performance required.

Materials are

- Aluminium 6061
- Silicon carbide (Sic)
- Graphite
- Fly ash

1) Aluminium6061

Aluminium6061 is a precipitation-hardened aluminium alloy, containing magnesium and silicon as its major alloying elements. Originally called "Alloy 61S", it was developed in 1935.It has good mechanical properties, exhibits good weld ability, and is very commonly extruded (second in popularity only to 6063. It is one of the most common alloys of aluminium for general-purpose use.

- Aluminium 6061 O

It is commonly available in pre-tempered grades such as 6061-O (annealed), tempered grades such as 6061-T6 (solutionized and artificially aged) and 6061-T651 (solutionized, stress-relieved stretched and artificially aged).

- Aluminium 6061 Physical Properties
- Density: 2.7 g/cm^3
- Melting Point: Approx 580°C
- Modulus of Elasticity: 70-80 GPa
- Poisson's Ratio: 0.33

2) Silicon Carbide

Siliconcarbide(SiC) also known carborundum is compound of silicon and carbon with chemical formula SiC. It occurs in nature as the extremely rare mineral moissanite. Silicon carbide powder has been mass-produced since 1893 for use as an abrasive. Grains of silicon carbide can be bonded together by sintering to form very hard ceramics that are widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plates in bulletproof vests. Electronic applications of silicon carbide as light-emitting diodes (LEDs) and detectors in early radios were first demonstrated around 1907, and today SiC is widely used in high-temperature high-voltage semiconductor electronics. Large single crystals of silicon carbide can be grown by the Lely method; they can be cut into gems known as synthetic moissanite. Silicon carbide with high surface area can be produced from SiO_2 contained in plant material.

Silicon carbide is an important non-oxide ceramic which has diverse industrial applications. In fact, it has exclusive properties such as high hardness and strength, chemical and thermal stability, high melting point, oxidation resistance, high erosion resistance, etc. All of these qualities make SiC a perfect candidate for high power, high temperature electronic devices as well as abrasion and cutting applications. Quite a lot of works were reported on SiC synthesis since the manufacturing process initiated by Acheson in 1892. In this chapter, a brief summary is given for the different SiC crystal structures and the most common encountered polytypes will be cited. We focus then on the various fabrication routes of SiC starting from the traditional Acheson process which led to a large extent into commercialization of silicon carbide. This process is based on a conventional carbothermal reduction method for the synthesis of SiC powders. Nevertheless, this process involves numerous steps, has an excessive demand for energy and provides rather poor quality materials. Several alternative methods have been previously reported for the SiC production.

An overview of the most common used methods for SiC elaboration such as physical vapour deposition (PVT), chemical vapour deposition (CVD), sol-gel, liquid phase sintering (LPS) or mechanical alloying (MA) will be detailed. The resulting mechanical, structural and electrical properties of the fabricated SiC will be discussed as a function of the synthesis methods. TheSiC particles, used as reinforcement in the aluminium matrix for synthesizing the Composites, were obtained from M/s. Grindwell Norton ltd., Bangalore, India. The Particles are sieved using standard sieving practice through different grades of sieves In a vibratory sieving machine, with an aim to get particles within the size range of 40-80 µm.

3) Graphite

Graphite is generally grayish black, opaque and has a lustrous black sheen. It has the property of both the metal and nonmetal and it is flexible but not elastic, and has a thermal and electrical conductivity. It is highly refractory and chemically inert. Graphite fibers are made from two precursor materials, polyacrilonitrite (PAN) and petroleum pitch. Graphite and graphite powder are valued in industrial applications for their self-lubricating and dry lubricating properties.

Graphite promotes galvanic corrosion between similar metals. Natural graphite is mostly consumed for refectories, batteries, steel making, expanded graphite, brake linings, foundry facings and lubricants.

4) Fly Ash

Fly ash, also known as "pulverised fuel ash" in the United Kingdom, is one of the coal combustion products, composed of the fine particles that are driven out of the boiler with the flue gases. Ash that falls in the bottom of the boiler is called bottom ash.

Fly ash material solidifies while suspended in the exhaust gases and is collected by electrostatic precipitators or filter bags. Since the particles solidify rapidly while suspended in the exhaust gases, fly ash particles are generally spherical in shape and range in size from 0.5 µm to 300 µm. The major consequence of the rapid cooling is that few minerals have time to crystallize, and that mainly amorphous, quenched glass remains. Nevertheless, some refractory phases in the pulverized coal do not melt (entirely), and remain crystalline. In consequence, fly ash is a heterogeneous material.

IV. Composition

MMCs are made by dispersing a reinforcing material into metal matrix composites. In this project the material like aluminium 6061, SiC, Graphite and Flyash are mixed with appropriate composites. There are two different composites are selected with aluminium as major contribution.

– Sample 1

The composition-1 has aluminium 6061 as 80%, silicon carbide as 10%, graphite as 5% and fly ash as 5%.

– Sample 2

The composition-2 has aluminium 6061 as 85%, silicon carbide as 5%, graphite as 5% and fly ash as 5%.

– Sample 3

The composition-3 has aluminium 6061 as 90%, silicon carbide as 5%, graphite as 2.5% and fly ash as 2.5%.

V. Manufacturing methods

A. Stir Casting

Discontinuous reinforcement is stirred into molten metal, which allow the molten metal to solidify is known as stir casting.

Stir casting (vortex technique) is commonly accepted commercially as a low-cost method fabrication technique for aluminium metal matrix composites. Stir casting common advantages are simplicity, flexibility, and applicability to large volume production.

This process is the most economical when compare to all other available routes for AMMCs production, and it allows very large-sized components to be fabricated easily.

B. Stir Casting Process

In a stir casting process, usually the particulate reinforcement is distributed into aluminium melt by mechanical stirring. Mechanical stirring is the key element of this process. Composites which up to 30% volume fractions can be suitably manufactured by using this method. A problem associated with the stir casting process is the segregation of reinforcing particles due to settling of particles during solidification. The distribution of the particles in the final solid depends on strength of mixing, rate of solidification, wetting condition of the particles with the melt and relative density.

Geometry of the mechanical stirrer, position of the stirrer in the melt, melt temperature and the properties of the particles added determines the distribution of the particles in the molten matrix. In a recent development in stir casting is a two-step mixing process. The matrix material is heated to above its liquids temperature so that the metal is totally melted. The melt is then cooled down to a temperature between the liquids and solidus points and kept in a semi-solid state. At this stage, the preheated particles are added and mixed. The slurry is again heated to a fully liquid state.

Stir casting is an economical process for fabricating aluminium matrix composites. There are many parameters in this process can easily affect the final microstructure and mechanical properties of the composites. In this study, micron-sized SiC, graphite and flyash particles were used as reinforcement, and Al-6061 by stir casting.

The Al6061 reinforced with SiC, Graphite and flyash composites fabricated by stir casting method. Al6061 required amount are taken is heated about 760°C till the entire metal in the crucible was melted. Then the silicon carbide particles are pre heated to 700° C for one hour. The stirrer made up of stainless steel coated with zirconium was lowered into the melt slowly to stir the molten metal at a speed of 300 rpm for 5mins.

VI. TESTING

A. Impact Test

The Charpy impact test also known as the Charpy v-notch test is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture.

The purpose of impact testing in material is to measure the ability to resists high rate loading. This impact test has that the material should resists the impact load.

B. Charpy Impact Test

A test specimen is machined with either V or U notches. The specimen sub size specimens are used where the material thickness is restricted.

C. Brinell hardness Testing

It is oldest hardness method still commonly used in the many application. The brinell hardness test has larger indenter ball about in 10mm in diameter and also has high load about 3000kgf. The most commonly used industry standards for brinell hardness are ASTM E10 6506-1.

D. Microstructure Analysis

Microstructure is the very small structure of material, defined as the structure of a prepared surface of material by above 25×magnification. The microstructure of the material such as metal, polymer, ceramics or composites can strongly influence on various properties like strength, hardness, corrosion resistance, wear resistance.

E. Charpy 'V' Notch Impact Test

- Specimen Size (mm): 75*10*10mm
- Test temperature: Room temperature

Test	Sample	Sample ID Absorbed Energy-Joules
Charpy Impact test	Sample 1	4
Charpy Impact test	Sample 2	4
Charpy Impact test	Sample 3	2

Table 1:

VII. MICROSTRUCTURE STUDIES

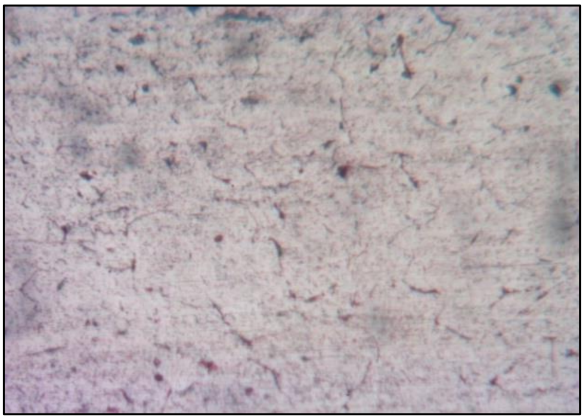

Fig. 1:

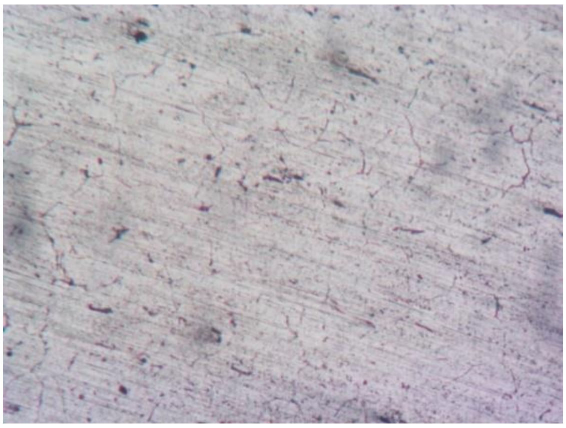

Fig. 2:

Location	Sample Id	Hardness values in HBW(10mm ball/3000kgf load)	
		Observed values	Average
Surface	1	55.5,56.8,56.3	56.2
Surface	2	53.8,54.3,56.8	54.9
Surface	3	57.9,58.4,59.2	58.5

Table 2:

VIII. RESULTS

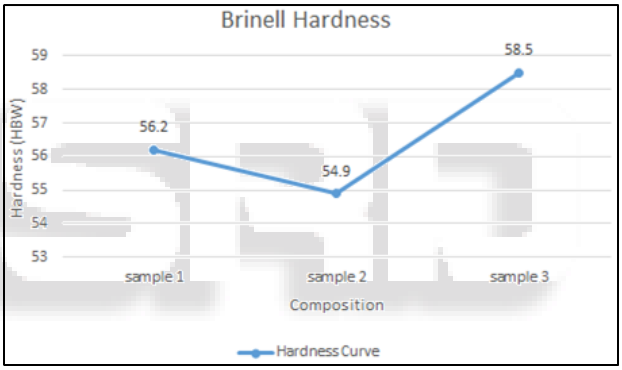

Fig. 3:

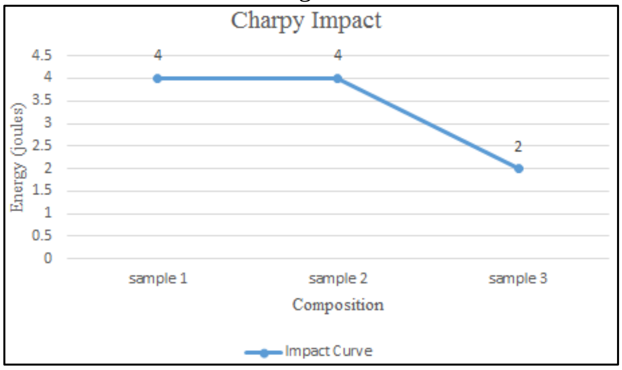

Fig. 4:

IX. CONCLUSION

Thus we conducted experiment and analysis on the fabricated composite material. The results of the composite material which is fabricated by using reinforcement particles like graphite, fly ash and silicon carbide. This will increase the hardness of the aluminium 6061.the strength of the fabricated composite material is tested by using brinell hardnes test and microstructure test has been conducted and also impact test has been conducted and result was plotted.

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