Development of Aluminium Metal Matrix Composite for Automobile Components

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Abstract: **Composite material is a combination of two or more materials, differing in from on a macro scale. Now a days the composite materials occupy the place of conventional materials. In the composite materials the metal matrix composites is a new trend in manufacturing of composites. The metal matrix composite having two main phases. One is matrix phase, another one is reinforcement phase. The metal matrix phase is aluminum 6061, the reinforcement phase is flaks of EN19 of 3%, 6%, 9% weight. That flaks like a short fibers. This metal matrix composite material is manufacturing by stir casting process. A reaction between aluminum and iron was anticipated to result in strengthening phase forming in the material. The attractiveness of aluminum is that it is relatively low cost, light weight metal that can be heat treated to fairly high strength levels and it is one of the most easily fabricated high performance materials, which usually correlates with lower costs. The mechanical properties like tensile strength, hardness, percentage of elongation will be carried out.**

Keyword: Composite material, the metal matrix phase, stir casting process, performance analysis.

INTRODUCTION

From the last few years in much industrial application the important parameter in material selection is specific strength, weight and cost. we must know the difference between the composite and MMC. The composite defined as the made of several part or element but only combined different material not a nonmetal whereas the nonmetal is mixed with material this called MMC. In the transportation sector when earlier large bulky automobiles are compared with today's light weight, technologically superior vehicles. Man has been using iron, copper & their alloys for thousands of years, but surprisingly until the last century he was oblivious of the bauxite ore (which has aluminium) is the second most abundant ore in earth crust. It became an economic competitor to steel & cast iron in engineering applications because of its excellent combination of properties like lightweight, high specific strength, stiffness& good corrosion resistance, higher ductility. Realizing the potential as well as availability of Aluminium, considerable efforts are being made to explore the possibilities of improving the mechanical strength and wear resistance so as to meet the requirements of various applications. More aluminium is being consumed now a days than all other nonferrous metals/ alloys including Copper. In order to improve the mechanical strength & modulus of aluminium, it is alloyed with various alloying elements such as Cu, Zn, Mg, Si, Mn etc. Amongst the various Aluminium alloys AlZnMg alloys are found to show tremendous improvement in mechanical strength and finds its application in aerospace and automobile structural components. AlMg cast alloys show excellent corrosion resistance, good machinability and attractive appearance.

1.1COMPOSITES

Composite materials are extending the horizons of designers in all branches of engineering, and yet the degree to which this is happening can easily pass unperceived. In composites, materials are combined in such a way as to enable us to make better use of their virtues while minimizing to some extent the effects of their deficiencies. This process of optimization can release a designer from the constraints associated with the selection and manufacture of conventional materials. He can make use of tougher and lighter materials, with properties that can be tailored to suit particular design requirements. And because of the ease with which complex shapes can be manufactured, the complete rethinking of an established design in terms of composites can often lead to both cheaper and better solutions.

The simple term 'composites' gives little indication of the vast range of individual combinations that are included in this class of materials. First, within each group of materials metallic, ceramic and polymeric there are already certain familiar materials which can be described as composites. Many members of the commonest and largest group of engineering materials, the family of steels, consist of

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combinations of particles of hard ceramic compounds in a softer metallic matrix.

These particles are sometimes platelike, sometimes needleshaped, and sometimes spherical or polygonal. Polymers, too, are often twophased, consisting of a matrix of one polymer with distributions of harder or softer particles contained within it; wood is a perfect example of this, as we have seen. And concrete is a classic example of a ceramic/ceramic composite, with particles of sand and aggregate of graded sizes in a matrix of hydrated Portland cement. These materials have been well known for many years, and Materials Scientists have learned to control their properties by controlling their microstructures; that is to say, the quantity, the form, and the distribution of what we might refer to as the 'reinforcing phase'. The idea of mixing components across the materials class boundaries is a natural extension of this idea. Making additions of hard, or fireresistant, or simply cheap, ceramic powders to plastics to make filled polymers; and making additions of very hard, or abrasive, or thermally stable ceramic particles to metals to make the class of materials known as 'cermets' to produce machine tool tips capable of cutting hard metals at high speeds or high temperatures; are only two examples of important developments in our exploitation of these materials.

But even more significant is the extension of this principle to incorporate filamentary metals, ceramics and polymers into the bulk forms of any of these three classes of materials to make fiber composites reinforced plastics, like CFRP and GRP, metalmatrix composites (MMCs) like silicon carbide fiber reinforced aluminium, and ceramic matrix composites (CMCs) like carbon fiber reinforced glass.

1.2CONVENTIONAL MATERIALS

It is difficult to draw up a table of materials characteristics in order to assess the relative strengths and weaknesses of metals, plastics and ceramics because each of these terms covers whole families of materials within which the range of properties is often as broad as the differences between the three classes. A comparison in general terms, however, can identify some of the more obvious advantages and disadvantages of the different types of material.

1.2.1 Plastics

Plastics are of low density. They have good shortterm chemical resistance but they lack thermal stability and have only moderate resistance to environmental degradation (especially that caused by the photochemical effects of sunlight). They have poor mechanical properties, but are easily fabricated and joined.

1.2.2 Ceramics

Ceramics may be of low density (although some are very dense). They have great thermal stability and are resistant to most forms of attack (abrasion, wear, corrosion). Although intrinsically very rigid and strong because of their chemical bonding, they are all brittle and can be formed and shaped only with difficulty.

1.2.3 Metals

Metals are mostly of medium to high density only magnesium, aluminum and beryllium can compete with plastics in this respect. Many have good thermal stability and may be made corrosion resistant by alloying. They have useful mechanical properties and high toughness, and they are moderately easy to shape and join. It is largely a consequence of their ductility and resistance to cracking that metals, as a class, became (and remain) the preferred engineering materials.

On the basis of even so superficial a comparison it can be seen that each class has certain intrinsic advantages and weaknesses, although metals pose fewer problems for the designer than either plastics or ceramics.

1.3 CLASSIFICATION BASED ON REINFORCEMENT

The classification of composite materials based on the reinforcement

- Particle reinforced composites
- Fibre reinforced composites

1.3.1 Particle Reinforced Composites

Particle reinforced composites have again been divided into large particle composites, the size of the particle is larger than that of the dispersion strengthened composites. If the binding is good then the matrix movement can be restrained. Concrete and reinforced concrete has been the examples of large particle composites. In dispersion strengthened composites, the particle size varies from 10 to 100 micron. Small particles have been dispersed throughout the matrix and that prevent plastic deformation by blocking the motion of dislocations. Sintered aluminium powder is an example of dispersion strengthened composite.

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1.3.2 Fiber Reinforced Composites

Fibers are responsible for high strength and stiffness ratio to weight of the composite. This class can be further subdivided into continuous and discontinuous Fibers. Continuous Fibers are those which have lengths normally greater than 15 times the critical length and discontinuous Fibers have length shorter than this. The discontinuous Fibers can be aligned or randomly oriented. It is obvious that for better strength of the composite and better load transfer ability, the fiber should be continuous. Examples of some Fibers are carbon Fibers, boron Fibers, E-glass Fibers, SiC Fibers, etc.

1.4THE COMBINING OF MATERIALS

In considering the scope for reinforcing conventional materials, we have already examined the functions of the matrix in a composite and the general nature of available reinforcing filaments. The problem facing the manufacturer of composites is to develop suitable methods for combining the matrix and the reinforcement so as to obtain the required shape of component with properties appropriate to the design requirements. In the early days of the subject, attention was focused on first producing a 'piece' of the composite a sheet, or rod, or billet, with the fibers arranged in one or more directions and then using that intermediate product to construct a finished 'component' in much the same way as steel castings were bolted together to build a car engine or steel plates were welded together to make a pressure vessel. Early use of composites in practical applications was on the basis of piecemeal substitution of the composite for a metallic part of identical shape without any consideration of the special nature of the composite, notably its anisotropic mechanical properties. The idea of bolting GRP 'top hat' stiffeners to the underside of GRP ship decking seems ridiculous now, but the procedure was certainly investigated in the 1970s.

It is essentially the reinforcement 'architecture' that determines the loadbearing characteristics of a fiber composite, and the beauty of modern composites design and manufacturing procedures is that in many cases the composite material and the finished component can be created and final in a single operation. A typical example is in the process of resintransfer molding (RTM) which we shall discuss later. A fiber preform a skeleton of the approximate shape of the finished component with the fibers arranged in the directions determined by the design requirements is placed into a closed mold, and precatalyzed resin is injected into the mold, which is often preheated. The resin cures in a short time, and the finished component, requiring only final cleaning up, is removed from the mold, the composite material and the finished article being formed in a single operation.

The ratecontrolling step in this nearnetshape manufacturing process is probably the manufacture of the fiber preform. In the filamentwinding of hollow containers, fibers wetted by catalyzed resin are wrapped onto a mandrel and, again, as the resin cures the component and the material are formed simultaneously. In this case, the locations of the fibers may have been determined by a computer programme and the same computer code can then be used to control an automatic filament winding machine a good example of CAD/CAM.

1.5.2CARBON FIBERS

By oxidizing and pyrolysing a highly drawn textile fiber such as poly acrylonitrile (PAN), preventing it from shrinking in the early stages of the degradation process, and subsequently hotstretching it, it is possible to convert it to a carbon filament with an elastic modulus that approaches the value we would predict from a consideration of the crystal structure of graphite, although the final strength is usually well below the theoretical strength of the carboncarbon chain (Watt, 1970). The influence of strength limiting defects is considerable, and cleanroom methods of production can result in substantial increases in the tensile strength of commercial materials. Prior to sale, fibers are usually surfacetreated by chemical or electrolytic oxidation methods in order to improve the quality of adhesion between the fiber and the matrix in a composite. Depending on processing conditions, a wide range of mechanical properties (controlled by structural variation) can be obtained, and fibers can therefore be chosen from this range so as to give the desired composite properties. Although the fiber is highly organized and graphitelike, the structure is not identical with that of graphite and the fibers should not, strictly speaking, be referred to by that name, although this is common in the US (and in UK advertising jargon for sports equipment!). Recent developments in this field have led to the use of pitch as a precursor in place of textile fibers, and these newer materials have extremely high stiffness, compared to PAN based fibers, but rather lower strengths (Fitzer and Heine, 1988).

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The properties of glasses can be modified to a limited extent by changing the chemical composition of the glass, but the only glass used to any great extent in composite materials is ordinary borosilicate glass, known as Eglass. The largest volume usage of composite materials involves Eglass as the reinforcement. Sglass (called Rglass in France) has somewhat better properties than Eglass, including higher thermal stability, but its higher cost has limited the extent of its use. Wallenberger and Brown (1994) have recently described the properties of experimental calcium aluminate glass fibers.

Table 1.1. Typical properties of some familiar reinforcing fibers

Material	Trade name	Density, 10^3 kg/m^3	Fiber diameter, μm	Young's Modulus, GPa	Tensile Strength, N/MM^2
Highcarbon steel wire Short fibers:	eg. piano wire	7.8	250	210	2800
αAl_2O_3 (whisker crystals)		3.96	110	450	20000
$\delta Al_2O_3 + SiO_2$ (discontinuous) Continuous fibers (inorganic)	Saffil (UK)	2.1	3	280	1500
αAl_2O_3	FP (US)	3.9	20	385	1800

Method	Range of shape and size	Range of vol. fraction	Damage to reinforcement	Cost
Stir casting	wide range of shapes; Larger size; up to 500kg	Up to 0.3	No damage	Least expensive
Squeeze casting	limited by pre form shape Up to 2cm height	Up to 0.5	severe damage	Moderate expensive
Powder metallurgy	wide range; restricted size		Reinforcement fracture	Expensive
Spray casting	Limited shape, large shape	0.3 to 0.7		Expensive

1.5.3ORGANIC FIBERS

Bulk polymers have elastic moduli no greater than 100MPa, but if the polymer is spun into fibers and cold drawn so as to develop a high degree of molecular orientation, substantial improvements in both strength and rigidity can be achieved. In this process, both the crystalline and noncrystalline phases of the initially isotropic polymer are stretched out and aligned and there is an increase in crystal continuity. Such fibers have high strengths, and their elastic moduli are similar to those of glass and aluminium. Apart from their excellent mechanical properties such fibers have the important advantage over inorganic fibers that they are not brittle. These polymers are based on porienteddiamine and dibasic acid intermediates which yield liquid crystalline solutions in amide and acid solvents.

These solutions contain highlyorderedextendedchain domains which are randomly oriented in the absence of force, but which may be oriented by inducing shear forces in the liquid. Highlyoriented fibers can therefore be produced by wetspinning these solutions, and poly(paraphenyleneterephthalamide) fibers such as Kevlar and Twaron have strengths of the order of 2.6GPa and moduli up to 130GPa, depending on the degree of alignment of the polymer chains. Having properties intermediate between those of carbon and glass, aramids offer an extra degree of flexibility in composite design.

1.5.4STYLES OF REINFORCEMENT

Many reinforcing fibers are marketed as wide, semicontinuous sheets of 'prepreg' consisting of single layers of fiber tows impregnated with the required matrix resin and flattened between paper carrier sheets. These are then stacked, as discussed in chapter 3, the orientations of each 'ply' being arranged in accordance with design requirements, and hot pressed to consolidate the laminate. This process is able to cope with curved surfaces, provided the degree of curvature is not too great, but there may be a possibility of local wrinkling of the fibers when prepregs are pressed into doubly curved shapes. One means of overcoming this problem is to use the reinforcement in the form of a woven cloth since textile materials can readily be 'draped' over quite complex formers.

Many of the fine filamentary reinforcing fibers like glass, carbon and SiC can be readily woven into many kinds of cloths and braids, the fibers being effectively placed by the weaving process in the directions required by the designer of the final composite structure. In simple designs, this may call for nothing more elaborate than an ordinary plain weave or satin weave, with fibers running in a variety of patterns but in only two directions, say 0° and 90°, but weaving processes to produce cloths with fibers in several directions in the plane of the cloth are all readily available. Fibers of different types may also be intermingled during the weaving processes to produce mixedfiber cloths for the

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manufacture of some of the 'hybrid' composites that will be discussed later.

Most of the continuous fibers that we have considered are expensive raw materials, and it is often only the fact that the overall cost of a manufactured composite product may nevertheless be lower than a competing product made from cheaper, conventional materials by more costly processes that makes a composites design solution an attractive alternative. Thus, although large quantities of glass fibers are supplied in chopped form for compounding with both thermoplastic and thermosetting matrix polymers, it may not seem economical to chop the more expensive types of reinforcement. Nevertheless, there are some advantages in using even these fibers in chopped form, provided they can be arranged in the composite in such a way as to make good use of their intrinsically high strengths and stiffness.

Parratt and Potter (1980) described a process for producing both chopped fibers, like glass and carbon, and naturally short filaments, like whiskers or asbestos fibers, in the form of prepreg sheets with fibers that were very well aligned in either unidirectional or polydirectional patterns. These prepregs also have excellent 'drapability' and can be used to form complex shapes, as discussed by Tsuki et al. (1997). As will be seen in chapter 4, provided the short fibers are well above some critical length, which for carbon, for example, may be of the order of only a millimetre, they are able to contribute a high fraction of their intrinsic properties to the composite without the loss that occurs with woven reinforcements as a result of the outofplane curvature of the fibers.

1.6THE INTERFACE

In materials where the mechanical response depends on loads being shared between two or more separate constituents or 'phases' and where paths for the propagation of cracks will be affected by the different mechanical properties of the components, the manner in which these adhere to each other becomes an important consideration. When we come to discuss the strength and toughness of composites, we shall see that the strength of the interfacial bond between the fibers and the matrix may make all the difference between a satisfactory material and an inadequate one. The problem is that the ideal situation for load sharing a perfect bond between the fiber and the matrix, forcing them to deform as one, which is the first assumption that we shall make in attempting to calculate the elastic modulus of a fiber composite often results in a lower tensile strength than expected because of the way cracks run in such a composite. In the early days of carbonfiber technology, it was quickly established that the greater the degree of order in the graphitized fiber structure the poorer was the adhesive bond between the new highmodulus fibers and the existing polyester and epoxy resins. As a consequence, the higher the fiber stiffness the poorer the extent to which the composite was able to resist shear forces acting in the plane of a laminate i.e.The lower the interlaminar shear strength (ILSS).

Hasty attempts were made to improve the ILSS by a variety of surface treatments, including coating with polymers, hightemperature and electrolytic oxidation, and vapour deposition of other compounds onto the fiber surface. Electrolytic treatment became the established method, but the need for control over the extent of the treatment was not appreciated and some early fibers were supplied by manufacturers with heavily oxidized surfaces that were very well wetted by the resins. This facilitated manufacture, but resulted in composites that were disastrously brittle, causing a serious setback for aeronautical use of carbon fibers. In early work on the use of carbon fibers as reinforcements for aluminium alloys, the choice of an aluminium/silicon alloy as matrix (on account of the well-known fluidity of these alloys) led to a rapid reaction between the silicon and the carbon fiber, with the result that a very strong bond was created but the fiber properties were ruined.

1.7MANUFACTURING PROCESSES

This book is not about manufacturing, yet it is necessary to know something of the nature of the main processing methods used in order to appreciate how what happens during processing may affect the properties of the product. In this chapter, therefore, we shall take only a very general look at the major processes currently being used to produce composite artefacts.

1.7.1Polymer Matrix Composites

The wide range of processes used to produce reinforced plastics is partly new, and partly derived from established methods of processing ordinary polymeric materials. The manner of combining fibers and matrix into a composite material depends very much on the particular combination in question and on the scale and geometry of the structure to be manufactured.

The commoner varieties of thermoplasticbased materials, like glassfilled Nylon and glassfilled polyacetal, are made largely by the injection molding of granules of material in which the chopped fibers and matrix have been precompounded. The principal problem in such cases is that the flow of material during molding may be no uniform, especially in molds of complex geometry. There may be regions in which the fibers are highly

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oriented and others where the degree of orientation is almost nil, as well as variations in fiber content from place to place. Preferential fiber orientation is often useful, but only if it can be adequately controlled.

Continuousfiber thermoset composites are produced by quite different methods. Cylindrically symmetric structures such as pressure vessels, tanks, rocketmotor casings, centrifuge cylinders, and a variety of pipes, can be made by winding fibers or tapes soaked with precatalyzed resin onto expendable or removable mandrels. Winding patterns may be simple or complex and may be accurately calculated to resist a prescribed stress system. (eg. a given ratio of hoop stress to longitudinal stress) in service. Variations in winding pattern or in the combination of stresses subsequently applied to the structure will clearly change the extent to which the fibers are loaded purely in tension or to which shear stresses are introduced between separate layers of winding. After the resin has hardened the mandrel is removed and, if size permits, the product may be postcured at an elevated temperature. Extremely large vessels can be made by this method, but these must usually be left to cure at ambient temperature. Since the winding procedure can be closely controlled, a high degree of uniformity is possible in the fiber distribution of filamentwound structures, but planes of weakness sometimes occur between winding layers, especially if resin rich pockets are allowed to form. An important feature of this process is that after a structure has been designed according to well-defined principles based on stress analysis of composite materials, the design software can be extended to provide instructions to a computer or numericallycontrolled winding machine to manufacture the vessel to close tolerances.

1.7.2Metal Matrix Composites

The basic attributes of metals reinforced with hard ceramic particles or fibers are improved strength and stiffness, improved creep and fatigue resistance, and increased hardness, wear and abrasion resistance, combined with the possibility of higher operating temperatures than for the unreinforced metal (or competing reinforced plastics). These properties offer potential for exploitation in a range of pump and engine applications, including compressor bodies, vanes and rotors, piston sleeves and inserts, connecting rods, and so forth.

Components of this type are still under development, but few are in commercial production apart from one or two limited applications in Japanese automobiles. Thus, although a wide range of manufacturing methods has been used over the past twenty years on a laboratory or development scale, at this stage relatively little can be said about largescale production processes for MMCs.

Some of the techniques that have been described in detail are

1. Unidirectional solidification of eutectics or other constitutionally appropriate alloys

2. Liquidmetal infiltration, often under vacuum, of prepacked fiber bundles or other preforms

3. Liquidphase infiltration during hot pressing of powder compacts containing whiskers or fiber bundles

4. Hot pressing of compacts consisting of matrix alloy sheets wrapped or interleaved with arrays of reinforcing wires

5. Hot pressing or drawing of wires precoated with the matrix alloy (eg. by electroplating, plasma spraying or chemical vapour deposition (CVI)

The most important MMC systems are:

Aluminum matrix

1. Continuous fibers: boron, silicon carbide, alumina, graphite
2. Discontinuous fibers: alumina, alumina-silica
3. Whiskers: silicon carbide
4. Particulates: silicon carbide, boron carbide

Magnesium matrix

1. Continuous fibers: graphite, alumina
2. Whiskers: silicon carbide
3. Particulates: silicon carbide, boron carbide

Titanium matrix

1. Continuous fibers: silicon carbide, coated boron
2. Particulates: titanium carbide

Copper matrix

1. Continuous fibers: graphite, silicon carbide
2. Wires: niobium-titanium, niobium-tin
3. Particulates: silicon carbide, boron carbide, titanium carbide.

1.7.3Ceramic Matrix Composites

Fabrication processes are complex and need to be carefully optimized because of the inevitable sensitivity of materials properties to microstructures

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controlled by processing conditions and interactions. Much of the recent work on CMCs in the US, Japan and Europe has largely followed relatively familiar routes in attempting to reinforce glasses (like borosilicate) and glassceramics (like lithium aluminosilicate or LAS and calcium aluminosilicate or CAS) with fibers such as the commercial Nicalon and Tyranno varieties of silicon carbide. Substantial improvements in mechanical properties have been achieved, by comparison with early carbonfiber/glass composites.

The fibers are usually impregnated with a slurry of fine glass powder and subsequently hotpressed. If the matrix is a glassceramic, the final stage in manufacture is the 'ceramming' process, the final heat treatments to convert the glass to a fully dense ceramic. Critical control of manufacturing conditions is needed to produce appropriate interfacial conditions for the optimum combination of strength and toughness. The advantage of the glassceramic route is that relatively modest processing temperatures are involved, although even so a typical residual thermal stress of the order of only 200MPa may still be sufficient to cause cracking of the matrix in asmanufactured or lightlyloaded composites. However, for all work involving the production of ceramicfiberreinforced ceramic composites by conventional pressing methods, there remains the problem of compatibility.

1.7.4Hybrid Composites

Reference to hybrid composites most frequently relates to the kinds of fiberreinforced materials, usually resinbased, in which two types of fibers are incorporated into a single matrix. The concept is a simple extension of the composites principle of combining two or more materials so as to optimize their value to the engineer, permitting the exploitation of their better qualities while lessening the effects of their less desirable properties. As such, the definition is much more restrictive than the reality. Any combination of dissimilar materials could in fact be thought of as a hybrid.

A classic example is the type of structural material in which a metal or paper honeycomb or a rigid plastic foam is bonded to thin skins of some highperformance FRPs, the skins carrying the high surface tensile and compressive loads and the core providing lightweight (and cheap) structural stability. The fibers are usually impregnated with a slurry of fine glass powder and subsequently hot pressed. If the matrix is a glass ceramic, the final stage in manufacture is the 'ceramming' process, the final heat treatments to convert the glass to a fully dense ceramic. Critical control of manufacturing conditions is needed to produce appropriate interfacial conditions for the optimum combination of strength and toughness. The advantage of the glass ceramic route is that relatively modest processing temperatures are involved, although even so a typical residual thermal stress of the order of only 200MPa may still be sufficient to cause cracking of the matrix in as manufactured or lightly loaded composites. However, for all work involving the production of ceramic fiber reinforced ceramic composites by conventional pressing methods, there remains the problem of compatibility.

The combination of sheets of aluminium alloy with laminates of fiberreinforced resin, as in the commercial product ARALL (aramidreinforced aluminium, Davis, 1985) is a related variety of layered hybrid, and the mixing of fibrous and particulate fillers in a single resin or metal matrix produces another species of hybrid composite.

Figure 3.1. Stir Casting Apparatus

Thisis the layout of the stir casting apparatus. It consist of conical shaped graphite crucible is used for fabrication of AMCs, as it withstands high temperature which is much more than required temperature [680°C].Along that graphite will not react with aluminum at these temperature. This crucible is placed in muffle which is made up of high ceramic alumina. Around which heating element of wound. The coil which acts as heating element is KantholA1. This type of furnace is known as resistance heating furnace. It can work up to 900°C reach within 45 min. Aluminium, at liquid stage is very reactive with atmospheric oxygen. Oxide formation occurs when it comes in contact with the open air. Thus all the process of stirring is carried out in closed chamber with nitrogen gas as inert gas in order to avoid oxidation. Closed chamber is formed with help of steel sheet. This reduces heat loss and gas transfer as compare open chamber. A K type Temperature thermocouple whose working range is 200°C to 1250°C is used to record the current temperature of the liquid. Due to corrosion resistance to atmosphere EN 19 is selected as stirrer shaft material. One end of shaft is connected to 0.5 hp PMDC motor with flange coupling.

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While at the other end blades are welded. 4 blades are welded to the shaft at 45°C. A constant feeding rate of reinforcement particles is required to avoid coagulation and segregation of the particles. This can be achieve by using hopper. Aluminium alloy matrix will be formed in the crucible by heating aluminium alloy ingots in furnace. A stirring action is started at slow rate of 30 rpm and increases slowly in between 300 to 600 rpm with speed controller. A mixture of reinforcements is to be incorporated in the metal matrix at semisolid level near 640°C. Dispersion time is to be taken as 5 minutes. After that slurry is reheated to a temperature above melting point to make sure slurry is fully liquid and then it is poured in mold.

3.2 PROCEDURE

Stir casting process starts with placing empty crucible in the muffle. At first heater temperature is set to 500°C and then it is gradually increased up to 900°C. High temperature of the muffle helps to melt aluminium alloy quickly, reduces oxidation level, enhance the wet ability of the reinforcement particles in the matrix metal. Aluminium alloy Al6061 is used as Matrix material. Required quantity of aluminium alloy is cut from the raw material which is in the form of round bar. Aluminium alloy is cleaned to remove dust particles, weighed and then poured in the crucible for melting. During melting nitrogen gas is used as inert gas to create the inert atmosphere around the molten matrix. Powder of alumina, Magnesium (Mg) and flakes are used as reinforcement. 1% by weight ofpure magnesium powder is used as wetting agent. At a time total 700 gram of molten composite was processed in the crucible. Required quantities of reinforcement powder and magnesium powder are weighed on the weighing machine. Then it is thoroughly mixed with each other with the help of blending machine for 24 hour. This mixture is kept ready 1 day before the test has to carry out. Prior to conducting the test this mixture is kept for heating in another heater.

Reinforcements are heated for half hour and at temperature of 500°C. When matrix was in the fully molten condition, Stirring is started after 2 minutes. Stirrer rpm is gradually increased from 0 to 300 RPM with the help of speed controller. Temperature of the heater is set to 630°C which is below the melting temperature of the matrix. A uniform semisolid stage of the molten matrix was achieved by stirring it at 630°C.Pouring of preheated reinforcements at the semisolid stage of the matrix enhance the wet ability of the reinforcement, reduces the particle settling at the bottom of the crucible. Reinforcements are poured manually with the help of conical hopper. The flow rate of reinforcements measured was 0.5 gram per second. Dispersion time was taken as 5 minutes. After stirring 5 minutes at semisolid stage slurry was reheated and hold at a temperature 900°C to make sure slurry was fully liquid. Stirrer RPM was then gradually lowered to the zero.

The stir casting apparatus is manually kept side and then molten composite slurry is poured in the metallic mold. Mold is preheated at temperature 500°C before pouring of the molten slurry in the mold. This makes sure that slurry is in molten condition throughout the pouring. While pouring the slurry in the mold the flow of the slurry is kept uniform to avoid trapping of gas. Then it is quick quenched with the help of air to reduce the settling time of the particles in the matrix.

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3.3 PROCESS PARAMETERS

For manufacturing of composite material by stir casting knowledge of its operating parameter are very essential. As there is various process parameters if they properly controlled can lead to the improved characteristic in composite material.

3.3.1 Stirring Speed

Stirring speed is the important process parameter as stirring is necessary to help in promoting wet ability i.e. bonding between matrix & reinforcement. Stirring speed will directly control the flow pattern of the molten metal. Parallel flow will not promote good reinforcement mixing with the matrix. Hence flow pattern should be controlled turbulence flow. Pattern of flow from inward to

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outward direction is best. In our project we kept speed from 300 to 600 rpm. As solidifying rate is faster it will increase the percentage of wet ability.

3.3.2Stirring Temperature

It is an important process parameter. It is related to the melting temperature of matrix i.e. aluminium. Aluminium generally melts at 650◦C. The processing temperature is mainly influence the viscosity of Al matrix. The change of viscosity influences the particle distribution in the matrix.

The viscosity of liquid decreased when increasing processing temperature with increasing holding time stirring time. It also accelerates the chemical reaction between matrix and reinforcement. In our project in order to promote good wet ability we had kept operating temperature at 630°C which keeps Al (6061) in semisolid state.

3.3.3 Reinforcement Preheat Temperature

Reinforcement was preheated at a specified 500◦C temperature 30 min in order to remove moisture or any other gases present within reinforcement. The preheating of also promotes the wettability of reinforcement with matrix. The reinforcement flakes of EN19 steel.

3.3.4Addition of Mg

Addition of Magnesium enhances the wettability. However increase the content above 1wt. % increases viscosity of slurry and hence uniform particle distribution will be difficult.

3.3.5 Stirring Time

Stirring promotes uniform distribution of the particles in the liquid and to create perfect interface bond between reinforcement and matrix. The stirring time between matrix and reinforcement is considered as important factor in the processing of composite. For uniform distribution of reinforcement in matrix in metal flow pattern should from outward to inward.

3.3.6 Blade Angle

The blade angle and number of blades are prominent factor which decides the flow pattern of the liquid metal at the time of stirring. The blade with angle 45° & 60° will give the uniform distribution. The number of blade should be 4. Blade should be 20mm above the bottom of the crucible. Blade pattern drastically affect the flow pattern.

3.3.7 Inert Gas

As aluminium melt it start reacting with environment oxygen and will produce an oxide layer at the top. This oxide layer will avoid further oxidation but along that it will difficult to brake. So such layer will be big trouble for reinforcement mixture with metal. So in order to avoid this we had used inert gas like nitrogen.

3.3.8 Preheated Temperature of Mold

In casting porosity is the prime defect. In order to avoid these preheating the permanent mold is good solution. It will help in removing the entrapped gases from the slurry in mold. While pouring molten metal keep the pouring rate constant to avoid bubble formation.

3.3.9 Powder Feed Rate

To have a good quality of casting the feed rate of powder particles must be uniform. If it is nonuniform it promotes clustering of particles at some places which in turn enhances the porosity defect and inclusion defect, so the feed rate of particles must be uniform.

4.RESULTS & DISCUSSION

4.1 TENSILE STRENGTH

SPECIMEN	TENSILE STRENGTH
	N/mm^2
Al6061	58.2
Al6061+3% flakes of EN19+2%Mg	67.27
Al6061+6% flakes of EN19+3%Mg	89.11
Al6061+9% flakes of EN19+4%Mg	91.67

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Table 4.1 shows the tensile strength property of Al6061 and their composite containing flakes of EN19 respectively as a function of percentage weight. From figure it can be observed that the tensile strength of the composites are higher than that of their base matrix also it can be observed that the increase in the filler content contributes in increasing the tensile strength of the composite. Also from the figure it can be observed that the tensile strength of the Al7075-Al_2O_3 composites is higher than that of the composites of Al6061-SiC. But the %'age increase in tensile strength of Al6061-SiC& B_4C is 68 where as for Al7075-Al_2O_3 is 24 which clearly indicates the super ironers of Al6061-SiC& B_4C composites and hence the greater contributions of SiC with regards to the increased tensile strength of its composites.

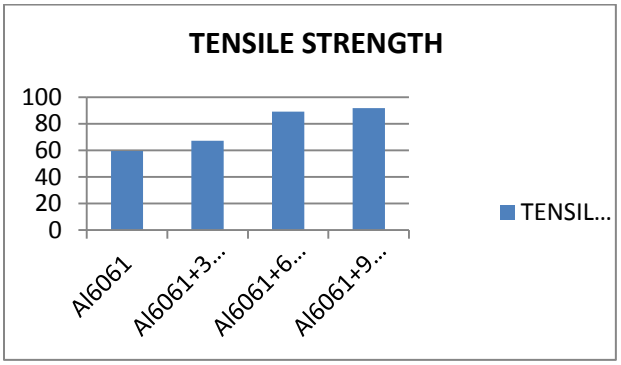

Figure 4.1. Tensile Strength Comparison of Various Composition of Al6061

4.2 HARDNESS

It is reported that higher hardness is associated with lower porosity of MMCs. The hardness of cold extruded composites are higher when compared with hot extruded ones for a given reinforcement content. This may be due to strain hardening of cold extrusion. Higher the hardness, lower will be the ductility of composites which leads to lowering of impact strength. Cold extruded composites possess lower impact strength when compared with hot extruded composites.

The drastic reduction in impact strength values of the cold extruded composites can be attributed to the inherent brittleness exhibited by cold extrusion and also due to the high level of residual stress that remains after the cold extrusion. In hot extruded composites there is absence of residual stress coupled with recrystallization which results in better impact strength when compared with cold extruded. This may be due to strain hardening of cold extrusion. Higher the hardness, lower will be the ductility of composites which leads to lowering of impact strength. Cold extruded composites possess lower impact strength when compared with hot extruded composites.

The percentage decrease in impact strength of matrix Al6061 alloy is 4.6% on cold extrusion whereas increase in impact strength on hot extrusion is 71%.

Table 4.2. Hardness Testing

SPECIMEN	HARDNESS
	HR15T
Al6061	59
Al6061+3% flakes of EN19+2%Mg	66
Al6061+6% flakes of EN19+3%Mg	67.2
Al6061+9% flakes of EN19+4%Mg	80

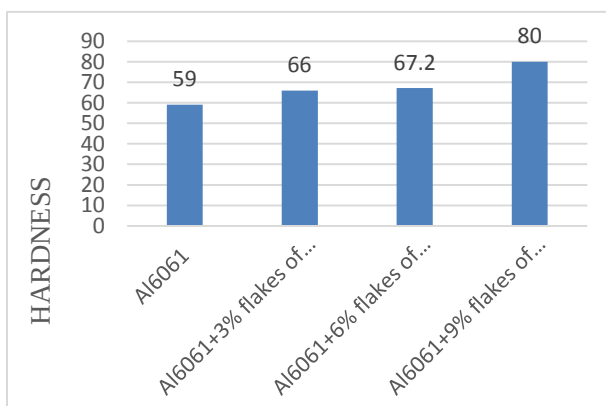

Figure4.2. Hardness Comparison ofVarious Composition of Al6061

4.3 ELANGATION

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Wear has been defined as the displacement of material caused by hard particles or hard protuberances where these hard particles are forced against and moving along a solid surface. Two body sliding wear tests were carried out on prepared composite specimens. A Ducom, Bangalore made computerized pin on- disc wear test machine was used for these tests. The wear testing was carried out at different sliding velocities with normal loads of 10N, 15N, 20 N. A cylindrical pin of size 1.1cm diameter and 2.1cm length, prepared from composite casting, was loaded through a vertical specimen holder against horizontal rotating disc.

Before testing, the flat surface of the specimens was abraded by using 2000 grit paper. The rotating disc was made of carbon steel of diameter 50 mm and hardness of 64 HRC. Wear tests were carried out at room temperature without lubrication for 30 min. The principal objective of investigation was to study the coefficient of friction and wear. The weights were measured before and after each test segment to determine the wear loss of each sample. Scanning electron microscopy was used to analyze the morphology of the worn surfaces of sample.

Table 4.3 % of Elongation

SPECIMEN	ELANGATION
	%
Al6061	5.7
Al6061+3% flakes of EN19+2%Mg	5.0
Al6061+6% flakes of EN19+3%Mg	4.3
Al6061+9% flakes of EN19+4%Mg	4.0

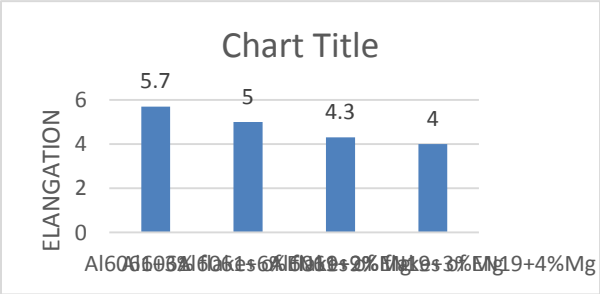

Figure 4.3. % of Elongation

4.4 APPLICATIONS OF COMPOSITES

This is a brief listing of current and proposed applications of composite materials in various branches of industry. It is not intended to be comprehensive or all embracing, but merely to give an indication of the range of possibilities for designers.

1. Aerospace
2. Automotive Engineering
3. Bioengineering
4. Chemical Engineering
5. Electrical Engineering
6. Marine Engineering
7. Sport

CONCLUSION

In this paper the aim is to study and investigate the tribological behavior of different percentage of Silicon Carbide with Boron Carbide particulates in Aluminum 6061 matrix hybrid composite. Hardness test, Tesile test were performed and the following results were obtained:

1. The fabricate Al6061 alloy and composites with 3,6,9wt % flakes of EN19 and 2,3,4g of Mg reinforcements were found using stir casting method.
2. The uniform distribution of the particles was get in the Al6061/9 wt % flakes of EN19 and 4g of Mg cast at stirring speed of 600 rpm as compared to the other composites. From optical microscope is observed in the 6061 Al alloy matrix and other reinforcements act as a good bonding.
3. Hybrid composites showed high hardness as compared to unreinforced alloy due to hard phase silicon carbide and Titanium particulates bonded uniformly in aluminum 6061 based matrix.

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