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Experimental and Investigation of Aluminium Metal Matrix Composite and Its Application

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***Abstract*-Aluminium metal matrix composites are gaining widespread acceptance for automobile, aerospace, agriculture farm machinery and many other industrial applications because of their essential properties such as high strength, low density, good wear resistance compared to any other metal. The addition of reinforcements into the metallic matrix improves the stiffness, specific strength, wear, creep and fatigue properties com- pared to the conventional engineering materials. This paper presents the overview of the effect of addition on different reinforcements in aluminium alloy highlighting their merits and demerits. Major issues like agglomerating phenomenon, fiber-matrix bonding and the problems related to distribution of particles are discussed in this paper. Effect of different reinforcement on AMCs on the mechanical properties like tensile strength, strain, hardness, wear and fatigue is also dis- cussed in detail.**

***Keywords*-Aluminium; Reinforcement; Stir Casting AMCs, SEM, Tool wear etc.**

I.INTRODUCTION

The motive behind the use of metal matrix composite components in the automotive, agriculture and mining sectors is based on requirements for weight reduction and in pursuit of high efficiency and performance in the material. The automotive industry is subjected to increasingly restrict fuel economy requirements by consumers, demanding improved comfort and safety. To meet these requirements, automotive manufacturers are turning to light weight and improved efficient products. Aluminium metal matrix composites (AMMC's) with high specific stiffness and high strength could be used in long-term application in which saving weight is an important feature, such applications include robots, high speed machinery, high-speed rotating shafts, and automotive engine and brake parts.

Aluminium metal matrix composites (AMMC) are the composites in which aluminium is used as the matrix and several reinforced materials are embedded into the matrix. Some of the reinforced materials are silicon carbide, graphite, fly ash, particulate alumina, red mud, cow dung The combinations provide unique properties. The composite industry has begun to recognize the commercial application of composites which promise to offer much larger business opportunities in aerospace and automotive sectors [2]. The most commonly used metal matrix is aluminium, magnesium, titanium and their alloys. The AMMC can be manufactured by various manufacturing techniques such as stir casting, powder metallurgy, pressure infiltration, squeeze casting [6], chemical vapor deposition etc. Amongst all the processes, stir casting is the most common method used by the researchers.

The development of metal matrix composite with SiC in various proportions and its mechanical and machinability properties have been studied. Recently due to the necessity of engineering materials with high strength, increased wear resistance and enhanced temperature performance hybrid aluminium metal matrix composites are developed. Al2O3 is one of the widely used second reinforcement. But it has its own demerits like poor wetting behaviour with aluminium and more weight percentage leads to increase in porosity. An attempt has been made to fabricate Al/SiC/Al2O3 composite in our previous work. In this present work an attempt has been made to introduce TiB2 an outstanding reinforcement among all the other reinforcements.

The enormous amount of R&D that has gone into Al-based MMCs of every possible alloy with different dispersoids establishing beyond doubt the usefulness of making composites but a choice has to be made with both the base alloy selection and dispersoid size and volume percentage for making engineering components. Another point is that all engineering components will undergo somewear related degradation with use even in an otherwise nonwear environment.

The popularity of aluminium grew due to its good attributes related to its unique properties, mainly of light-weight combined with good thermal/electrical conduction and reasonably good strength and resistance to corrosion. With alloying, aluminium has found more applications

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than previously envisioned, making aluminium a serious competitor with the traditional "strong" metals iron and steel.

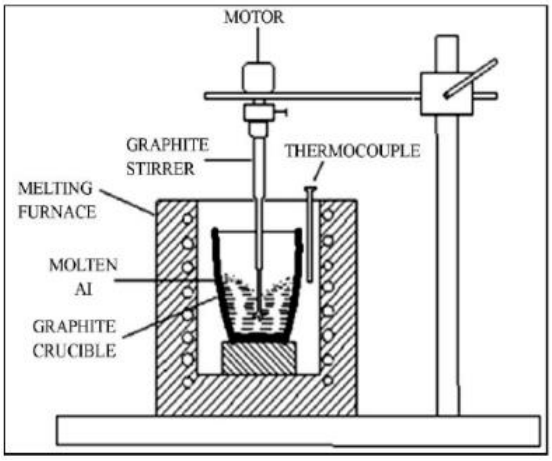

Fig 1 Stir Casting Process.

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II. LITERATURE REVIEW

The constituents have to be present in reasonable proportions, and the constituent phases should have distinctly different properties, such that the properties of the composite are noticeably different from the properties of the constituents. The constituent which is continuous and, in most cases, available in larger quantities is termed the matrix. It is commonly viewed that it is the properties of the matrix that are improved upon in the process of producing a composite. The second constituent is known as the reinforcing phase, or reinforcement, as it enhances or reinforces the mechanical properties of the matrix. In most cases the reinforcement is harder, stronger and stiffer than the matrix, although there are some exceptions.

In the early development of MMCs, continuous ceramic fibres and single-crystal ceramic whiskers were the preferred reinforcements as they provided the most remarkable increase in strength and stiffness. Later, particulate and discontinuously reinforced MMCs then followed, registering substantial progress on many fronts especially in composites with aluminium as the metal matrix. In aluminium metal matrix composites (AlMMCs), aluminium or its alloy forms a percolating network and is the matrix phase, while the other constituent, which is embedded in this matrix, is the reinforcement. The reinforcement is usually ceramic such as silicon carbide (SiC) or aluminium oxide (Al2O3).

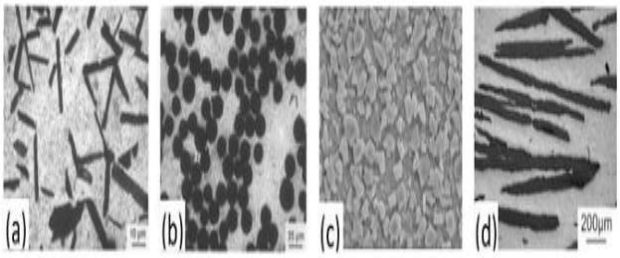

Fig 2 (a) Al/Al2O3 platelets. (b) Al/Al2O3 continuous fibres. (c) Al/SiCp. (d) Al/graphite with 20 vol.% graphite flakes taken along the basal plane.

III. EXPERIMENTAL SETUP

Aluminium metal matrix composites are suitable replacements, not only for steel but also for aluminium alloys in various automotive systems and components. There are many ways to achieve light-weight without compromising the strength and safety requirements. Ideally, it is common practice to completely replace the existing structural material with the material of higher yield strength, with a possible reduction in section dimensions. The other way of achieving weight saving is to selectively replace conventional steel at specific areas with the lighter materials. By applying the mass reduction techniques, the mass of vehicles can be reduced independent of vehicle size, functionality, class or model. In most of these techniques, lower density aluminium composites continue to replace the carbon steels. Aluminium-based engine blocks, suspension components, body panels and frame members are increasingly becoming common.

The possibility to further enhance the thermal conductivity (TC) of the composite material by the use of high TC reinforcements and the flexibility to adjust the CTE by controlling the volume fraction of the reinforcement. Aluminium and copper were usually used as matrices due to their high TCs, and the reinforcements involved SiC, carbon and diamond. However, owing to the fact that the specific thermal conductivity of aluminium-based composites was higher than that of Cu-based composites, aluminium-based composites are more desirable in avionic applications where light-weight is demanded. the powder metallurgy bristles are normally used or fibers of reinforcing materials tailored. These are usually bonded to the matrix powder and then compressed to combine the matrix. In most cases, a gap in the process is the end of porosity. In addition, there is a multi-layered nature in obtaining an arrangement of the reinforcing material. There are two ways to make a bond that can be considered a throw. In the main technique, a continuous reinforcing fiber through a liquid metal pot is preferred.

Al matrix with minerals. Moreover, in the distributed publications, tribological studies of mineral-enriched

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composite materials having particle size diversity and media measurement have not been effectively concentrated. Wear characteristics at high temperatures and moreover under heavy duty must be investigated for auxiliary applications at high temperatures.
Method is used for small examples of composites containing metal son or cooked in aluminum mesh, silver, magnesium, copper and their compounds dissolving outbreaks explicitly used extremely low. The composites are framed under vacuum by casting the matrix around the coated fibers

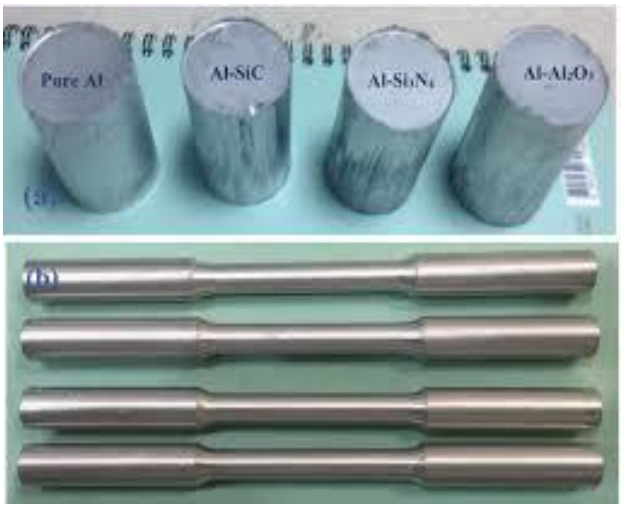

Fig 3 Metal Matrix Composites using microwave sintering.

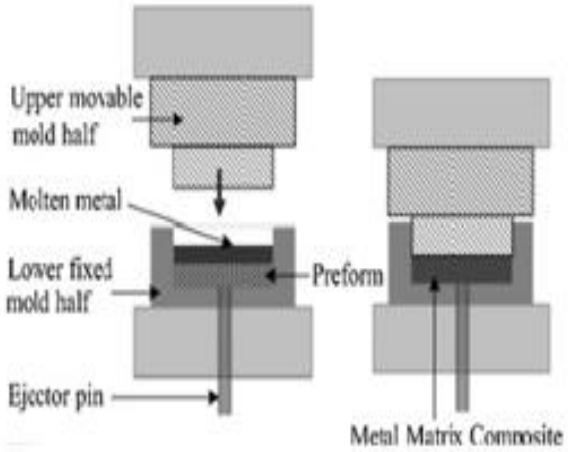

Fig 4 Squeeze Casting Infiltration.

IV. EXPERIMENTAL INVESTIGATION

It was found by generating thermal stress response curve for varying proportions of SiC and graphite that increasing amount of graphite in SiC reinforced base alloy points to higher strain rate but the low coefficient of thermal expansion values.

Increasing the graphite content leads to grain refinement for both primary and aluminium dendrites and eutectic silicon. Thus, it results in low thermal expansion. On the other hand, the inclusion of more amount of graphite gives a dimensional stability to the composite because the graphite particles absorb thermal expansion due to their layered structure. It was found by generating thermal stress response curve for varying proportions of SiC and graphite that increasing amount of graphite in SiC reinforced base alloy points to higher strain rate but the low coefficient of thermal expansion values. Increasing the graphite content leads to grain refinement for both primary and aluminium dendrites and eutectic silicon.

Thus, it results in low thermal expansion. On the other hand, the inclusion of more amount of graphite gives a dimensional stability to the composite because the graphite particles absorb thermal expansion due to their layered structure. The scanning electronmicroscope (SEM) and optical microscope was usedfor examine the microstructure of composites. Thevarious effects on microstructure and strength havebeen studied due to stirring speed and time. Byincrease in stirring speed and time resulted in uniformdistribution of particles, the mechanical propertieshardness of composites is also affected by stirringspeed and stirring time. The most uniform value ofhardness was achieved at 580 rpm with 12 min.stirring.

Fig 5 Stir Casting.

The design of Taguchi parameters is an important tool for a dynamic design. It provides a simple and methodical way to improve design, quality and cost. The Taguchi method is a mixture of the theory of analysis design and work on the quality of the disaster. This idea is related to the coherent design of elements and processes.

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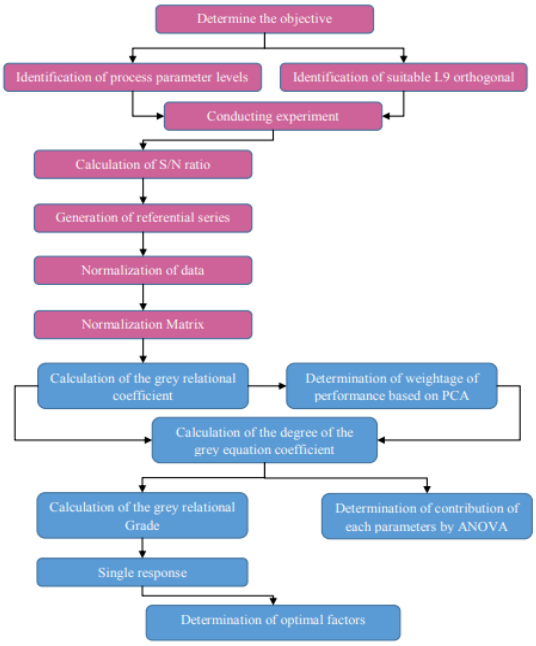

Fig 6 GRA-PCA method table.

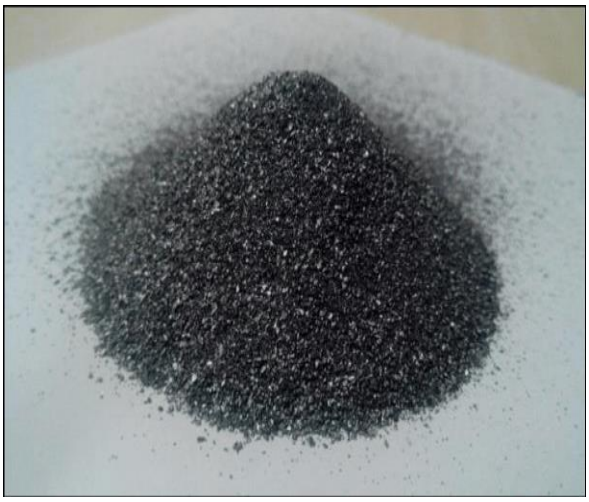

Fig 7 Ferro alloy.

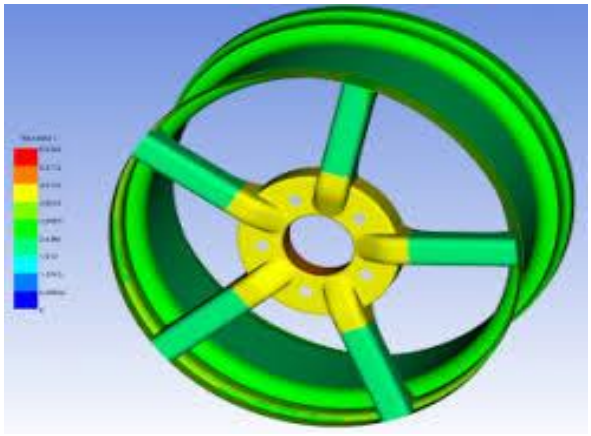

Fig 8 Composite Part.

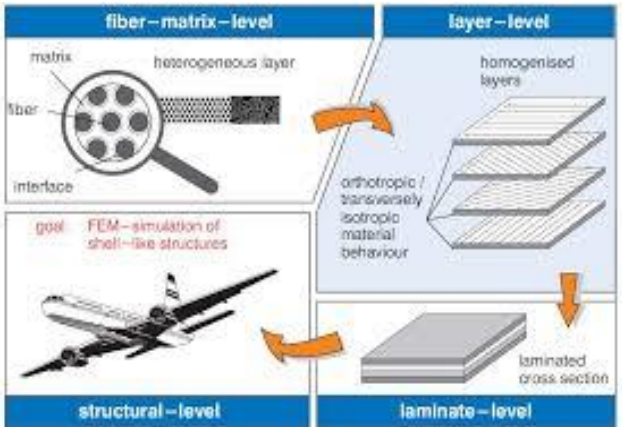

Fig 9 Composites modelling with ANSYS.

V. RESULTS AND DISCUSSION

Aluminium metal matrix composites are very attractive as materials for sporting goods applications. The material used generally consists of an aluminium matrix reinforced with particles of silicone carbide or boron carbide. The specific strength and modulus of these materials can offer design advantages not possible with steel or carbon/epoxy composites.

Wear test was carried out and a graph is plotted using experiment results.Wear resistance property of composite increases due to the addition of TiB2. Test is carried out for 60 minutes and the wear value of Sic-10% and 0% of TiB2 is 118.11µm whereas for Sic-10% and 2.5% of TiB2 is 94.03 µm. This show wear resistance property increases by 20% due to addition of TiB2. Also the results show that 5 % of TiB2 reduces wear resistance property. This is probably not due to TiB2 addition but porosity of the specimen.

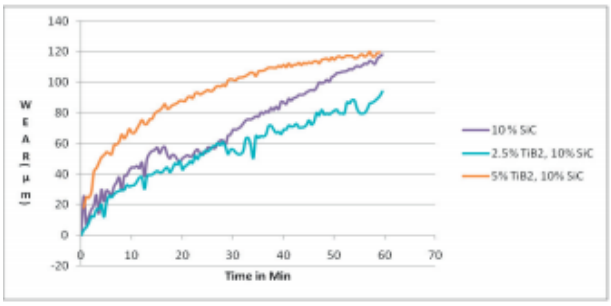

Fig 10 Wear Vs Time.

This is due to pull out of abrasive particle during machining and the broken abrasives which slide along with work piece during turning operation. Abrasive particles which has been also observed in micro structural analysis leads to poor surface finish and the optimal machining parameter for good surface finish. Aluminium Matrix Composites (AMC) are used forfabrication of aeronautical and aerospace components,automotive parts

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like pistons, cylinders, head and block,chassis, connecting rods, brake components,clutchesetc, brake rotors for high speed trains, bicycles,golf clubs, electronic substrates, cores for highvoltage electrical cables, defence weapons, safetyinstrument like Bullet proof jacket, Helmet, Bulletscarrier.

The maximum hardness was obtained at the peakaging 6h of heat treatment and wear rate increasedwith increasing sliding speed and load. AdditionofSiC particle increased the seizure pressure andtemperature. The uniform distribution of SiCparticles in aluminium alloy matrix was observedand the dendrites of Al and precipitates along theinter-dendritic regions were present. Low cutting speed causes high cutting force which leads to rise in temperature. This is due to aluminium's affinity to stick to the cutting edge of the tool. It has been observed from the experiment that built up edges is due to high depth of cut and low cutting speed.

VI.CONCLUSIONS

- The addition of the SiC particulates improved thewear resistance by a factor of two in the mild wearregion, and the transition temperature was raised by approx. 50 °C.
- New developments in CNT and nanotechnology have, for example, offered possibilities of production of AlMMCs with enhanced properties for high-temperature applications and improved wear and corrosion resistance. Other developments such as the novel rheocasting process of semi-solid alloys and FGMs have also offered new possibilities of cost reduction in primary production and secondary processing of AlMMCs, respectively. New alloys of aluminium have been developed for application in such areas as crash management (crash alloy)—an area previously dominated by steel. These alloys offer new R&D opportunities for further development of AlMMCs and will redefine new roles and potential of AlMMCs in automotive applications.
- The results underline the fact that for the 14% fly ash fixer with a different SiC content, the wear volume is poor compared to other flyash creations. SEM studies of wear examples were examined along these lines and an example of a minute surface was observed.

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