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A Review on Aluminium (LM 25) reinforced with Boron Carbide (B_4C) & Tungsten Carbide (WC) Hybrid metal matrix composite for Automotive Applications

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Abstract - *Automobile & Aerospace industries are eager on introducing Hybrid aluminium metal matrix composites due to their excellent mechanical & tribological properties which makes reduction in the weight of the component. In the present study, based on the literature review, the fabrication of Hybrid Aluminium metal matrix composite (Al/ B_4C/WC) is discussed. This fabrication of Hybrid Aluminium metal matrix composites can be done by Liquid State Metallurgy process called Stir Casting Technique. Material Selection for the fabrication of Hybrid Aluminium metal matrix composite (Al/ B_4C/WC) is discussed. The reinforcement particulates like Boron Carbide (B_4C) & Tungsten Carbide (WC) weight percentage is selected. For the Evaluation of Mechanical & Tribological of Hybrid Aluminium metal matrix composite (Al/B_4C/WC) selection of experimentation tests which can be done are discussed. Microstructures of Aluminium (LM25) reinforced with Boron Carbide & Tungsten Carbide composites worn surface were discussed. Carbide Hybrid Aluminium metal matrix composite helps us to know the recent technology in automotive industry.*

1. INTRODUCTION

Composites are the combination of two or more constituent material with significantly different physical and chemical properties with characteristics different from individual components. They commonly consist of a continuous phase called matrix and discontinuous phase in the form of fibers, whiskers, or particles called as reinforcement. Due to their characteristics of behavior with their high strength to weight ratio, Composite materials are gaining wide spread acceptance. Recently modern industry rapidly introducing different composites due to their unique properties such as low density and very light weight with high temperature strength, hardness and stiffness, high fatigue strength and wear resistance, in order to meet the challenge of liberalization and to maintain global competitiveness in the market. Side by side modern manufacturing engineers are also trying to introduce the better properties in the composite like, hybridizing our usually available conventional composites. Hybrid Metal Matrix Composites (HMMCs) are materials with metals as the base and distinct (Matrix) phase and typically the two or more ceramic phases added as reinforcements to improve the mechanical properties. In current decade, demand in material characteristics like light weight, superior strength to weight ratio, improved surface properties and enhanced wear resistance for complex engineering applications like automobile, aerospace and nuclear are researcher's interest. However, performance of hybrid composites depends on right combination of reinforcements. Excellent mechanical performance, high working temperature, wear resistance, low creep rate etc are the main advantages of HMMCs. The aluminum alloy, reinforced with two or more discontinuous ceramic reinforcements, is rapidly replacing conventional materials in various automotive, aerospace and automobile industries. In the field of automotive industry, HMMCs are used for pistons, brake drum and cylinder block because of better corrosion resistance and wear resistance.

Hybrid composites primarily consist of one matrix and two or more reinforcement. Hybrid Composite materials are produced by reinforcing two or more materials of varying properties with matrix phase. Various processing routes have been in use for the fabrication of HMMCs. Selection of a proper processing technique for the fabrication of HMMCs is very important since the properties and cost are determined by the used fabrication method. The processing routes can be classified based on the state of the matrix, i.e., whether it is in liquid or solid or vapor state during processing. Generally the fabrication of aluminium based HMMCs was done Stir Casting method. In general, the major advantages of Hybrid metal matrix composites over monolithic materials e.g. iron, steel and other non-ferrous common metals are as follows:

- High specific strength
- High specific stiffness
- Higher elevated temperature strength
- Improved wear resistance
- Low density
- High strength to weight ratio
- Improved damping capabilities
- Good Thermal expansion coefficients

2. Literature Review

Blaza et. al. [1], studied on Hybrid aluminium metal matrix composites application in the automotive industries for the production of engines, piston rings, cadar shaft &

sockets are studied. The use of Hybrid aluminium metal matrix composites instead of monolithic or metal matrix composites results in reduction of weight improves the decrease in fuel consumption of automobile vehicles.

G. Sivakaruna et. al. [2], conducted a survey was made on effects of reinforcement on aluminium metal matrix composites. The reinforcements are ceramics materials like Silicon Carbide, Aluminium-di-oxide, Boron Carbide & Tugsten Carbide which are reinforced with aluminium & their properties were studied. The survey results the ceramic reinforcement materials improves the mechanical properties like Tensile strength & Hardness compared with base metal aluminium.

N. Venkat Kishore et. al. [3], studied on Al (LM25) is reinforced with the Boron Carbide (B_4C) metal matrix was produced. The fabricated composites were introduced to study the Wear behaviour in Wear testing machine. Wear rate decreases and an increasing trend of hardness and Tensile strength with increase in weight percentage of B_4C. This showed B_4C reinforcement particulates improves the mechanical & wear resistance.

Keshav singh et. al. [4], investigated on Fabrication & Characterization of Aluminium (LM25) metal matrix reinforced with Boron Carbide (B_4C). In the study the fabricated MMC showed very good Tensile strength. 7% weight fraction of Boron Carbide showed very good Hardness & Tensile strength. Increase weight fraction of Boron Carbide reinforcement with base alloy Al increases the mechanical properties of MMC was studied.

A.Basithrahman et. al. [5], investigated on Wear Behaviour of aluminium Hybrid Metal Matrix Composites. Hybrid aluminium metal matrix composites are fabricated by stir casting method. Aluminium is used as a matrix material & Al_2O_3, B_4C & SiC are used as reinforcement particles. The weight fraction of & Al_2O_3 is varied, B_4C & SiC are kept constant. The fabricated composites are machined for Wear Test according to ASTM standard. Wear test was done by varying load of 9.81N, 19.62N, 29.43N & 39.24N. The microstructural study of worn specimens was done using Scanned Electron Microscope (SEM), which revealed the uniform distribution of reinforcement particles with base metal.

Michael et. al. [6], investigated on different combination of reinforcements used in the production of Hybrid Aluminium metal matrix composites & studied the mechanical, corrosion & tribological characteristics. Comparison of Hybrid Aluminium metal matrix composites with single reinforcement composite is done which showed the improvement in the mechanical, corrosion & tribological properties as increase in the weight fraction of reinforcement with the base metal.

Siddhartha Prabhakar et. al. [7], investigated on Hybrid aluminium metal matrix composites which was fabricated by reinforcing 5 % weight fraction of Boron Carbide (B_4C) with aluminium (LM25) using stir casting method. The fabricated of Hybrid aluminium metal matrix composites were introduced for the study the wear behaviour using wear testing machine. The wear test results showed low wear loss compared with the base metal.

V.M. Ravindranath et. al. [8], investigated on Aluminum is reinforced with 8% Boron carbide and 3% Graphite particulates. Hybrid Aluminium metal matrix were produced by stir casting method. Wear test is conducted by pin-on-disc wear testing machine at room temperature on Hybrid composite & base alloy. The wear behavior of composites was studied by varying various parameters such as normal load; sliding distance and sliding speed were taken for this study. The result shows that wear rate increase with increase in load and sliding distance. The worn out surface was analyzed by Scanning Electron Microscope (SEM).

T.S.A. Suryakumari et. al. [9], investigated on Hybrid Al MMC was fabricated by stir casting method. The experimental result showed the enhanced mechanical properties, tensile strength & microstructure of Hybrid Al MMC. The addition of reinforcement particulates improved the hardness and the improved wear properties. The micro graphs of hybrid composite studied and revealed the uniform distribution of reinforcements in the matrix.

K. Punith Gowda et. al [10], conducted investigation on 5% weight percentage of Tungsten Carbide (WC)which was reinforced with aluminium by liquid metallurgy process. The Al/WC metal matrix composites were subjected to study the mechanical properties like Tensile strength, Hardness & Impact strength. The results of this study showed addition of Tungsten Carbide (WC) with aluminium improved the mechanical properties.

N. Venkat et. al. [11], conducted investigations on Al (LM25) & Boron Carbide (B_4C) in which they were took as matrix & reinforcement respectively. The weight percentages 5%, 7.5% & 10% of B_4C were reinforced with Al (LM25) using Stir Casting method. Further wear test was carried which results wear rate increases with increase in weight percentage of B_4C with Al (LM25). The internal structure of the composite was observed using Optical Metallurgical Microscope.

M. Marimuthu et. al. [12], conducted investigation on tensile properties, hardness and microstructure of Al-Boron Carbide particulate composites fabricated by stir casting were studied. The composites are prepared with of size ranging from 30 to 100 μm by varying weight % from 3 to 7%.he revealed that the tensile properties and hardness

are increased at 6% weight of B_4C. From SEM, the uniform distribution of B_4C particles was observed

V.Chandramohan et. al. [13], conducted investigation on the fabrication of Al/Graphite/Boron Carbide Hybrid metal matrix composite was done using stir casting process and studied the properties of the fabricated composite. The study showed the Tensile strength of composite material compared to the as cast Al LM25 alloy, increased significantly by 60-70%. From the microstructure analysis it is evident that the composites fabricated have fairly even distribution of reinforcements in the composite material.

T. Thirumala et. al. [14] studied on fabrication of Al reinforced with Graphite & Boron Carbide Hybrid metal matrix composite by using stir casting method. The prepared composite showed the improvement in Hardness, as increase in weight fraction of reinforcement materials like Graphite & Boron Carbide. This study reviewed that mechanical properties can be improved by the addition of Graphite & Boron Carbide to the base metal aluminium.

L. Prince Jeya La et. al. [15], studied on Aluminium hybrid composites were fabricated by reinforcing Boron Carbide (B_4C) with aluminium using Stir casting method. The wear test was carried, to investigate the fabricated Aluminium hybrid composites in wear testing machine (pin-on-disc). The wear test results showed the decrease in weight loss & wear rate as increase in weight percentage of Boron Carbide (B_4C) with aluminium.

3. Microstructure Study

The study of microstructure is very useful for the analysis of properties & proportion of reinforcement particulates mixing with the matrix. Microstructure studies of composite worn surfaces were examined in Scanning Electron Microscope. The scanning electron microscope (SEM) is a type of electron microscope that images the sample surface by scanning it with a high-energy beam of electrons in a raster scan pattern. The electrons interact with the atoms that make up the sample producing signals that contain information about the sample's surface topography, composition and other properties.

The SEM microstructures of Al+B_4C composite is shown in the figure 2 where Boron Carbide particulates were dispersed uniformly with the Aluminium matrix. Good retention of tungsten carbide particles was clearly seen in the microstructures of Al/WC composites in the figure 3. Micro structure discussion shows the uniform distribution of Boron Carbide & Tungsten Carbide particulates with the Aluminum. The microstructure also revealed good interfacial bonding between Aluminium and reinforcement particulates like Boron Carbide & Tungsten Carbide. The work has to be extended for reinforcing Boron carbide and tungsten carbide has to be extended.

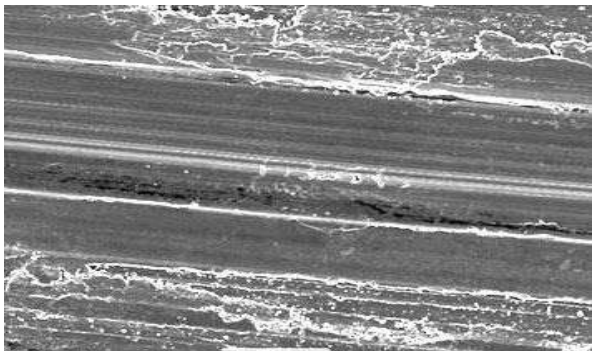

Figure 1: SEM micrographs of worn surface of Base alloy Aluminium (LM25)

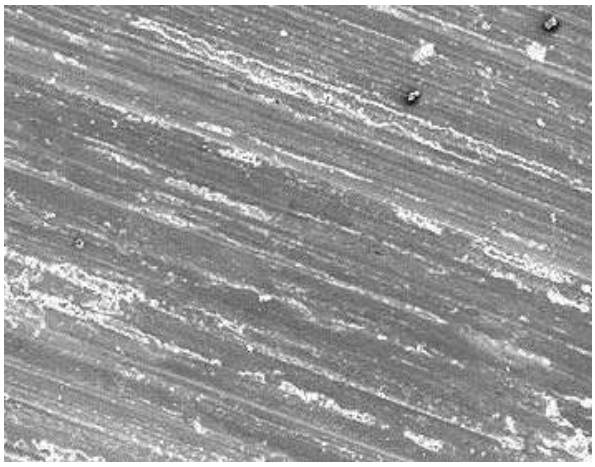

Figure 2: SEM micrographs of worn surface of Al (LM25) +B_4C composite

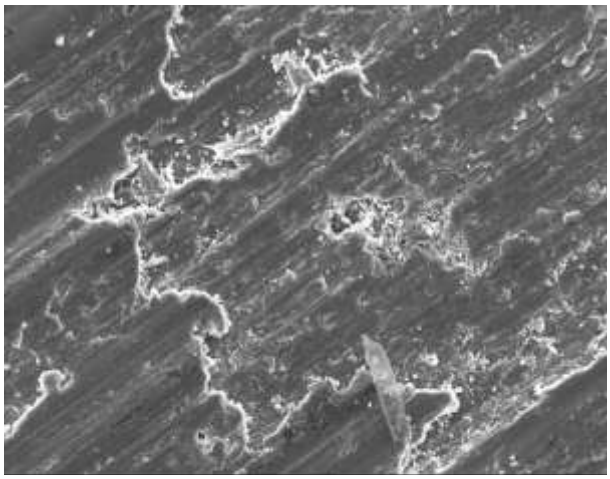

Figure 3: SEM micrographs of worn surface of Al (LM25) +WC composite

4. Conclusions

From the literature survey, it is clear to know the recent technology aided with the composite materials like Hybrid aluminium metal matrix composites manufacturing and its applications. Different methods for production of Hybrid aluminium metal matrix composites were studied. Selection of materials like Boron Carbide (B_4C) & Tungsten Carbide (WC) can be used for the fabrication of Hybrid aluminium metal matrix composites by stir casting process. From the study, Stir casting method can improves the distribution of reinforcement particulates with base metal compared to other method. The investigation shows the increase in weight percentage of Boron Carbide (B_4C) with Aluminium (LM25) can improves the mechanical & tribological properties of the composite. The mechanical properties like tensile strength, impact strength, and hardness can be increased with increase in content of reinforcement. The tribological properties were concluded that the wear resistance increases with increase in content of reinforcement. The microstructure study of Aluminium reinforced with Boron Carbide & Tungsten Carbide was discussed. It was concluded that the use of Hybrid aluminium metal matrix composites instead of monolithic or metal matrix composites results in reduction of weight which improves the decrease in fuel consumption of automobile vehicles.

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