A Review Paper on Study of Aluminum Matrix Composite

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Abstract -- *A composite material 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. Development of composite materials is a major step in the optimization of materials. Current engineering applications require materials that are stronger, lighter and less expensive. Conventional monolithic materials have limitations with respect to composite material. Development of hybrid metal matrix composites has become an important area of research interest in Material Science. Hybrid composite material containing Aluminum 6061 as matrix and B4C and fly ash as reinforcements with varying weight percentages of 3%, 6% and 9%. Stir casting method was selected for manufacturing of composite. After manufacturing the specimen mechanical behavior of these specimens were studied by carrying out tensile test, compression test, impact strength, hardness and wear test. The aim of the present investigation is provide the detailed study on effect of hybrid reinforcement on mechanical and wear behavior of aluminum matrix composite. From experimental results, we will compare mechanical properties like tensile strength, compressive strength, hardness & wear with base material.*

Key Words: Composite materials, conventional monolithic materials, reinforcements, aluminum matrix composite.

1. INTRODUCTION

Aluminium (Al) is one of the most plentiful elements on earth and it became an economic competitor in the engineering applications at the end of the 20th century. In recent years the efforts were done to make the aluminium alloy products at low cost and low density. Among various discontinuous dispersions used fly ash has been found to be one of the most inexpensive and low density reinforcement available in large quantities as solid waste. Hence, composites with fly ash as reinforcement are likely to overcome the cost barrier for wide spread applications in automotive and small engine applications [1]. Boron carbide (B4C) is an extremely hard reinforcement material with excellent hardness, corrosion resistance, and mechanical properties, which makes it a desirable material for a number of engineering applications. Aluminum and aluminum-based metal matrix composites (MMCs) have become attractive engineering materials in several applications, such as armor, the nuclear- power industry, for aerospace, automotive, marine, and automobile products because of their low density and superior mechanical properties such as hardness, wear resistance, and tensile and flexural strengths. Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. The composites industry has begun to recognize that the commercial applications of hybrid composites to offer much larger business opportunities than the aerospace sector due to the sheer size of transportation industry. Thus the shift of composite applications from aircraft to other commercial uses has become prominent in recent years.

1.1 Classification of Composites

Matrix material can be classified into following groups:-

a) Metal-matrix composites (MMC)

The matrix in these composites is a ductile metals. These composites can be used at higher service temperature than their base metal counterparts. These may improve specific stuffiness specific strength, abrasion resistance, creep resistance and dimensional stability. The MMCs are light in weight and resist wear and thermal distortion, so it is mainly used in automobile industry. They are much more expensive than PMCs and, therefore, their use is somewhat restricted.

b) Ceramic-matrix composites (CMC)

One of the main objectives in producing CMCs is to increase the toughness. Ceramics materials are inherent resistant to oxidation and deterioration at elevated temperatures; some of these materials would be ideal candidates for use in higher temperature and severe- stress applications, specifically for components at automobile an air craft gas turbine engines.

c) Polymer-matrix composites (PMC)

The most common matrix materials for composites are polymeric. Polyester and vinyl esters are the most widely used and least expensive polymer resins. These matrix materials are basically used for fiber glass reinforced composites. For mutations of a large number resin provide a wide range of properties for these materials .The epoxies are more expensive and in addition to wide range of ranging commercials applications, also find use in PMCs for aerospace applications.

d) Hybrid Composites

Hybrid composites are more advanced composites as compared to conventional simple composites. Hybrids can have more than one reinforcing phase and a single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing and multiple matrix phases. They have better flexibility as compared to other composites. In general, the major advantages of Hybrid Matrix Composites (HMMCs) over composite materials 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
- High thermal expansion coefficients
- Good corrosion resistance etc.

1.2 Classification of Reinforcements

a) Particle reinforced composites

Particulate reinforcements have dimensions that are approximately equal in all directions. The shape of the reinforcing particles may be spherical, cubic, platelet or any regular or irregular geometry.

b) Fiber reinforced composites

A fibrous reinforcement is characterized by its length being much greater than its cross-sectional dimension. However the ratio of length to the cross sectional dimension known as the aspect ratio, can vary considerably. In single layer composite long fibers with high aspect ratios are called as continuous fiber reinforced composites whereas discontinuous fiber reinforced composites are fabricated using short fibres of low aspect ratio. The orientation of the discontinuous fibres may be random or preferred.

2. LITERATURE REVIEW

The research efforts and directions related to the present work have been identified through literature survey. The research papers concerning with the various properties of composite materials are discussed in this section.

Vipin K. Sharma et. al. [1] have investigated effect of fly ash particles on the wear of aluminum metal matrix composite. Stir casting method was used to fabricate the MMC with 2, 4 & 6% weight of fly ash contents in aluminum. The wear resistance of the fabricated composites increases with the increase in the fly ash contents. The composites with 6% fly ash contents resulted in 13.6% less wear as compared to 2%fly ash content composites. The sample with fly ash content 4% resulted in the lowest average coefficient of friction (0.12) and sample with high fly ash contents 6% shows the maximum average coefficient of friction (0.161).

Sumit Kumar Tiwari et. al. [2] studied effect of heat treatment on mechanical properties of aluminum alloy-fly ash metal matrix composite. This study reveals that, there is an improvement in tensile strength, compressive strength, hardness as we increases the weight percentage of fly ash & there is an decrease in ductility with increase percentage. Also it is concluded that the tensile strength, compressive strength & hardness decreases with increase in particle size of fly ash. Heat treatment and ageing further improves these properties.

I.A. Alkadir et. al. [3] investigated effect of B4C/fly ash addition on wear and mechanical properties of Al-Cu-Mg alloy. Stir casting method has been used to fabricate the alloy and hybrid composite samples containing 2wt% of B4C and 5, 10, 15‹20 wt % fly ash. The results showed an increase in the tensile and yield properties with the increase of weight percentage of fly ash content up to 15%. Wear rate examination has been concluded by using pin on disc apparatus under different loads and sliding velocities. The results showed decrease in wear rate at 20% fly ash composite sample when compared with other composites samples and base alloy.

Şener Karabulut et. al. [4] have evaluated influence of B4C particle reinforcement on mechanical and machining properties of Al6061/ B4C composite. Four aluminum 6061 composite specimens reinforced with 5 wt. %, 10 wt. %, 15 wt. %, and 20 wt. % B4C were fabricated using a powder metallurgy and hot-extrusion method. Result revealed that the fracture toughness decreases and the hardness increases as the weight fraction of the reinforcement increases. The highest tensile and transverse rupture strength are for Al6061/5 wt.% B4C and Al6061 reinforced with 10 wt.% B4C composite material has the best fracture toughness.

Dinesh Patidar et. al. [5] studied effect of B4C particle reinforcement on the various properties of aluminum matrix composites. Initially by increasing the wt. % of B4C particles the hardness value increases drastically and with further reinforcement, the increase in hardness value is lower. The ultimate stress, breaking load, max displacement and flexural strength increases with reinforcement of B4C particulates in aluminum matrix. The wear rate and wear volume is found increasing by increase in load and sliding velocity and by decrease in weight percentage of boron carbide. The density was decreased with increasing the amount of the boron carbide in the matrix phase.

Temel Varol et. al. [6] investigated effect of reinforcement properties on the physical and mechanical properties of Al2024–B4C composites. Al2024–B4C composites with 5, 10 and 20 wt. % B4C for two different reinforcement size was fabricated by powder metallurgy method. The relative density decreased with increasing the content of B4C particles in the consolidated samples. The strengthening of composites was improved with the increasing milling time (from 1 h to 5 h), and then decreased with further increasing the milling time.

Mohd. Suhail et. al. [7] effect of process parameter on metal matrix composite (Al+4%Cu+5%Sic) by stir casting. In this 5% SiC as the reinforcement material and balanced Al + 4% Cu as matrix phase were used. The grit sizes of SiC were selected 400, 600 and 800 mesh. Results showed that the hardness of the composites found increased with increased grit size of SiC. Impact (Izod) of the composites found increased with increased grit size of SiC. The tensile strength of the composites found increased with increased grit size of SiC. The pouring temperature at 725°C which gave the best optimum value of hardness.

S. Mohan Kumar et. al. [8] evaluated mechanical and wear properties of aluminum AA430 reinforced with SiC and Mgo. Experiments were conducted by varying weight fraction of SiC + MgO (2.5%, 5% and 7.5%) while keeping all other parameters constant. An increasing trend of hardness and tensile strength with increase in weight percentage of SiC+MgO has been observed. The results also reveal that the wear rate of the test specimen's increase with the increasing load and sliding distance. The coefficient of friction slightly decreased with increasing volume content of reinforcement.

2.1 Gaps from literature

- Work is reported on synthesis of Al & Fly ash composite but Hybrid composite materials is not studied up to the mark as this hybrid composite is lighter one & has vast potential in disposing industrial waste fly ash.
- Work related to tribological properties of Al6061+ Fly ash + B4C is less on the progress.
- Least work is reported on stir casting parameters like melting temperature, holding time, speed & depth of stirrer has crucial effect on composite.
- Heat treatment & secondary processing like forging is not attributed in research work.

3. CONCLUSIONS

The conclusions drawn from the present investigation are as follows:

- The strength of the metal matrix like tensile strength increased as the addition of reinforcement particles increased. But the ductility of the base metal suffers by the presence of hard reinforcement particles and gradually reduced as these particles increased in the metal matrix.

- The increase in tensile strength (15.33%) was recorded by adding 7.5 weight percentage of reinforcement particulate as compared to adding 5 and 2.5 weight percentage of reinforcement particulate.

- As the percentage of reinforcement increased, the hardness of the metal matrix composite under test increased. The highest hardness (61BHN) was recorded by adding 7.5 5 weight percentage of reinforcements.

- The specific wear rate was reduced as the weight percentage of reinforcement increased.

- The wear rate of the specimen was high at higher load (60 N) as compared to lighter loads (20 N and 40 N).

The specific wear rate of metal matrix composite specimen was comparatively less as compared to base alloy at various loads (20, 40 and 60 N) and speeds (200, 400 and 600 rpm).

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