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Enhancement of Aluminium Composite for Lightweight Automotive Components

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ABSTRACT:

This review paper highlights the major components in the field of composites and investigates current and future trends in lightweight composite materials for automobile engineering. A composite is a material made up of two or more separate components that have been combined or blended to create a new material with better qualities. The composite material that provides exceptional strength-to-weight ratio and thermal performance for automotive applications will be covered in this article. Additionally, the effects of fly ash and graphite reinforcements on the mechanical and thermal properties of aluminum alloy 6061 will be assessed. Fly ash is a low-density reinforcement that is affordable, according to most recent research.

Keywords*:* Composites, Alloy 6061, Fly ash, Graphite, Reinforcement, Stir Casting.

1. INTRODUCTION :

Applications for metal composite materials have long been recognized in many facets of daily life. primarily because it weighs less than other metals and has a low density. Steel has a higher density than certain aluminum alloys (7000 series), which have a higher tensile strength. In the last several decades, composites (MMCs) have drawn more attention as engineering materials. When a ceramic material is incorporated into a metal matrix, a composite material is created that offers an appealing mix of mechanical and physical qualities that are not possible with monolithic alloys. Graphite, silicon carbide, titanium carbide, tungsten, boron, Al203, flyash, Zr, TiB2, and other reinforcements have all been tested in the development of aluminum matrix composites (AMCs).

Incorporating hard reinforcements like silicon carbide, alumina, and titanium carbide enhances the composites' strength, hardness, and resistance to wear. Alloys of aluminum continue to be the focus of intense research. Aluminum is used in automobiles to strengthen their strength and decrease their weight. As a result of weight reduction, the power to weight ratio rises and automotive fuel efficiency increases. Cast iron and bronze have begun to give way to these alloys in the production of wear-resistant components. In the production of parts like engine blocks, alloys, bolts, and master cylinders, the automotive industry is assisted in substituting aluminum for some other metals, such as steel and brass.

Reduced weight is associated with decreased fuel usage in cars, and Al-fly ash composites have been identified as suitable materials for automotive clutch plates. The inclusion of fly ash enhances ductility and significantly increases hardness, while graphite improves machinability. The 6000 series of aluminium alloys is chosen for its lower cost compared to other grades. However, the 6000 series have inferior hardness and tensile strength when compared to other aluminium grades. Therefore, to enhance its mechanical and chemical properties, reinforcement is increasingly utilized today. The study of the mechanical properties of aluminium alloys that are reinforced with microhard particles like graphite and fly ash is a compelling research topic.

2. REINFORCEMENT :

The filler material is the primary determinant of the resultant properties of any composite material. The selection of the filler material is the primary criterion in the design of any composite material, as the optimal results are directly linked to the selection and distribution of the filler material. In the current study, fly ash is chosen as the filler material. To enhance the bonding between the matrix and filler material, graphite is employed as a solid lubricant. The 6061-aluminum matrix was reinforced with fly ash and graphite, as determined by the literature review.

The aluminium metal matrix composite will be further fabricated using the stir casting technique, and the microstructural and mechanical characterization of the prepared composite sample will be examined using optical micrographs, a Universal Testing Machine, and a Brinell hardness tester. Three samples with varying fly ash and graphite compositions were compared, and the results showed that the specimen's compressive strength, percentage elongation, and hardness increased as the fly ash content increased. The effect of adding eggshell to the aluminum 6061 matrix through the powder metallurgy route was examined, and it was found that the eggshell was successfully reinforced with the Al matrix, resulting in a strong bond.

Further, it was observed that hardness of composite increases with the increase in % of eggshell.

3. MATERIALS :

3.1. Aluminium:

Aluminium is represented by the atomic number 13 and the symbol Al. Its density is approximately one-third that of steel, making it lighter than most common metals. Due to its strong tendency to bond with oxygen, it develops an oxide layer that safeguards its surface when it encounters air. The colour of aluminium and its remarkable light-reflecting capabilities give it a resemblance to silver. It is soft, ductile, and does not respond to magnetic fields. Aluminium is the twelfth most abundant element in the universe, largely because of its only stable isotope, 27Al, which is very prevalent. The isotope 26Al is used in radiometric dating because of its radioactive nature.

Aluminium shares a similar appearance to silver due to its coloration and impressive light-reflective properties. It is soft, malleable, and not magnetic. The Al7000 series is commonly used in contemporary industries because of its outstanding mechanical and tensile characteristics. However, the Al7000 series is the most expensive among all series. The high costs associated with the Al7000 series significantly increase material expenses. The primary goal of this project is to improve the mechanical characteristics of the Al6000 series by incorporating reinforcement materials to match the strength and properties of the Al7000 series. This approach can help lower costs while maintaining an equivalent level of mechanical quality with the Al6000 series. Consequently, this leads to cost savings in various practical applications.

3.2. Fly ash:

One of the leftovers produced after coal burning is fly ash. It is a byproduct of industry that is extracted from the flue gas of electric power plants that burn coal. The components of fly ash produced vary greatly depending on the coal's composition and source. The principal components of fly ash are Fe2O3, Al2O3, and SiO2, whereas the minor components are oxides of Ca, Na, Mg, and other elements. The physical characteristics of fly ash are mostly determined by the kind of coal burned and the burning environment. Class C fly ash is made from low rank coals, while Class F fly ash is made from burning high rank (high carbon) coals like bituminous and anthracite.

3.3. Graphite:

The addition of graphite, which has a particle size of 50 mm and is introduced in powdered form in a quantity of 1 kg, to cement in an aluminum matrix results in improved wettability and smoother machining.

The below table gives the chemical composition of 6061Al.

Si	**Fe**	**Cu**	**Mn**	**Ni**	**Pb**
0.43	0.7	0.24	0.139	1.05	0.24
Zn	**Ti**	**Sn**	**Mg**	**Cr**	**Al**
0.25	0.15	0.001	0.802	0.25	Balance

Table 1 – Composition of Al 6061

4. METHODS FOR MANUFACTURING :

4.1. Stir casting:

In the stir casting process, a mechanical stirrer is used to create a vortex that mixes reinforcement into the matrix material. Because of its affordability, mass production suitability, ease of use, nearly net shaping, and simpler control over the composite structure, it is a good procedure for creating metal matrix composites. Stir casting is a cost-effective method that is favoured for large-scale manufacturing, making it an appropriate processing technique for creating aluminum matrix composites and hybrid aluminium matrix composites.

To achieve uniformity during the solidification of the manufactured composite, reinforcement is aggressively introduced to the molten stage of aluminium and is dependent on the following criteria.

- Time and stirring speed
- Stirring blade angle
- Reinforcement size, percentage, its relative density
- Pouring temperature and solidification rate.

4.2. Tensile test:

A key test in engineering and materials science is tensile testing, often known as tension testing, which involves subjecting a sample to controlled tension until it breaks. A tensile test can ascertain properties such as ultimate tensile strength, breaking strength, maximum elongation, and decrease in area firsthand. Utilizing these findings, one may compute Young's modulus, Poisson's ratio, yield strength, and strain hardening characteristics. Uniaxial tensile testing is the technique most used to ascertain the mechanical characteristics of isotropic materials. Biaxial tensile techniques are used to test certain materials.

4.3. Hardness test:

One type of aluminum alloy that is frequently utilized in many industrial applications is Al6061. It is possible to ascertain the hardness of the alloy using a variety of testing methods, such as the Brinell, Rockwell, Vickers, and Knoop trials. The Vickers Hardness test is like the Rockwell test; however, it uses a diamond pyramid indenter that is square in shape. The size of the indentation is measured, and the hardness value is computed based on the force exerted and the surface area of the indention.

4.4. Microstructure analysis:

Microstructural study usually uses optical or scanning electron microscopes to magnify properties of the material being examined. It is possible to compute and compare the size and quantity of these attributes to acceptable norms. In failure analysis, these investigations are commonly used to determine the type of material in question and if the material was processed appropriately.

4.5. WEAR TEST:

The rotating disk uses the output to receive standard loads in this test. Both scenes and return sliding movements are possible. Tests can perform drying or lubrication. This test can provide friction coefficients at any stage of friction coefficient or experiment. To ensure proper contact with the disk, the test surface was polished using various kinds of dinner. The sample was loaded with slippage and was closely contacted with the rotary disk on the radius of the path. The circular disk was rotated throughout the test, and the fixed sample was maintained perpendicular to the disk. The wear test was performed under various working conditions and used the electronic sensor to monitor wear and record it in the system.

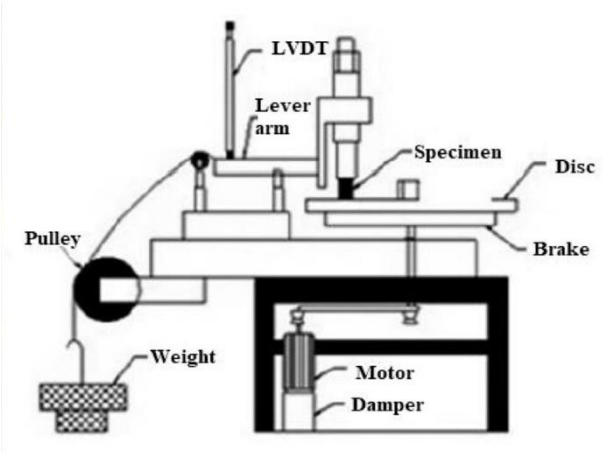

Fig. 1 – Pin On Disc Apparatus

5. CONCLUSION :

According to this article, the composite material of the metal matrix is especially useful for automobiles. An important factor in improving mechanical properties is re -flying. If you add ashes to aluminium, you can go to some extent to improve certain mechanical properties, but if you add up to 30%flush ash, you can add up to 30%of flush ash compared to the initial value to increase the strength of up to 30%of aluminium. The implementation of flight ash can reduce the amount of aluminium used. Thus, the experiment has proven that the addition of flight materials and graphite increases the strength and hardness of stretching, while the presence of many reinforced particles can improve the mechanical and microstructure characteristics of the compound of metal matrix based on aluminium alloys.

Process optimization: The focus of future studies may be on improving the process variables that are employed in the production of composites. It might be feasible to create composites with better mechanical properties and at a reduced cost by doing this. To gain a deeper understanding of the characteristics and functionality of the composites, more study might be conducted in several areas.

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