Fabrication, Testing And Analysis Of Aluminium Composites With Base Alloy.

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Abstract**—** Aluminum Matrix Composites (AMCs) are advanced materials featuring aluminum matrices reinforced with fibers, whiskers, or particulates. These composites, with reinforcement volumes ranging from a few to 70%, offer customizable properties for various industrial needs. Extensive research has elucidated the impacts of ceramic reinforcement on their physical, mechanical, thermo-mechanical, and tribological properties. AMCs have found applications in aerospace, defense, automotive, thermal management, and sports, evolving from research roots in India during the 1970s to widespread industrial adoption globally. This paper presents a concise overview of AMC material systems, covering processing techniques, microstructure, properties, and applications

***Keywords* -** reinforcement, ceramic, tribological, aerospace, automotive, whiskers

I. Introduction

Composite materials are formed by combining two or more materials at a microscopic level to create a new material with desired properties. They are categorized as metal matrix composites (MMCs), ceramic matrix composites (CMCs), and polymer matrix composites (PMCs).

Metal Matrix Composites (MMCs) typically consist of ductile metals reinforced with strong, low-density materials such as fibers, whiskers, or particulates. This enhances properties like stiffness, abrasion resistance, and thermal conductivity. Common matrix materials include aluminum, magnesium, titanium, nickel, and copper, with reinforcements ranging from 3 to 60% volume.

Aluminum Matrix Composites (AMCs) are lightweight, high-performance systems where aluminum serves as the matrix. Reinforcements vary from fibers to particulates, typically comprising a few percent to 70% volume. These composites offer improved strength-to-density ratios, stiffness, fatigue resistance, and thermal properties compared to monolithic metals.

Both MMCs and AMCs find applications in aerospace, automotive, defense, and other high-tech industries due to their superior properties and versatility in design.

Researchers continue to explore novel combinations and processing techniques to tailor these composites for specific industrial needs

II. Scope of Study

1. The current investigation focuses on Eutectic Al-Si Alloy that has different proportions of graphite and kyanite
2. Compared to traditional metals and alloys, aluminum metal matrix composites are thought to be an advanced material due to their low weight, increased strength and specific modulus, improved wear resistance, and improved corrosion resistance.
3. The primary alloying element for ease of casting is silicon, which also has a low density (2.34 g/cm-3) and is an unimpressive raw material. It also promotes fluidity, lowers melting temperatures, and reduces shrinkage after solidification.
4. Kyanite (Al_2SiO_5) is a mineral that is used as hard reinforcement because of its high hardness, increased compressible strength, low coefficient of thermal expansion, and high specific strength—all of which are maintained even at high temperatures and pressures.
5. Because of its strong resistance to wear and corrosion, graphite is utilized as a soft reinforcement.
6. Eutectic Al-Si alloy has numerous uses in the automotive, electrical vehicle, chemical, food, and

marine industries, particularly in engine parts.Methodology

III. Methodology

After conducting a comprehensive literature review, our research focused on exploring the fabrication and characterization of composite materials utilizing a Eutectic Aluminum-Silicon Alloy as the base matrix. In our study, we introduced reinforcements such as Kyanite and Graphite into the alloy matrix. The fabrication process involved utilizing an Electric Resistance Furnace, followed by casting using the vortex method. During casting, we employed a preheated metallic mold into which the composite material was carefully placed. Different compositions of the composite were prepared, varying the percentage of reinforcement, including Eutectic Al-Si alloy, Eutectic Al-Si alloy-Al2SiO5, and Eutectic Al-Si alloy-Al2SiO5–Graphite.

Subsequently, the fabricated composites underwent thorough characterization using various techniques. These included:

1. Microstructure analysis: Optical microscopy and scanning electron microscopy (SEM) were employed to observe and analyze the internal structure of the composite materials.
2. Worn surface observation: The surfaces of the composites were examined to assess their performance under tribological conditions, providing insights into their wear resistance.
3. Hardness testing: Vickers's Microhardness method was utilized to measure the material's resistance to indentation, which is indicative of its mechanical strength.
4. Tensile strength testing: A Universal Testing Machine (UTM) was employed to evaluate the material's mechanical properties, particularly its tensile strength.
5. Tribological properties assessment: A dedicated tribology machine was used to study the friction and wear behavior of the composite materials, providing valuable data on their performance in real-world applications.

Through these characterization techniques, we gained comprehensive insights into the properties and performance of the composite materials, which are essential for assessing their suitability for various industrial applications.

IV. Material selection

1. Kyanite: -

Properties of Kyanite: -

Chemical Classification	Silica
Chemical Composition	Al2So5
Specific Gravity	3.5 to 3.7
Color	Blue, white
Crystal system	Triclinic
Mohs Hardness	6.5 to 7
Melting Point	1850°C

Table 1:- Properties of Kyanite

Advantages of Kyanite Powder: -

1. High Tensile Strength.
2. High temperature resistance, so mostly used in areas of heat application like railways, automotive, etc.
3. Better hardness than conventional materials.

2. *Graphite:-*

Properties of Graphite: -

Chemical Classification	Carbon allotrope
Chemical Composition	C
Specific Gravity	1.9 to 2.3
Color	Iron Black , Metallic Gray
Crystal system	Hexagonal
Mohs Hardness	1 to 3
Melting Point	3550°C

Table 2: - Properties of Graphite

Advantages of Graphite: -

1. High temperature resistance: - The graphite powder has a melting point of 3550±50° C. and a boiling point of 4250° C.
2. Good electrical and thermal conductivity: - The conductivity of graphite powder is one hundred times higher than that of general non-metallic minerals.
3. Prominent lubricity: - The lubricating properties of graphite powder depend on the size of the graphite scales. The larger the scales, the smaller the friction coefficient and the better the lubrication performance.

4. Good chemical stability of graphite powder: - Graphite powder has good chemical stability at normal temperature, and is resistant to acid, hydrazine and organic solvent.

1. Properties of Materials

Material	Hardness (BHN)	Melting Point (°C)	Tensile Strength (MPa)	Density (g/cm²)
Aluminum	42	660	90	2.7
Graphite	25	3550	18	2.23

Table 3 Properties of Materials

V. TEST SET-UP

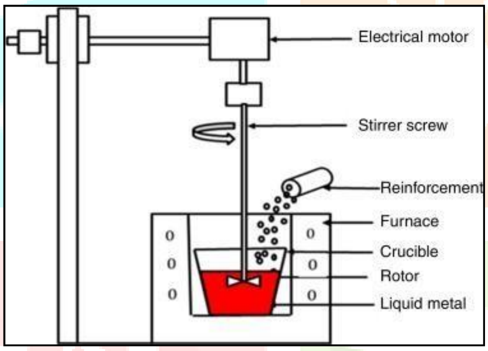

Fig 1. Stir Casting Set-up

Fig 2. Real-life set-up

Fig 3. Ash removing

VI. FABRICATION

The process for manufacturing of MMCs generally depends on the types of reinforcement. Researchers have used different methods to fabricate MMCs, i.e., vapor deposition, liquid state, solid-state, semi-solid state, and in situ fabrication technique. Other than liquid state methods, all require expensive set-ups and are difficult to absorb in general industrial purpose. The liquid state method is more convenient than others because of the following reasons: cheaper, simpler, flexible, and most economical no limitation of shape, size, and production quantity. Surappa and Taha compared stir casting with the other fabrication processes based on different parameters. Specifically, Surappa compared on the basis of range of shape, size, material yield, damage to reinforcement and cost. It is apparent from Table 1 that in all aspects stir casting is better than the other processes. Lower cost of stir casting process compared to other processes makes stir casting a viable process for mass production at industrial scale.

Fig 3. Fabrication

Fig 4. Fabrication

Fig 5. Fabrication

VII. PROCESS OF CASTING

1. **Melting and Mixing**: Begin by melting the aluminum alloy in a furnace and then incorporating the desired reinforcements into the molten metal.
2. **Stirring Process**: Employ stirring equipment to uniformly disperse the reinforcements throughout the molten aluminum matrix.
3. **Pouring and Molding**: Transfer the stirred composite mixture into molds to achieve the desired shape and size.
4. **Solidification Phase**: Allow the composite to cool and solidify within the molds, forming the final product.

VIII. RESULTS

Sample No.	Material	Hardness in vhn	UTS in Mpa
1	Base alloy i.e. Al-si eutectic alloy	94	166.43
2	2 wt.% kyanite + graphite 2.5 weight% + remaining eutectic aluminium silicon alloy	96.5	171
3	4 wt. %kyanite + 2 wt. % graphite + remaining al-si alloy	99	184.86
4	6 wt. %kyanite +2wt. % graphite + remaining al-si alloy	105	196.45

Table No. 4 Result Table

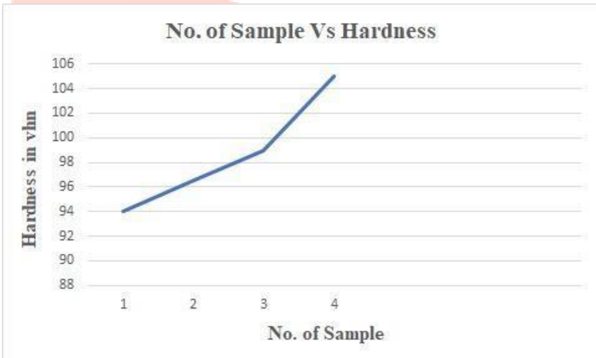

Fig. 4 Graph of No. of Sample Vs Hardness

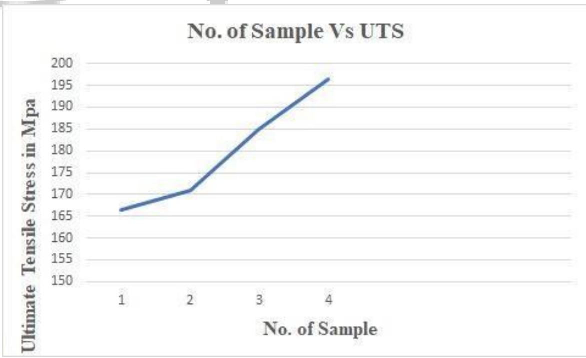

Fig. 5 Graph of No. of Sample Vs UTS

CONCLUSION

- It is observed that the 6 wt. %kyanite +2wt. % graphite + remaining al-si alloy as maximum hardness with 9 % with respect to sample No.1 and ultimate tensile stress with 29.97 % with respect to sample No. 1 as compare to the other 3 material.

- So from the graph of hardness and UTS we concluded that when the kyanite and graphite % is increasing in al-si alloy the hardness and ultimate tensile stress both are increasing.

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