International Journal of Scientific Research & Engineering Trends
Volume 11, Issue 1, Jan-Feb-2025, ISSN (Online): 2395-566X

Preparation and Characterization of Al-Cu Composite by Using Stir Casting Technique

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Abstract- Composite materials have emerged as a critical area of research and development, rapidly gaining importance as structural materials. Among polymer applications, composite materials are poised for significant advancements. Aluminum matrix composites (AMCs) are particularly favored in automotive and aerospace industries due to their exceptional mechanical properties, such as a high strength-to-weight ratio, superior wear resistance, increased stiffness, enhanced fatigue resistance, controlled thermal expansion, and stability at elevated temperatures. Stir casting is widely recognized as an efficient and cost-effective method for AMC fabrication. This study investigates the mechanical behavior of composites made from pure aluminum reinforced with copper, fabricated using the stir casting method. The composites were produced with reinforcement levels of 0%, 2%, 4%, and 6%. Results indicate that the inclusion of copper particles significantly enhanced the hardness, tensile strength, and wear resistance of the composites, though an increase in copper content resulted in decreased density. These findings highlight the potential of copper as a reinforcement material for aluminum-based metal matrix composites, offering valuable insights for diverse engineering applications.

Index Terms- AMCs, stir casting, metal matrix composites, Hardness, Tensile strength, Wear Resistance etc

I. INTRODUCTION

Anything composed of one or more substances that is comprised of matter is called material. Some examples of materials include water, air, hydrogen, wood, cement, and air. When used more specifically, the word "material" can refer to substances or parts that have particular Cu characteristics and are employed as inputs in production or manufacturing. In this sense, materials are the components needed to create something else, such as structures, works of art, stars, and even computers. In the modern world, metal-matrix composites (MMCs) are regarded as the most beneficial and advanced composite materials. Due of its high strength-to-weight ratio, high young modulus, and strong abrasive characteristics, MMCs are particularly essential. Since the beginning of human history, material science has influenced the growth of civilizations. Humanity has been able to spread and conquer because to better tools and weapons, and modern society is still being impacted by advances in material processing like the creation of steel and aluminum. The study of how various materials have been used and developed throughout Earth's history, as well as how those materials have impacted various peoples' cultures, is known as the history of materials science. MMCs are materials made by combining a matrix such as AL or Cu with reinforcing materials, such as ceramics, carbon fibers or metallic particles. The resulting material has improved mechanical, thermal, and electrical properties compared to the base metal. Both AMCs and CMCs have the potential to replace conventional materials in many applications, as their offer a unique combination of properties that cannot be achieved with single phase metals.

II. EXPERIMENTAL PROCEDURE

Agitated casting is the process of producing composite materials in the liquid state in which the dispersed phase (ceramic particles, short fibers) is mixed with a molten metal matrix by mechanical agitation. Agitated casting is the easiest and most cost-effective method of manufacturing in the liquid state. Figure 1 show typical installation of stir casting machine. The liquid composite can then be cast in a conventional manner and processed by conventional metal forming techniques. The characteristics of stirring casting are as follows. The content of dispersed phase is limited (typically 30% by volume or less).

Fig 1: Stir Casting Equipment

Preheating of dies and reinforcement materials was done in an oven which heat up to a maximum of 4000 C shown in the fig 2. The Preheating temperature of reinforcement is 2500 C. Place the molding material and reinforcing material in an oven and preheat to a temperature of 330-360 °C for 30 minutes.

Fig 2:PreHeating

Pure AL alloy is placed in the furnace section of a stir casting plant and can be heated to 640°C. Gradually add Copper-(CU) reinforcement from the pouring chamber to the melt to achieve uniform mixing and set the rotor speed to 600 rpm. The reinforcement is then inserted by weight into the molten metal from the same chamber. Rotate the agitator for approximately 2 to 5 minutes and move it up and down to evenly mix the molten metal. Remove the mold from the preheating furnace and set it in the furnace throat. When the valve is open, the melt is poured into the mold through the lander and riser pipes. Allow the die to cool for some time before removing the cast sample from the die. Finishing work removes unnecessary parts with the help of machining. The sample is now ready for testing and characterization.

Fig 3: Casting Specimens

III. RESULTS & DISCUSSIONS

Compression behavior of Composite
(Pure Al + Cu (2%,4%6%)
The compressive strength of composites is measured on specimens using a universal testing machine. The compressive strengths of composites from C1 to C3 are shown in Table .1. The strength of composites has been found to increase with increasing reinforcement loading. The maximum compressive stress obtained was 362 N/mm2 for the C3 composite.

Table 1. Metal Matrix Composition vs. Compression Strength

Sample	Composites	Compressive Strength (N/mm^2)
C1	Pure Al + 2 % Cu	199.98
C2	Pure Al + 4 % Cu	251.36
C3	Pure Al + 6 % Cu	361.82

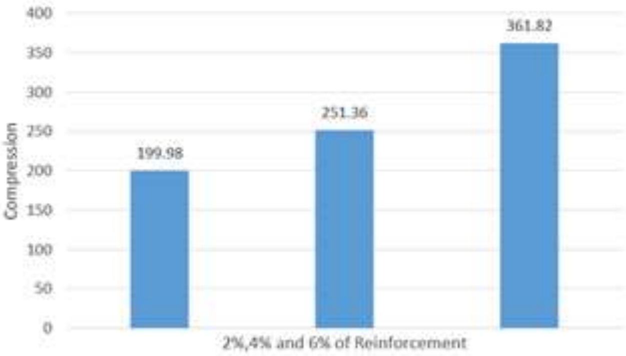

Fig 3: Compression Vs Reinforcement

Tensile behavior of Composite
(Pure Al + Cu (0%,2%,4%6%)
The Tensile strength of composites is measured on specimens using a universal testing machine. The Tensile strengths of composites from C1 to C2 are shown in Table 2.. The strength of composites has been found to increase with increasing reinforcement loading. The maximum compressive stress obtained was 197 N/mm2 for the C2 composite. But 4% and 6% of tensile samples are failed due to the induced brittleness of the material.

Table 2. Metal Matrix Composition vs. Tensile Strength

Sample	Composites	Tensile Strength (N/mm^2)
C1	Pure Al + 0 % Cu	56.63
C2	Pure Al + 2 % Cu	196.33

Hardness Test
The hardness test values observed that due to increase of percentage of reinforcement hardness was increased.

Table 3: Reinforcement Vs Hardness

Reinforcement	0%	2%	4%	6%
Hardness (HRC)N/mm2	67.23	69.45	75.09	84.13

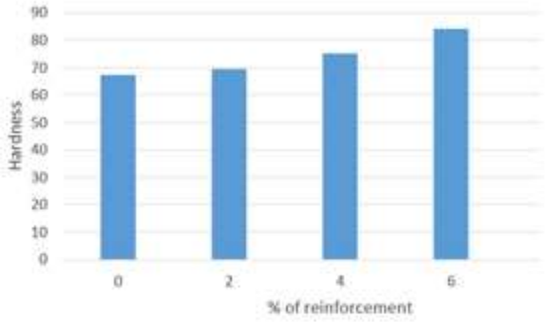

Fig 3: Hardness Vs Reinforcement

Impact (Charpy) Test

The Charpy impact test is a standardized test that measures the energy absorbed by a material due to a high-speed impact and the impact strength of composites of C1 to C3 results are shown below. But 6% of impact sample are failed due to increased brittleness of the material.

Table 4. Impact Test Values.

Sample	Composite	Initial	Final	Energy Observed (J)
C1	Pure Al	300	130	170
C2	Pure Al + 2 % Cu	300	74	226
C3	Pure Al + 4 % Cu	300	35	265

IV. CONCLUSION

Pure Al reinforced with copper with various proportions of 0%, 2%, 4% and 6% are tested to determine the mechanical, Cu metallurgical and tribological properties such as compressive strength and micro structure, hardness, tensile strength and Charpy impact strength.

- It is observed that due to increase of percentage of reinforcement compression was increased.
- It is observed that due to increase of percentage of reinforcement tensile was increased. But 4%, 6% of tensile samples are failed due to the induced brittleness of the material.
- The hardness of the composite increases with increase in composition of the material.
- It is observed that due to increase percentage of reinforcement impact (Charpy) increased. But 6% of impact samples are failed due to the induced brittleness of the material.

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