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INVESTIGATION ON MECHANICAL AND TRIBOLOGICAL BEHAVIOUR OF AL6061/ SIC/BAGASSE ASH HYBRID REINFORCED METAL MATRIX COMPOSITES USING STIR CASTING.

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ABSTRACT:

The study investigates the mechanical and metallurgical properties of hybrid aluminum metal matrix composites (MMC) reinforced with silicon carbide (Sic) particles and Sugar Cane materials. The increasing demand for lightweight, high-strength materials in various industries has spurred interest in developing novel composite materials with enhanced properties. This study investigates the mechanical properties and wear behavior of aluminum hybrid metal matrix composites (MMCs) using AA6061 as the base material, reinforced with silicon carbide (Sic) and Bagasse ash. Castings were prepared with reinforcement percentages of 1%, 2%, and 3%. Results indicate a progressive increase in hardness and compressive strength with higher reinforcement percentages, while impact strength demonstrates a decline with increasing reinforcement percentage. Wear tests were conducted, revealing that composites with 3% reinforcement exhibited the lowest wear rate. Furthermore, an L9 orthogonal array analysis was performed on the specimen with the best wear rate to optimize its performance.

INTRODUCTION

METAL MATRIX COMPOSITES (MMC) usually consist of a low-density metal, such as aluminum or magnesium, reinforced with particulate or fibers of a ceramic material, such as silicon carbide or graphite. Compared with unreinforced metals, MMCs offer higher specific strength and stiffness, higher operating temperature, and greater wear resistance, as well as the opportunity to tailor these properties for a particular application.

A metal matrix composite (MMC) is a composite material with fibers or particles dispersed in a metallic matrix,

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such as copper, aluminum, or steel. The secondary phase is typically a ceramic (such as alumina or silicon carbide) or another metal (such as steel). They are typically classified according to the type of reinforcement: short discontinuous fibers (whiskers), continuous fibers, or particulates.

There is some overlap between MMCs and cermet's, with the latter typically consisting of less than 20% metal by volume. When at least three materials are present, it is called a **hybrid composite**. MMCs can have much higher strength-to-weight ratios, stiffness, and ductility than traditional materials, so they are often used in demanding applications. MMCs typically have lower thermal and electrical conductivity and poor resistance to radiation , limiting their use in the very harshest environments.

MMCs are made by dispersing a reinforcing material into a metal matrix. The reinforcement surface can be coated to prevent a chemical reaction with the matrix. For example, carbon fibers are commonly used in aluminum matrix to synthesize composites showing low density and high strength. MMCs are fabricated at elevated temperatures, which is an essential condition for diffusion bonding of the fiber/matrix interface. Later on, when they are cooled down to the ambient temperature

DISADVANTAGES:

- MMCs are comparatively expensive
- MMCs are of moderate use.
- For MMCs, fracture toughness is medium.
- MMCs have lower chemical resistance.
- Difficult to fabricate.

ADVANTAGES:

- MMCs possess very high modulus and high strength .
- It contains higher density.
- MMCs have higher electric and thermal conductivities.
- MMCs can endure higher processing temperature.
- MMCs are insensitive to moisture.

LITERATURE SURVEY

Ashish Kumar Srivastava (2020) This experimental investigation deals with the effect of Sic content on aluminum alloy Al 6061. Composites were fabricated with varied (0, 1, 2, 3 and 5) weight percent of Sic content via stir casting method.

Scanning electronic microscope test had confirmed the uniform distribution of reinforced particles. It was seen that the density of Al 6061/Sic composite was improved with the reinforcement of Sic content. Hardness and tensile tests were conducted to observe the mechanical properties of fabricated specimen. The hardness and tensile strength was significantly improved up to 5 wt.% of Sic particles.

Laxmi et al. (2017) Investigated, ALMMCs, manufactured by the stir casting technique, matrix material Al 6061, reinforced with a weight fraction of 10, 15, 20 percentage of Silicon carbide (Sic). A brief microstructural examination was performed on the electron microscope scanning (SEM). The test findings indicate that the hardness value of the composites is increased with the rise in reinforcement from 10 to 15 %.

A.P.Kumbhar et al. (2018) conducted research in which the effects of the Sic reinforcement on the characteristics of the metal matrix composite investigated. Al 6061 taken as matrix material and with different weight % (0.3, 6 and 9) of Sic as reinforcement, stir casting process was used to prepare composite material. The conclusions obtained that The Al 6061 matrix with Sic boosts mechanical properties

A Q Wang et al. (2018) study powder-metallurgy method to fabricate ALMMC in which Al 6061 reinforced by 35% vol. Sic particles of varying sizes. The reinforcement is of Sic , particles size (7.5 µm, 25 µm, 15 µm, 40 µm) and Al6061 powders of 10 µm mean particle size is used as matrix material. The analysis found that the coefficient of thermal expansion (CTE)of ALMMC has improved, the Sic particles spread more evenly in the matrix, but the tensile strength has been decreased with increase in the size of Sic particle. Sic particles spread more evenly in the matrix by raising the particle size

RELATED WORK

Stir casting is a suitable processing technique to fabricate aluminum matrix composites and hybrid aluminum matrix composites as it is an economical process and preferred for mass production.

The first step of stir casting involves melting of aluminum.

During melting, aluminum melt reacts with the atmosphere and moisture and forms a layer of aluminum oxide.

This layer shields the surface of the melt form further reaction with atmosphere.

Stir casting process involves stirring of melt, in which the melt is stirred continuously which exposes the melt surface to the atmosphere which tend to continuous oxidation of aluminum melt.

The metal matrix is melted in a furnace to form a molten state. The temperature is carefully controlled to ensure that the matrix remains in a liquid state throughout the process.

Once the matrix is molten, the solid particles of the reinforcement material are added to the melt. The particles are gradually added while stirring to ensure even distribution.Stirring is a crucial step in the process, as it helps disperse the reinforcement particles uniformly throughout the matrix. The stirring can be done using mechanical means, such as a rotating blade or rod, or by electromagnetic stirring, which uses a magnetic field to agitate the melt.

Once the reinforcement particles are evenly dispersed, the molten composite material is poured into a mold. The mold is usually made of a heat-resistant material and is designed to give the desired shape to the final product.The filled mold is allowed to cool and solidify, during which the metal matrix solidifies and the reinforcement particles are embedded in the solid matrix.

After solidification, the casting is removed from the mold and may undergo additional processing steps such as heat treatment, machining, or surface finishing to achieve the final desired properties and dimensions.

SAMPLE RESULTS

IMPACT STRENGTH:

SPECIMEN	SAMPLE 1	SAMPLE 2	SAMPLE 3	AVG
AL 6061 98% + SIC 1% + BAGASSE ASH 1%	0.68	0.68	0.65	0.67
AL 6061 98% + SIC 1% + BAGASSE ASH 1%	0.575	0.625	0.625	0.608
AL 6061 98% + SIC 1% + BAGASSE ASH 1%	0.55	0.55	0.6	0.56

COMPRESSION TEST:

SPECIMEN	SAMPLE 1	SAMPLE 2	SAMPLE 3	AVG
AL 6061 98% + SIC 1% + BAGASSE ASH 1%	458.52	462.13	460.43	460.36
AL 6061 98% + SIC 1% + BAGASSE ASH 1%	467.84	492.32	485.41	481.85
AL 6061 98% + SIC 1% + BAGASSE ASH 1%	516.9	522.62	509.2	516.24

HARDNESS TEST:

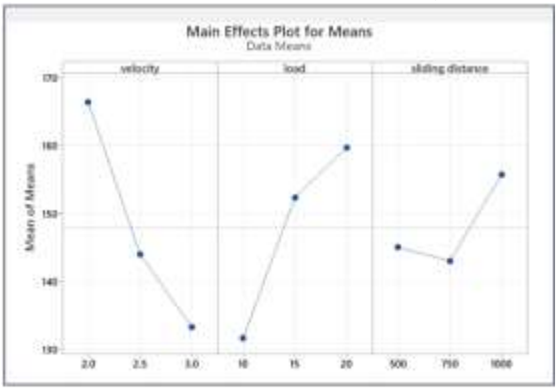
SPECIMEN	SAMPLE 1	SAMPLE 2	SAMPLE 3	AVG
AL 6061 98% + SIC 1% + BAGASSE ASH 1%	67.72	64.88	66.77	66.45
AL 6061 98% + SIC 1% + BAGASSE ASH 1%	74.68	72.35	77.12	74.71
AL 6061 98% + SIC 1% + BAGASSE ASH 1%	89.11	85.20	87.35	87.22

TRIBOLOGICAL TEST RESULTS ON DIFFERENT SAMPLES:

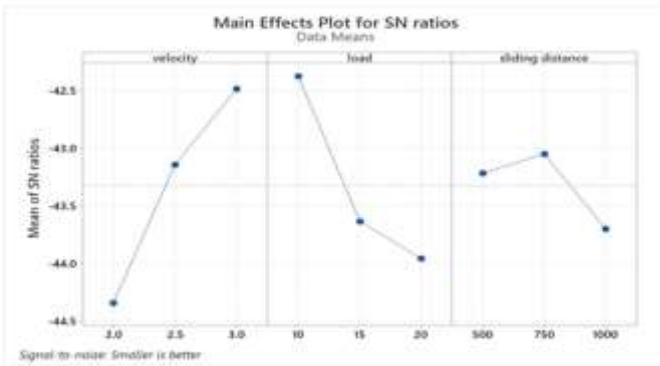
WEAR RATE:

SPECIMEN	TRAIL 1	TRAIL 2	TRAIL 3	AVG
AL 6061 98% + SIC 1% + BAGASSE ASH 1%	78	85	92	85
AL 6061 98% + SIC 1% + BAGASSE ASH 1%	58	64	68	63.33
AL 6061 98% + SIC 1% + BAGASSE ASH 1%	39	43	51.39	44.46

WEAR RATE VERSUS VELOCITY, LOAD AND SLIDING DISTANCE: -



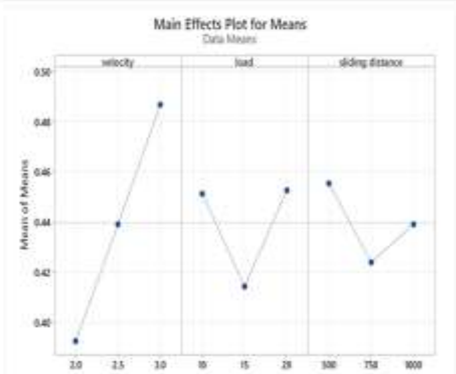
GRAPH 7.1: Main effects plot for means

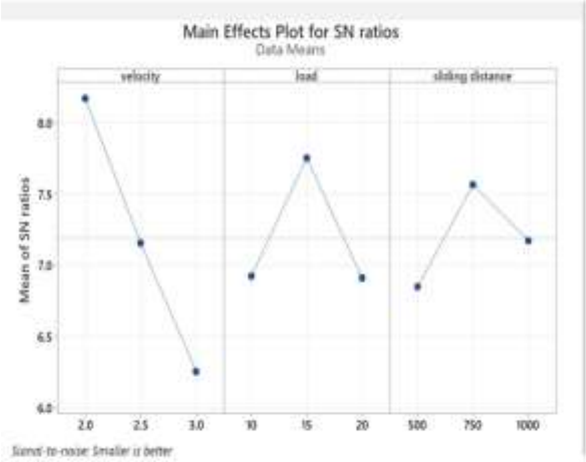


GRAPH 7.2: Main effects plot for SN ratio

COEFFICIENT OF FRICTION VERSUS VELOCITY, LOAD AND SLIDING DISTANCE:

Taguchi Analysis: coeffiction of friction versus velocity, load, sliding distance





CONCLUSION

Hardness Enhancement: The investigation demonstrated a notable increase in hardness values with the incorporation of reinforcements. Specifically, hardness values exhibited increments corresponding to reinforcement percentages of 1%, 2%, and 3%, respectively.

Compressive Strength Improvement: The study revealed significant enhancements in compressive strength values as the reinforcement percentages increased. Compressive strength values demonstrated increments corresponding to reinforcement percentages of 1%, 2%, and 3%, respectively.

Impact Strength Analysis: Despite the improvements observed in hardness and compressive strength, the impact strength values exhibited a decrement with increasing reinforcement percentages. Specifically, impact strength values decreased corresponding to reinforcement percentages of 1%, 2%, and 3%, respectively.

Sliding velocity has the highest influence on wear rate followed by applied load and sliding distance.

Sliding velocity has the highest influence on followed by coefficient of friction applied load and sliding distance.

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