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Evaluation of Mechanical Behavior of Hybrid Aluminium Metal Matrix by Using Stir Casting

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A B S T R A C T

In this study, ZrO_2 (varying from 2 to 6 wt.%) and Boron carbide 1 wt.% to 3% reinforced aluminum matrix composites were fabricated by conventional stir casting technique. The effects of reinforcement element, ZrO_2 & B_4C addition on the mechanical properties of aluminum composites were newly examined for large-scale distribution. From the experimental results, it was observed that the hardness value of pure aluminum was obtained 61 HRB. Also, the highest hardness values were obtained at 4%-ZrO_2 & 2% B_4C - 77 HRB at the second ratio of the composite. Similarly, the highest yield and ultimate impact strength were determined at 6%-ZrO_2 & 2% B_4C -composite. As a result, it has been observed that ZrO_2 & B_4C addition makes a positive contribution to the mechanical and tribological of aluminum composites. According to the wear test have found the ratio of 4%-ZrO_2 & 2% B_4C is very low wear rate occurred during this investigation. Such that ratio of composites should be used for the wear application of aluminum.

Keywords: AA6061, ZrO_2, Stir Casting, Hardness, Tensile Strength

1. Introduction

Because the applied load is distributed and transferred from the ductile matrix to the reinforcing phase, metal-matrix composites (MMCs) show resilience to high compressive and tensile stresses. Several methods, including liquid, powder, and squeeze casting, are used to create these MMCs by including a reinforcing phase into the matrix. Whiskers, discontinuous particulate matter, and continuous fibers can all be inclusions in MMCS. Particulates result in predictable isotropic behavior in the composition, which makes them suitable inclusions. Furthermore, several particulate metal matrix composites (PMMCs) are garnering interest because to their superior tribological, mechanical, and thermal characteristics. Because they require fewer fibers and less production, particle-reinforced composites are more affordable than fiber-reinforced composites.

2. Aluminium Metal Matrix Composites

Because of its excellent strength, low density, durability, machinability, availability, and affordable price as compared to other materials, aluminum alloys are used in high-tech applications. However, by utilizing composite materials with an aluminum matrix, the range of these qualities can be increased. The definition of aluminum matrix composites is as follows: (1) it has to be made by humans. (2) At least two chemically different materials, one of which is aluminum, must be combined, with a clear contact dividing the components.(3) Three-dimensional integration of the individual materials is required.(4) It should produce qualities that none of the component parts could produce on their own. The major advantages of AMCs compared to unreinforced materials are as follows:

1. Greater strength
2. Improved stiffness
3. Reduced density (weight)
4. Improved high temperature properties
5. Controlled thermal expansion coefficient
6. Thermal/heat management
7. Enhanced electrical performance
8. Improved abrasion and wear resistance

9. Control of mass (especially in reciprocating applications)
10. Improved damping capabilities.

3. Objectives of present work

Due to its many qualities, including low-density, strong wear resistance, good tensile strength, and superior surface quality, composite materials are becoming more and more necessary. One of the most affordable and low-density reinforcing materials, silicon nitride is produced in large numbers as a solid waste byproduct in ceramic plants. Additionally, the Hardness strength will be taken into account. An experimental setup with all the required inputs is ready for the above to be accomplished. In this work, a composite is created by varying the weight ratio at which silicon nitride is added to aluminum metal. The composite needs to be made using the stir casting method, and its mechanical properties need to be examined.

4. Casting through Stir Process

The primary use of the stir casting technique is in the production of particle reinforced metal matrix composites (PMMC). This is the first step in the creation of composites, when the molten metal is stirred to absorb the reinforcement constituent material. In the process of stir casting metal matrix composites, a chosen matrix material is melted, and then a reinforcement material is added. Prior to adding the reinforcement material, the melt needs to be degassed using an appropriate medium because the molten metal reacts with airborne oxides, oxidizing the base material and deteriorating its properties. The next step is the solidification of the melt containing suspended dispersions under selected conditions to obtain the desired distribution of the dispersed phase in the cast matrix

5. Metal Matrix Ratio

Ratio	AL 6061 grams	ZrO_2 weight percentage	BORON CARBIDE
I	800	2%-16	1%-8
II	800	4%-32	2%-16
III	800	6%-48	3%-24
	2400	96 gram	48 gram

6. Hardness value of various Ratio

S.No	Material	HRB
R1	2%-ZrO2 & 1% B4C Remaining Al-6061	63
R2	4%-ZrO2 & 2% B4C Remaining Al-6061	77
R3	6%-ZrO2 & 3% B4C Remaining Al-6061	70
R4	Al6061-100%	61

7. Impact Strength Values

S.No	Composition	Impact Strength (Joules)
R1	2%-ZrO_2 & 1% B_4C Remaining Al-6061	5
R2	4%-ZrO_2 & 2% B_4C Remaining Al-6061	7
R3	6%-ZrO_2 & 3% B_4C Remaining Al-6061	9
R4	Al6061-100%	4

8. Tensile Strength Values

sample	Dia (mm)	CSA (mm^2)	YL (kN)	YS (N/mm^2	TL (kN)	TS (N/mm^2	IGL (mm)	FGL (mm)	%E	FD	%RA
A1	13.34	139.82	9.34	66.80	13.57	97.05	50.00	50.64	1.28	12.67	9.79
A2	13.46	142.35	9.98	70.11	15.24	107.06	50.00	50.37	0.74	12.43	14.72
A3	13.05	133.81	10.24	76.53	15.96	119.27	50.00	50.49	0.98	12.59	6.93
A4	13.18	136.49	11.89	87.11	17.02	124.70	50.00	50.58	1.16	12.66	7.74

9. Compressive Strength Values

S.No	Composition	Compression Stress (N/mm^2)
R1	2%-ZrO_2 & 1% B_4C Remaining Al-6061	174.65
R2	4%-ZrO_2 & 2% B_4C Remaining Al-6061	187.64
R3	6%-ZrO_2 & 3% B_4C Remaining Al-6061	187.77
R4	Al6061-100%	200.60

10. Result & conclusion

The development of an aluminum alloy with various reinforcements added at consistent volume percentages served as the foundation for the current study. Mechanical testing was used to describe the developed composites in terms of impact, tensile strength, and hardness. The work completed allows for the conclusion of the following points. For large-scale distribution, the effects of adding ZrO_2 and B4 reinforcement element on the mechanical characteristics of aluminum composites were recently investigated. It was noted from the experiment findings that pure aluminum has a hardness rating of 61 HRB additionally, at 4% ZrO_2 & 2% B4C - 77 HRB in the second ratio of the composite, the maximum hardness values were recorded. Similarly, the composite with 6% ZrO_2 and 2% B_4C had the highest yield and final impact strength. Thus, it has been noted that adding ZrO_2 and B_4C improves the mechanical and tribological properties of aluminum composites. The wear test revealed that the ratio of 2% B_4C to 4% ZrO_2 was a very low wear rate during this inquiry. Aluminum wear applications should employ a composite ratio of that type.

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