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FABRICATION AND CHARACTERIZATION OF HYBRID ALUMINIUM MATRIX COMPOSITES

Sivaraman[1], Harish R[2], Hasta Vikram[3], Santhosh[4], Selvarasu[5]

[1]Assistant Professor, Aeronautical Engineering, Hindusthan College of Engineering and Technology, Coimbatore, Tamil Nadu

[2,3,4,5] UG -Aeronautical Engineering, Hindusthan College of Engineering and Technology , Coimbatore, Tamil Nadu

Abstract: The present research work reports the fabrication and evaluation of the mechanical properties of hybrid aluminium matrix composites (HAMC). Aluminium 7075 (Al7075) alloy was reinforced with particles of boron carbide (B_4C), silicon carbide (SiC) and coconut shell fly ash (CSFA). Al7075 matrix composites were fabricated by stir casting method. The samples of Al7075 HAMC were fabricated with different weight percentages and in different compositions B_4C, SiC and CSFA. The mechanical properties discussed in this work are hardness, tensile strength, and impact strength. Hardness of the composites increased 33% by reinforcements of 6wt.% B_4C, 6wt% SiC and 3wt.% CSFA in aluminium 7075 alloy. The tensile strength of the composites increased 66% by the addition of 9wt.% B_4C and 3wt.% CSFA in aluminium 7075 alloy. Further addition of reinforcements decreased the tensile strength of the composites. Elongation of the composites decreased while increasing B_4C and CSFA reinforcements in the matrix. The impact energy of the composites increased up to 2.3 J with 9wt.% B_4C and 3wt.% CSFA addition in aluminium alloy. Further addition of reinforcement decreased the impact strength of the composites. The optical micrographs disclosed the homogeneous distribution of reinforcement particles (B_4C and CSFA) in Al7075 matrix. The homogeneously distributed B_4C and CSFA particles added as reinforcement in the Al7075 alloy contributed to the improvement of hardness, tensile strength, and impact strength of the composites.

Key words: Aluminium 7075; boron carbide; silicon carbide; fly ash; casting; hardness; tensile strength; impact energy

INTRODUCTION

Composite material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them. Composites are used not only for their structural properties, but also for electrical, thermal, and environmental applications. Modern composite materials are usually optimized to achieve a particular balance of properties for a given range of applications. Range of materials that may be considered as composites and the broad range of uses for which composite materials may be designed, it is difficult to agree upon a single, simple, and useful definition. it contain a continuous matrix constituent that binds together and provides form to an array of a stronger, stiffer reinforcement constituent.

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The composite materials exhibit superior properties only in the fiber direction; hence the delamination of composite structures results in a significant loss of stiffness and strength. The resistance to de lamination is one of the most important characteristics of laminate and unidirectional composites. One major drawback of composite materials is de lamination separation of a laminate into layers. One major US Company, Kenetech, failed partly because of de lamination failure at the trailing edge.

This study is the extension of researches by Darrin Haugen and Robert More head, who studied de lamination of the skin-stiffener intersection geometry which is common in composite materials structures like wind turbine blades. This work combines, adds to, and revises their earlier work.

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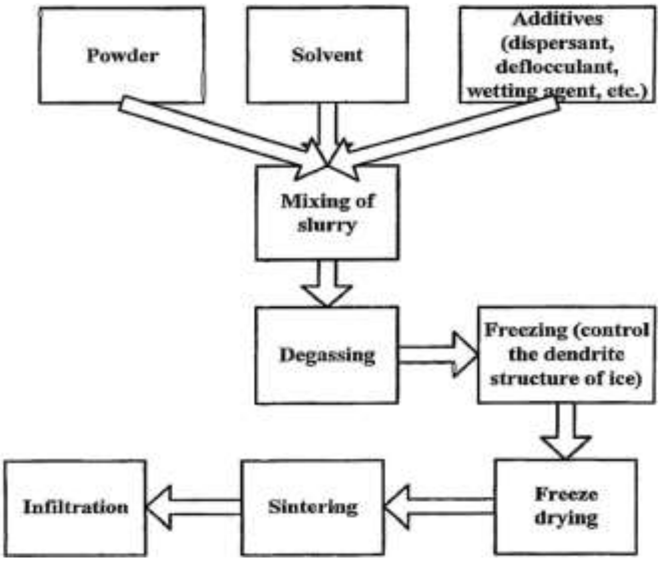

1. EXPERIMENTAL METHODS OR METHODOLOGY

STIR CASTING METHOD

The synthesis of the metal matrix composite that was used in this study was produced using double stir-casting method. Commercial pure aluminum was procured from bus bars of conductivity grade copper (99.95% Cu).

Copper pieces wrapped in aluminum foil were added to the aluminum melt at 800°C and the same temperature was maintained till copper completely melts. Magnesium in theform of thin slices wrapped with aluminum foil was added to the Al-Cu alloy melt after the furnace temperature was reduced to 750°C. The furnace temperature cooled down just below the liquid us at 5000 c to keep theslurry in a semisolid state.

It carried out for about 20 minutes at an average stirring rate of 150 rpm. The temperature of the furnace was gradually reduced with certain intervals.

Mold preparation

Fabrication

Coconut shell Ash (CSFA), Boron carbide and Silicon carbide are used as reinforcement and Aluminium Al7075 was used as matrix. The methodology has been showed in step by step below.

Fabrication process of coconut shell fly ash:

The coconut shell was easily available in the agricultural area and disposal of the waste is a major problem in the world. The use of coconut shell waste as reinforcement can reduce the cost of material and clean the environment. The coconut shell fly ash was prepared through rubbing the coconut shell by emery sheet which removed the impuritieson the outside of the shell. Subsequently, the coconut shell was dried in sunlight for 2-3 days to remove the moisture content. The dried coconut shells were sliced into small pieces and kept inside a furnace and heated for 2 h when the temperature was maintained at 400
°C. The burnt particles were subjected to a heat treatment at 800 °C for about 10 h to remove the carbonaceous material.

Experimental specimen preparation

Preparation of Aluminium alloy (Al7075)

Initially, Al7075 alloy was charged into the graphite crucible. At first the aluminiumalloy is heated to about 750 ºC till the entire alloy in the crucible was melted. After the molten metal was fully melted, it stirred manually in order to remove porosity, bubbles inside of aluminium alloy. The stirrer made up of stainless steel was lowered into the meltslowly to stir the molten metal.

Mixing of Aluminium alloy (Al7075) with coconut shell fly ash (CSFA):

In another crucible the reinforcement particles CSFA were preheated to 800°C for 1 hour before incorporation into the melt. The preheated CSFA particles were added into the molten metal at a constant rate during the stirring time. The stirring was continued foranother 5 min even after the completion of particle feeding. Constant stir is necessary in order to uniform mixture.

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Mixing of Aluminium alloy (Al7075) with Silicon Carbide (SiC) and CSFA:
In another crucible the reinforcement particles SiC and CSFA were preheated to 800°C for 1 hour before incorporation into the melt. The preheated SiC and CSFA particles were added into the molten metal at a constant rate during the stirring time. The stirring was continued for another 5 min even after the completion of particle feeding. Constant stir is necessary in order to uniform mixture.

Mixing of Aluminium alloy (Al7075) with Boron Carbide (B4C) and CSFA:
In another crucible the reinforcement particles B4C and CSFA were preheated to 800°C for 1 hour before incorporation into the melt. The preheated B4C and CSFA particles were added into the molten metal at a constant rate during the stirring time. The stirring was continued for another 5 min even after the completion of particle feeding. Constant stir is necessary in order to uniform mixture.

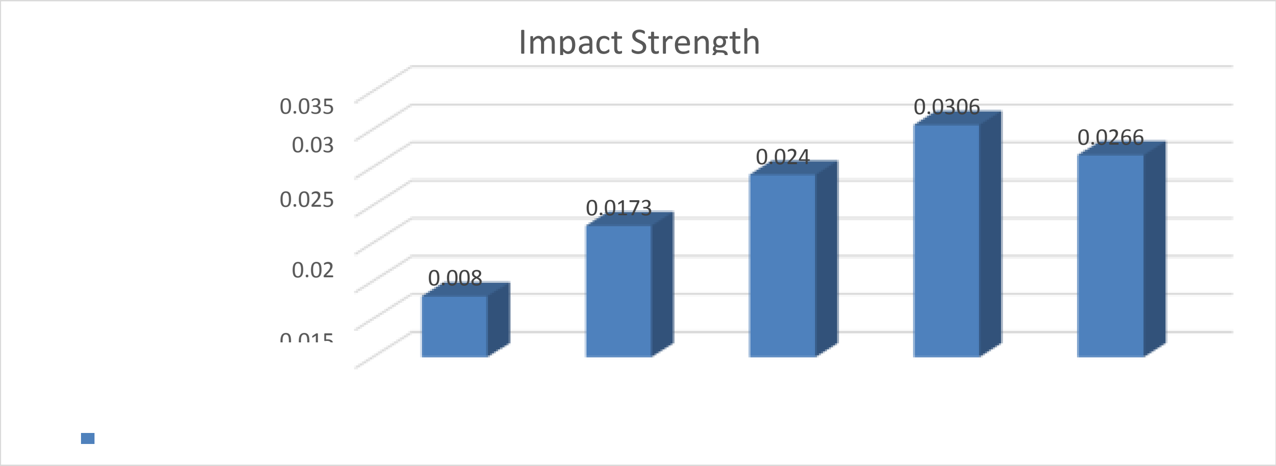
Mixing of Aluminium alloy (Al7075) with Boron Carbide (B4C) Silicon Carbide(SiC) and CSFA:
In another crucible the reinforcement particles SiC, B4C and CSFA were preheated to 800°C for 1 hour before incorporation into the melt. The preheated SiC, B4C and CSFAparticles were added into the molten metal at a constant rate during the stirring time. The stirring was continued for another 5 min even after the completion of particle feeding. Constant stir is necessary in order to uniform mixture.

Analyzing specimen preparation
For analyzing different composition of composites mainly prepared by B4C, SiC and Al7075 are given below:
Each specimen contains various compositions as follows,Specimen 1: Aluminium alloy Al7075 is fabricated.
Specimen 2: Aluminium alloy Al7075 is fabricated with 3% of CSFA.
Specimen 3: Aluminium alloy Al7075 is fabricated with 9% of SiC and 3% of CSFA. Specimen 4: Aluminium alloy Al7075 is fabricated with 9% of B4C and 3% of CSFA. Specimen : Aluminium alloy Al7075 is fabricated with 6% of B4C and 6% of SiC and 3% of CSFA.

Specimen ID	B4C quantity	SiC quantity	CSFA quantity	Al7075 quantity
1.	Nil	Nil	Nil	100% (500gm)
2.	Nil	Nil	3% (15gm)	97% (485gm)
3.	Nil	9% (45gm)	3% (15gm)	88% (440gm)
4.	9% (45gm)	Nil	3% (15gm)	88% (440gm)
5.	6% (30gm)	6% (30gm)	3% (15gm)	85% (425gm)

2. RESULTS AND DISCUSSION

Impact test: Impact energy of composites is increased by increasing the reinforcement content in the matrix. Maximum impact energy of 2.3 J is achieved for 9wt.% B4C and 3wt.% CSFA composite. The impact energy decreases with further addition of reinforcement particles in the matrix due to micro pores, crack initiation in the composites which bring about premature failure in the composites.



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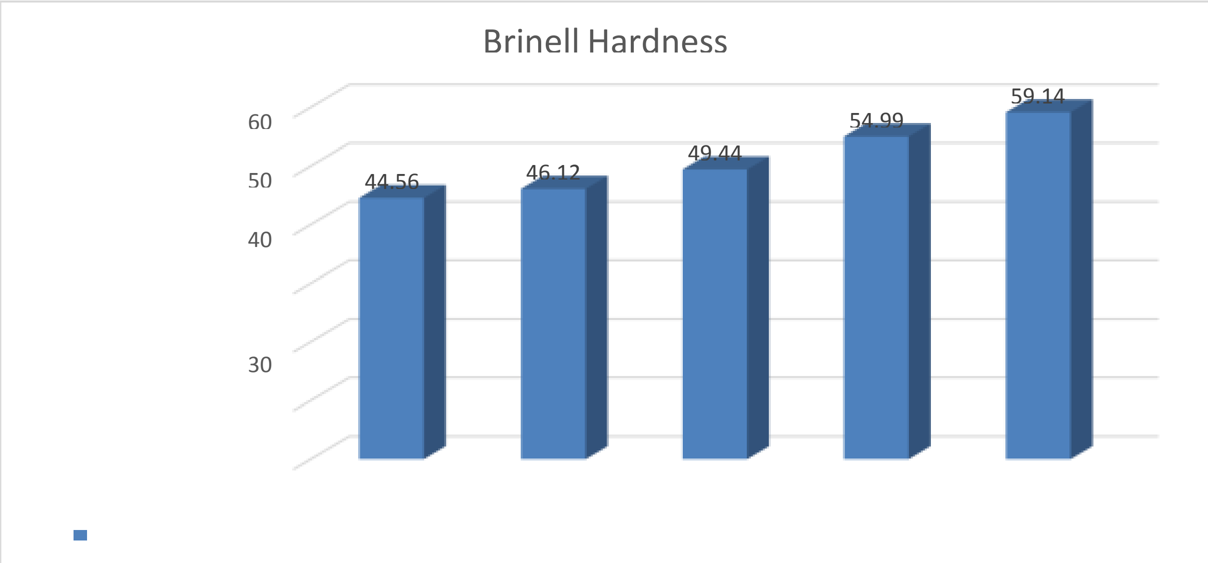
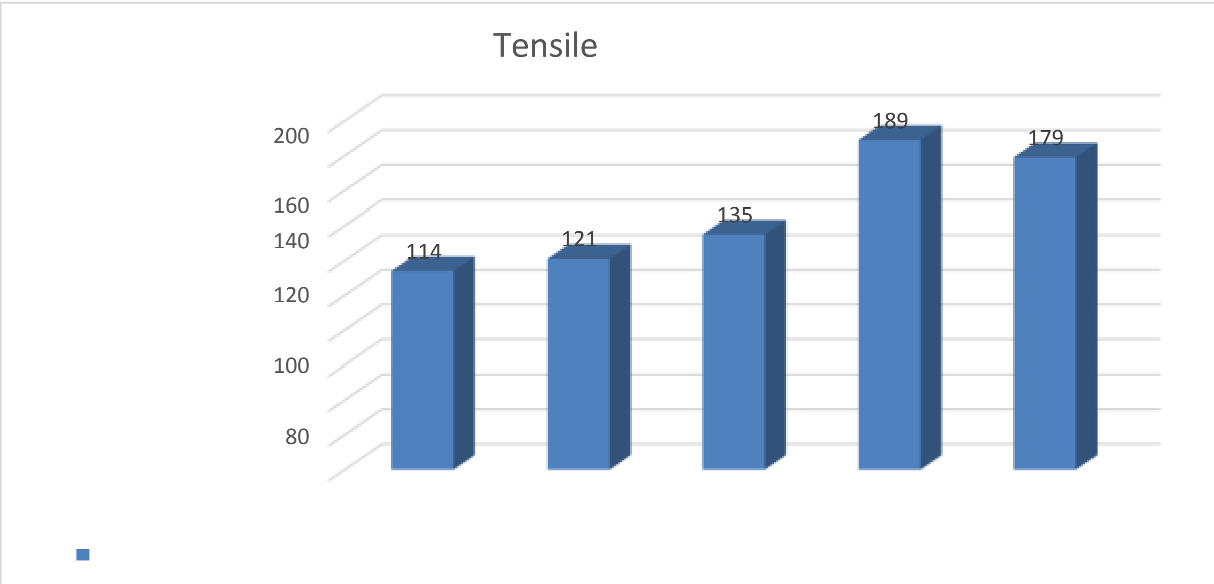
Hardness test:

Hardness of composites increases with increasing reinforcement content in the matrix. The maximum hardness 59.14 N/mm^2 (171 BHN) of composites is observed for the 6wt.% of B_4C, 6wt% of SiC and 3wt.% CSFA composite.



Tensile test:

Tensile strength of composites increases by the addition of reinforcement particles B_4C and CSFA in the aluminium7075. The maximum tensile strength (189 MPa) is obtained for 9wt.% B_4C and 3wt.% CSFA composite that increased by 66% compared with the unreinforced aluminium7075. The ductility of the composites decreases with increasing the weight percentage of reinforcement particles



CONCLUSION

Coconut shell fly ash particles were successfully incorporated in Al7075 alloy by using stir casting techniques. Specimen test results shows the uniform distribution of coconut shell fly ash, Boron carbide and Silicon carbide particles in the aluminium alloy. The hardness of Al7075/CSFA composites increases with increase in coconut shell fly ash and Boron carbide contents. The tensile strength of Al7075/CSFA composites also increases with the increase in

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coconut shell fly ash and B4C content. The Hardness increases with the increase in coconut shell fly ash, B4C and SiC content.

The toughness measured by impact test increases in coconut shell fly ash content. And according to the comparison 3% of CSFA and 9% of B4C (Specimen 4) has the efficient result comparatively equal to Al alloy specimens. The coconut shell was easily available in the agricultural area and disposal of the waste is a major problem in the world. And that disposed coconut shell is made into fly ash and is successfully used as a reinforcing material to produce Metal Matrix Composites (MMCs) components in aluminium matrix. Thus, the use of CSFA for the production of composites can turn agricultural waste into industrial wealth and inevitably solve the problem of storage and disposal of CSFA. Incorporation of coconut shell fly ash particles in aluminium matrix can lead to the production of low cost aluminium composites with improved hardness and strength. These composites can find application where lightweight materials are required with good stiffness and strength

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