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Characterization of Aluminium Hybrid Composite Reinforcement with Teak Wood Ash and Bamboo Ash by using Stir Casting Process

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Abstract:- **Composite matrix are materials that are attractive for a large range of engineering applications. Among the variety of manufacturing process Stir casting is generally accepted as a particular promising route currently practiced commercially. Its advantage lies in its simplicity, flexibility and applicability to large quantity production with cost advantages. The objective of this project is to develop a new class of natural wood ash based hybrid composites matrix to enhance the potential applications and to meet the ever increasing demand of modern day Technology.**

I. INTRODUCTION

In many industrial applications, the most important parameter in material selection is specific strength. For example it is the critical design criterion in rotating machinery components. Aluminum is a natural candidate for this type of application because of its low density. However, compared to titanium alloys, the strength of conventional commercial aluminum alloys is too low for aluminum to be a better solution. Owing to the many difficulties encountered in the production and use of titanium alloys, the drive to develop stronger aluminum alloys is very high. Compared with un-reinforced metals, metal-matrix. Composites matrix are suitable for applications requiring combined strength, thermal conductivity, damping properties and low coefficient of thermal expansion with lower density. These properties of composite matrix enhance their usage in automotive and many applications. In the field of automobile, composite matrix are used for pistons, brake drum and cylinder block because of better corrosion resistance and wear resistance. Composites reinforced with ceramic phases exhibit high strength, high elastic modulus, and improved resistance to wear, creep and fatigue, which make them promising structural materials for aerospace and automobile industries. Conventional monolithic materials have limitations in achieving good combination of strength, stiffness, toughness and density.

To overcome these shortcomings and to meet the ever increasing demand of modern day technology, composites are most promising materials of recent interest. A very small change in any one of these factors can seriously affect the corrosion characteristics of the metal. Aluminium-fly ash composites offer many potential applications particularly for internal combustion engine pistons and brake rotors due to their density and high mechanical properties. Additionally, the results of hardness and electrical conductivity of the investigated composites show that uniformly dispersed reinforcing phases and adequate machinability are possible. From both an economical and environmental standpoint the use of fly ash for reinforcing aluminium alloys is extremely attractive due to its waste material character and expected low costs of production.

1.1 Composite Materials

Compared to traditional materials a composite material (also called a composition material or shortened to composite, which is the common name) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure.
The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to other materials.
More recently, researchers have also begun to actively include sensing, actuation, computation and communication into composites, which are known as Robotic Materials.
Typical engineered composite materials include:

- mortars, concrete
- Reinforced plastics, such as fibre-reinforced polymer
- Metal composites
- Ceramic composites (composite ceramic and metal matrices)

Composite materials are generally used for buildings, bridges, and structures such as boat hulls, swimmingpoolpanels, racingcar bodies, shower stalls, b athtubs, storagetanks, imitation granite and culturedmarble sin ks and counter tops.

The most advanced examples perform routinely on spacecraft and aircraft in demanding environments.

The earliest man-made composite materials were straw and mud combined to form bricks for building construction.
Ancient brick-making was documented by Egyptian tomb paintings.

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Wattle and daub is one of the oldest man-made composite materials, at over 6000 years old. Concrete is also a composite material, and is used more than any other man-made material in the world. As of 2006, about 7.5 billion cubic meters of concrete are made each year-more than one cubic metre for every person on Earth.

II. PROPERTIES

2.1 Properties of Al5086

5086 is an aluminium alloy, primarily alloyed with magnesium. It is not strengthened by heat treatment, instead becoming stronger due to strain hardening, or cold mechanical working of the material.Since heat treatment doesn't strongly affect the strength, 5086 can be readily welded and retain most of its mechanical strength. The good results with welding and good corrosion properties in seawater make 5086 extremely popular for vessel gangways, building boat and yacht hulls.

2.1.1 Basic Properties

a) 5086 has a density of 2,660 kg/m^3 (0.096 lb/cu in), with a specific gravity of 2.66.

b) Melting point is 590 °C (1,090 °F).

2.1.2 Chemical Properties

The alloy composition of 5086 is

a) Chromium - 0.05%–0.25% by weight

b) Copper - 0.1% maximum

c) Iron - 0.5% maximum

d) Magnesium - 3.5%–4.5%

e) Manganese - 0.2%–0.7%

f) Silicon - 0.4% maximum

g) Titanium - 0.15% maximum

h) Zinc - 0.25% maximum

i) Others each 0.05% maximum

j) Others total 0.15% maximum

k) Remainder Aluminium

2.1.3 Mechanical Properties

The mechanical properties of 5086 vary significantly with hardening and temperature.

At “O” hardening, 5086 has a yield strength of 120 Mpa (17 ksi) and ultimate tensile strength of 260 Mpa (38 ksi) from −28 to 100 °C (−18 to 212 °F). At cryogenic temperatures it is slightly stronger: at −196 °C (−321 °F), yield of 130 Mpa (19 ksi) and ultimate tensile strength of 380 Mpa (55 ksi); above 100 °C (212 °F) its strength is reduced.

Elongation, the strain before material failure, ranges from 46% at −196 °C (−321 °F), 35% at −80 °C (−112 °F), 32% at −28 °C (−18 °F), 22% at 20 °C (68 °F), 30% at 24 °C (75 °F), 36% at 100 °C (212 °F), and increases above there.

–H32 hardening

–H34 hardening

–H112 hardening

–H116 hardening

H116 strain hardened 5086, with properties measured at 20 °C (68 °F), has yield strength of 210 Mpa (30 ksi), ultimate tensile strength of 290 Mpa (42 ksi), and elongation of 12%.

2.1.4 Uses

a) 5086 is the preferred hull material for small aluminium boats or larger yachts. Its high strength and good corrosion resistance make it an excellent match for yachting.
b) 5086 has a tendency to undergo Stress corrosion cracking and is not used much in aircraft construction as a result.
c) 5086 has been used in vehicle armor, notably in the M113 Armored Personnel Carrier and M2 Bradley Infantry fighting vehicle.

2.1.5 Welding

a) 5086 is often assembled using arc welding, typically MIG or TIG welding. The newer technique of Friction stir welding has also been successfully applied but is not in common use.

b) Arc welding reduces mechanical properties to no worse than –O hardening condition. For –H116 base material, measured at 20 °C (68 °F) ambient temperature, yield strength decreases from 210 Mpa (30 ksi) to 120 Mpa (17 ksi) and ultimate strength from 290 to 260 Mpa (42 to 38 ksi). The relatively low decrease in ultimate strength (about 10%) is extremely good performance for an aluminium alloy.

2.2 Properties of Bamboo

The mechanical properties of bamboo are often twice to three times higher than those of conventional timbers. However, legal uncertainties surrounding universal regulations and standards are preventing a bamboo boom in many parts of the world.Strength properties for bamboo have already been tested by universities around the world and present outstanding results which are in many cases much superior to conventional building materials. However, building code standards require more than the strength properties of a material alone, other properties to consider are:

- Durability
- Fire Safety
- Environmental Impact
- User Safety
- Energy Efficiency

Fire resistance and durability are areas that still need further research before a standard building code can be appointed to bamboo. Nevertheless, important progress has been made by introducing an international ISO 22157 standard for the mechanical properties of bamboo.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 05, May-2018

2.2.1 COMPRESSIVE STRENGTH

There are two types of compressive strength that need to be tested according to the ISO 22157 standard compressive strength parallel to grain and compressive strength perpendicular to grain. Strangely enough ISO 22157 guidelines only describe the testing methodology for compressive strength parallel to grain but do not provide a methodology for compressive strength perpendicular to grain. For that reason we will only discuss the former.

Because of the natural shape of a bamboo "tree", 3 different parts of the stem need to be tested: the bottom, middle and top part. This is necessary because a bamboo stem does not have a continuous cross-section and there are differences in structural properties between the lower part, which has a larger diameter, and the upper part, which has a smaller diameter.

The test samples cannot contain a node because the results of these samples would not provide accurate results as the nodes are the strongest areas in a bamboo stem. Therefore, test samples are taken from the section between two nodes (internodes), as this is the weakest part of a bamboo pole.For construction purposes only the bottom, middle and top part can be used as columns or beams. The 'leader' and 'stick' part of the bamboo culm are not considered useful in construction because of their small diameter.

The compressive strength of bamboo is roughly situated between 40 and 80 N/mm2 which is twice to four times the value of most timber species. The difference in results can be explained by the different test methods and samples that were used. However, it is clear that age and moisture content of bamboo samples have a significant influence on the compressive strength of bamboo. Bamboo with low moisture content has a higher compressive strength than bamboo with high moisture content.

2.2.2 Tensile Strength

The maximum tensile strength of bamboo is determined by testing the fibers (bamboo strips) and not on entire culm samples. As with compressive strength, the ISO 22157 standard does provide guidelines for tensile strength parallel to grain but not for tensile strength perpendicular to grain.

To test bamboo's tensile strength, 3 trips are used from the lower part, the middle part and the upper part of the entire bamboo stem. Each strip is between 10-20 mm wide, has the thickness of the bamboo culm, and is 100 mm long. Moisture content of each sample must be determined and samples must have a node. As the fiber direction of the node is opposite to the fiber direction of the internode, the node is here considered the weakest point of the stem (when testing compressive strength it is the other way around).

The average tensile strength of bamboo is situated roughly around 160 N/mm2 which is often 3 times higher than most conventional construction grade timbers.

2.2.3 Shear Strength

The maximum shear stress for bamboo is an important factor to design appropriate joinery systems and connections. Shear stresses can occur in two ways, parallel to the grain and perpendicular to grain. Again, ISO 22157 standards only provides guidelines for measuring shear stress parallel to grain.

Three samples from the lower, middle and upper part of the bamboo stem are tested. The difference this time is that half of the test samples should have a node and the other half should not have a node.

Each sample is carefully measured before testing. The height of the test piece and the thickness of the culm are measured at the 4 zones where shear will occur. This is important because a bamboo culm isn't uniform in thickness and the sample cross cuts may not be perfectly executed.

Shear stress parallel to grain is approximately 10 times lower than compressive strength and even 20 times lower than the tensile strength of the same bamboo species. Still, the shear strength of bamboo is often twice the value of popular timber species.

2.2.4 Bending Strength

Bending strength has a direct influence on the behavior of a structure, it is necessary to predict the deflection of each element of a structure before it is build. The most commonly used method for determining the deflection of a beam or column is the four-point bending test.

The bending strength of most bamboo species varies between 50 and 150 N/mm2 and is on average twice as strong as most conventional structural timbers. Variations within the same species are caused by the different test methods, sample quality and moisture content of the tested bamboo.

III. REVIEW OF LITERATURE

K.Chandrasekar, S.A.Ajith, R.P.Abbas, A.Yasar Arafath, K.Vinoth kumar [2018] "Tribological behaviour for stir cast Al5086/Gr/Al2O3 Hybrid matrix composite" In this study, the author had discussed that the mechanical properties of hybrid aluminum increases with an increase in weight fraction of alumina particles.

M.Z butt, A.mannan majeed, M.waqas khaliq,Dilwar Ali [2017] "Structural,electrical and mechanical characterization of Al5086 alloy irradiated with 248nm-20ns KrF examiner laser" In this study, the author had discussed about the relationship between electrical resistivity and surface hardness was linear in Al5086.

P.B Madakson, D.S.Yawas and A. Apasi [2014] "Characterization of Coconut Shell Ash for Potential Utilization in Metal Matrix Composites for Automotive Applications" In this study the author had clearly discussed about the presence of hard element like SiO2, Al2O3,MgO as major constituent which can be used as a particulate reinforcement in automobile manufacturing and The coconut shell ash can withstand a temperature of up to 1500°C with a

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 05, May-2018

density of 2.05g/cm3 that means this ash can be use in production light weight component with good thermal esistance.

Izekor D N, Fuwape J A [2011] “Performance of teak wood on exposure to outdoor conditions” In this study, the author had discussed that the teak wood of older age class has higher resistance to shrinkage and surface splitting.

MD Tanwir Alam, Sajjad arif, Akhter Husain [2018] “Wear behaviour and morphology of stir cast aluminium /SiC nanocomposites” In this study, the author had discussed that the friction coefficient reduces with the addition of SiCn as well as with the increase in load. However, wear resistance increases as the reinforcement content increases because of the embedding and wettability effects.

Rajasekar Thiyagarajan, Vignesh Ganesan [2018] “Preparation and Characterization of Aluminium metal matrix composite by using stir casting Technique” In this study, the author had concluded that the stir casting method used to prepare the composites could produce a uniform distribution of the reinforcement.The hardness increased with the increase in the weight fraction of reinforcement.

Suardjaka, Sri nugrogo [2018] “Investigation of Mechanical Properties of Al7Si/ SiC and Al7SiMg/SiC Composites Produced by Semi Solid Stir Casting Technique” In this study, the author had discussed that porosities increases with increasing wt % of SiC reinforcements in composite.

IV. EXPERIMENTAL WORK

AVAILABLITIES OF MATRIX COMPOSITES

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PROBLEM IDENTIFICATION

↓

SELECTION OF COMPOSITE MATERIALS

↓

SELECTION OF REINFORCEMENT

↓

PREHEATING PROCESS

↓

FABRIFICATION PROCESSING USING STIR CASTING METHOD

↓

MECHANICAL TESTING PROCESS

↓

RESULTS AND DISCUSSION

4.1 Extraction of Teak Wood Ash

The bamboo wood was collected and dried under sunlight after that it was burnt in a mud furnace and left it for 24 hrs.

Figure.1. DRIED TEAK WOOD

Figure.2. Burning of Teak Wood For Getting Ash

4.2 Extraction of Bamboo Wood Ash

The bamboo wood was collected and dried under sunlight after that it was burnt in a mud furnace and left it for 24 hrs.

Figure.3. Dried Bamboo Wood

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 05, May-2018

Figure.4. Burning of Bamboo For Getting Ash

4.3 *Heat Treatment of Ash*

The heat treatment of the teak wood ash and the bamboo ash for removing the moisture content in the ash is done by the muffle furnace. The process is shown below

Figure.5. Heat Treatment of Ash in Muffle Furnace

4.4 Stir Casting Process

Liquid state fabrication of Metal Matrix Composites involves incorporation of dispersed phase into a molten matrix metal, followed by its Solidification. In order to provide high level of mechanical properties of the composite, good interfacial bonding (wetting) between the dispersed phase and the liquid matrix should be obtained.

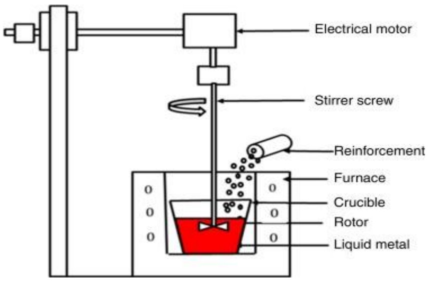

Figure.6. STIR CASTING SETUP

4.5 Mix Propotion of Al And Reinforcement

The table given above show the reinforcement % for various samples and they were done using the stir casting methods the resultant samples are as follows

Figure.7.Sample Mould

Table.1.MIX PROPORTION

SAMPLE 1	AL5086	TEAKWOOD ASH	BAMBOO WOOD ASH
SAMPLE 1	300g	9g	4.5g
SAMPLE 2	300g	18g	9g
SAMPLE 3	300g	27g	13.5g
SAMPLE 4	300g	nil	nil

Figure.8. Sample Mould After Casting Process

Figure.9.Samples After Taken From Mould

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 05, May-2018

Figure.10. Machining Process of the Samples

Figure.11. Samples After Machining Process

V. LABORATORY TESTS AND RESULTS

5.1 Microstructural Analysis

The micro structure of the reinforced samples and surface morphology of the wear debris were studied using a JOEL JSM 5900LV scanning electron microscope equipped with an Oxford INCA energy dispersive spectroscopy system at the department of Materials and Meteorology, National Institute of Technology, Trichy, India. The samples were firmly held on the sample holder using double sided carbon tape before putting them into the sample chamber.

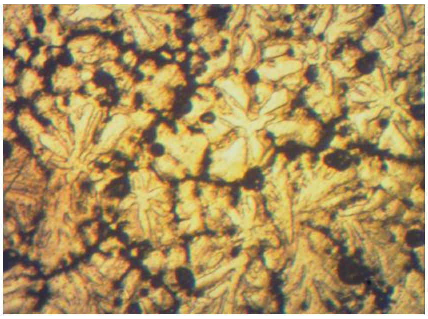

Figure.12.MICROSTRUCTURE OF SAMPLE1 AT 50X

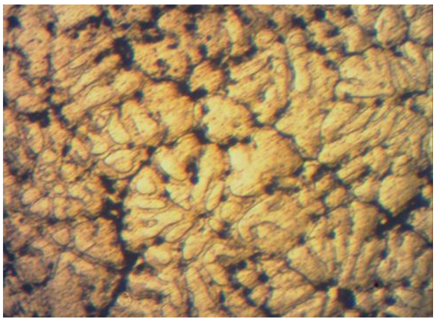

Figure.13. Microstructure of Sample2 At 50x

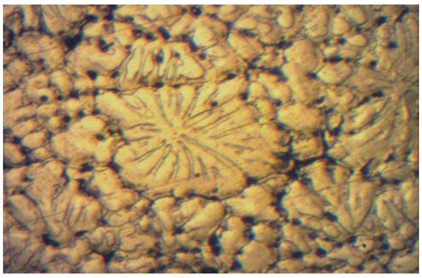

Figure.14.MICROSTRUCTURE OF SAMPLE3 AT 50X

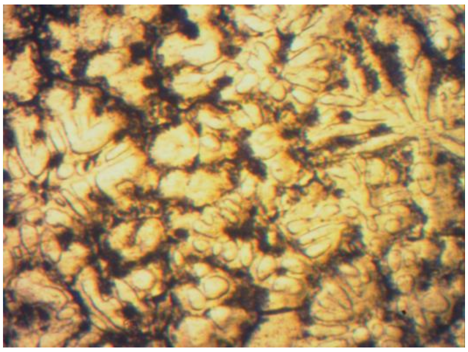

Figure.15 .Microstructure Of Sample4 At 50x

5.2 X-Ray Diffractometer (Xrd) Analysis

The XRD analysis of the reinforced samples was carried out using Philips X-ray differactrometer at the Department of physics,NIT, Trichy, India. The X-ray diffractrograms was taken using Cu Kα radiation at a scan speed of 3°/min. The samples were rotated at precisely one-half of the angular speed of the receiving slit, so that a constant angle between the incident and reflected beams is maintained. The receiving slit is mounted in front of the counter on the counter tube arm, and behind it is usually fixed a scatter slit to ensure that the counter receives radiation only from the portion of the specimen illuminated by the primarily beam.The intensity diffraction at the various angles was recorded automatically on a chart and the appropriate (θ) and (d) values were then obtained.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 05, May-2018

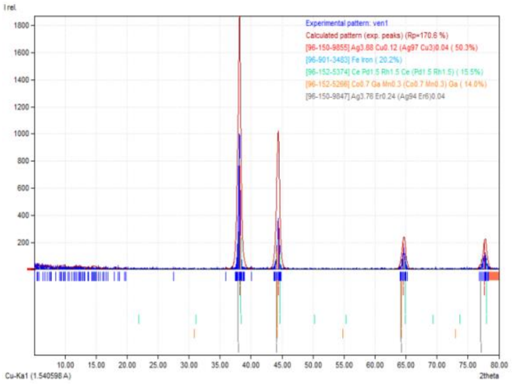

Figure.16. XRD RESULT FOR SAMPLE1

Table.2.MATCHED PHASE FOR SAMPLE1

S.NO	NAME	PERCENTAGE	FORMULA
1	(Ag97 Cu3)0.04	50.3	Ag3.88 Cu0.12
2	Iron	20.2	Fe
3	Ce (Pd1.5 Rh1.5)	15.5	Ce Pd1.5 Rh1.5
4	(Co0.7 Mn0.3)Ga	14.0	Co0.7 Ga Mn0.3

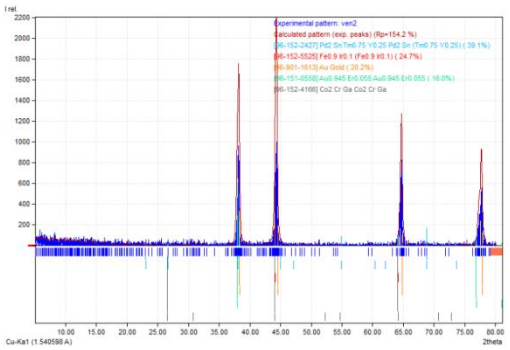

Figure.17.XRD RESULT FOR SAMPLE2

Table.3.MATCHED PHASE FOR SAMPLE2

S.NO.	NAME	PERCENTAGE	FORMULA
1	(Fe0.94 Rh0.06)	40.8	Fe0.94 Rh0.06
2	Gold	31.8	Au
3	Ho Pd3	19.3	Ho Pd3
4	(Au Hg3)0.2	8.1	Au3.4 Hg0.6

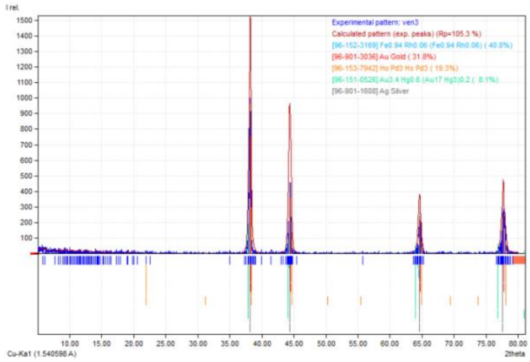

Figure.18.XRD RESULT FOR SAMPLE3

Table.4.MATCHED PHASE FOR SAMPLE3

S.NO.	NAME	PERCENTAGE	FORMULA
1	Pd2 Sn(Tm0.75 Y0.25)	39.1	Pd2 Sn Tm0.75 Y0.25
2	(Fe0.9 Ir0.1)	24.7	Fe0.9 Ir0.1
3	Gold	20.2	Au
4	Au0.945 Er0.055	16.0	Au0.945 Er0.055

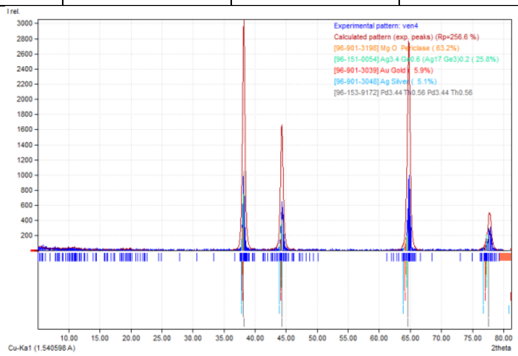

Figure.19.XRD RESULT FOR SAMPLE4

Table.5.MATCHED PHASE FOR SAMPLE4

S.NO	NAME	PERCENTAGE	FORMULA
1	Periclase	63.2	Mgo
2	(Ag17 Ge3)0.2	25.8	Ag3.4 Ge0.6
3	Gold	5.9	Au
4	Silver	5.1	Ag

V. CONCLUSION

The following conclusions can be drawn from the present study,

A) The composite was successfully cast using the stir casting technique under a teeming temperature of 750°C and a stirring speed of 600 rpm.

B) Addition of wood ash such us Teak wood ash and bamboo ash enhanced the existing Material.

C) The addition of 9grams and 18grams of teak wood ash and bamboo ash particulate to the composite matrix gave the best results in terms of Flexural properties.It increases Flexural strength by 39% when compared with unreinforced material.

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