AIJRRLJSM VOLUME 1, ISSUE 5 (2016, MAY) (ISSN-2455-6300) ONLINE

ANVESHANA'S INTERNATIONAL JOURNAL OF RESEARCH IN ENGINEERING AND APPLIED SCIENCES

FABRICATION OF CARBON NANO TUBE BY ADDING NANO FLYASH TO ALUMINA

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ABSTRACT:

The application spectrum of low cost material reinforced metal matrix composites is growing rapidly in various engineering fields due to their superior mechanical properties. In the present study it is proposed to explore the possibilities of reinforcing aluminium alloy (AlSiC) with locally available inexpensive rice husk and fly ash for developing a new composite material. A rice husk and fly ash particles of 5, 10 and 15% each by weight are proposed to develop metal matrix composites using liquid metal processing route. The mechanical properties such as tensile strength, compressive strength, hardness and percentage elongations are to be studied for reinforced composites.

1. INTRODUCTION TO COMPOSITE MATERIALS

A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties.

The two constituents are reinforcement and a matrix. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part.

The reinforcing phase provides the strength and stiffness. In most cases, the reinforcement is harder, stronger, and stiffer than the matrix. The reinforcement is usually a fibre or a particulate. Particulate composites have dimensions that are approximately equal in all directions. They may be spherical, platelets, or any other regular or irregular geometry. Particulate composites tend to be much weaker and less stiff than continuous fibre composites, but they are usually much less expensive. Particulate reinforced composites usually contain less reinforcement (up to 40 to 50 volume percent) due to processing difficulties and brittleness.

A fibre has a length that is much greater than its diameter. The length-to-diameter (l/d) ratio is known as the aspect ratio and can vary greatly.

Continuous fibres have long aspect ratios, while discontinuous fibres have short aspect ratios. Continuous-fibre composites normally have a preferred orientation, while discontinuous fibres generally have a random orientation. Examples of continuous reinforcements include unidirectional, woven cloth and helical winding (Fig.1.1a), while examples of discontinuous reinforcements are chopped fibres and random mat (Fig. 1.1b). Continuous-fibre composites are often made into laminates by stacking single sheets of continuous fibres in different orientations obtain the desired strength and stiffness properties with fibre volumes as high as 60 to 70 percent. Fibres produce high-strength composites because of their small diameter; they contain far fewer defects (normally surface defects) compared to the material produced in bulk. As a general rule, the smaller the diameter of the fibre, the higher its strength, but often the cost increases as the diameter becomes smaller.

In addition, smaller-diameter high-strength fibres have greater flexibility and are more amenable to fabrication processes such as weaving or forming over radii.

Typical fibres include glass, aramid, and carbon, which may be continuous or discontinuous.

The continuous phase is the matrix, which is a polymer, metal, or ceramic. Polymers have low strength and stiffness, metals have intermediate strength and stiffness but high ductility, and ceramics have high strength and stiffness but are brittle. The matrix (continuous phase) performs several critical functions, including maintaining the fibers in the proper orientation and spacing and protecting them from abrasion and the environment.

In polymer and metal matrix composites that form a strong bond between the fibre and the matrix, the matrix transmits loads from the matrix to the fibres through shear loading at the interface. In ceramic matrix composites, the objective is often to increase the toughness rather than the strength and stiffness; therefore, a low interfacial strength bond is desirable.

2. Scope of work for present research

Carbon nano tubes (CNTs) are regarded as ideal filler materials for polymeric fiber reinforcement due to their exceptional mechanical properties and 1D cylindrical geometry (nanometre-size diameter and very high aspect ratio). The reported processing conditions and property improvements of CNT reinforced polymeric fibre are summarized in this review. Because of CNT polymer interaction, polymer chains in CNTs' vicinity (inter phase) have been observed to have more compact packing, higher orientation, and better mechanical properties than bulk polymer. Evidences of the existence of inter phase polymers in composite fibres, characterizations of their structures, and fibre properties are summarized and discussed. Implications of inter phase phenomena on a broader field of fibre and polymer processing to make much stronger materials are now in the early stages of exploration. Beside improvements in tensile properties, the presence of CNTs in polymeric fibres strongly affects other properties, such as thermal stability, thermal transition temperature, fibre thermal shrinkage, chemical resistance, electrical conductivity, and thermal conductivity.

3. Methodology of fabrication

3.1 State processing

In solid-state processing, reinforcement is embedded in the matrix through diffusion at high pressures and high temperatures. Solid state processing of MMCs is done mainly using powder metallurgy processing. In powder metallurgy process, production of composites consists of three stages.

In the first stage, the aluminium alloy powder is blended in dry or liquid suspension with the particulates to produce composite powders. Mechanical alloying may also be employed to produce composite powders. Mechanical alloying, involves the introduction of hard dispersed particles in a relatively soft metal matrix with the aid of a high-energy ball mill (attritor).

The second stage involves Solid the compaction of powders under pressure to prepare a precursor. Compaction of the precursor may be performed either by die pressing, cold isostatic pressing, extrusion or forging.

This is followed by a third stage wherein the green compact is heated to a sufficiently high temperature (>0.7 Tm, where Tm is the melting point of matrix material in K) to promote the solid-state diffusion and facilitate bonding between the powder particles.

Stage three may also be performed by thixo-casting, hot forming, hot extrusion, forging, cold massive forming or super plastic forming. Stage two and three may be performed in one step as in the case of Hot Iso static Pressing wherein heat and iso-static pressure are simultaneously applied to produce the final component.

3.2 Liquid State Processing

In liquid state processing, liquid metal is infiltrated into the reinforcements. Infiltration may be carried out under atmospheric or inert gas pressure or under vacuum. The different techniques used for producing cast particulate composites using liquid metallurgy are stir casting, infiltration process, spray deposition and insitu methods.

3.3 Stir casting

The simplest and most commercially viable technique is the vortex technique or stir casting technique. The stir casting setup consists of a furnace, an electric motor with a stirrer arrangement and temperature sensors.

In this method, ceramic particulates are incorporated into liquid metal melt and the mixture is allowed to solidify. It is important to create a good wetting between the particulate reinforcement and the liquid metal. The vortex technique requires the introduction of pre-treated ceramic particles into the vortex of the molten matrix created by a rotating impeller. Generally, it is possible to incorporate up to 30% ceramic particles in the size range 5 to 100 m in a variety of molten aluminium alloys.

3.4 Infiltration technique

In the infiltration technique, a liquid alloy matrix is injected/infiltrated into a porous pre-form of continuous fibre/short fibre or whisker or particle. Depending on the nature of reinforcement and its volume fraction, performs can be infiltrated, with or without the application of pressure or vacuum. PAMCs having a reinforcement volume fraction ranging from 10 to 70% can be manufactured by means of infiltration. Some amount of porosity and local variations in volume fractions of the reinforcement are often noticed in the PAMCs processed by infiltration technique. The process is widely used to produce aluminium matrix composites having particle/ whisker/ short fibre/continuous fibre as reinforcement.

3.5 Spray deposition

Spray deposition techniques fall into two distinct classes, depending on whether the droplet stream is produced from a molten bath (Osprey process) or by continuous feeding of cold metal into a zone of rapid heat injection (thermal spray process). In the thermal spray process ceramic particle/whisker/short fibre are injected into the spray to produce PAMCs.

PAMCs produced in this technique often exhibit an inhomogeneous distribution of ceramic particles. Porosity in the as sprayed state is typically about 5–10%. Depositions of this type are typically consolidated to full density by subsequent processing.

3.5 Insitu methods

In insitu process, ultrafine ceramic particles are formed by the exothermic reaction between the elements or their compounds with molten matrix alloy. These insitu routes provide advantages such as uniform distribution of reinforcement, finer particle size, clean interface, thermodynamically stable reinforcement phase and process economy in comparison with the conventional ex-situ processes. One example is the directional oxidation of aluminium also known as DIMOX process.

While investigating the opportunity of using fly-ash as reinforcing element in the aluminum melt, R.Q.Guo and P.K.Rohatagi observed that the high electrical resistivity, low thermal conductivity and low density of fly-ash may be helpful for making a light weight insulating composites.

Mechanical properties of composites are affected by the size, shape and volume fraction of the reinforcement, matrix material and reaction at the interface. These aspects have been discussed by many researchers. Rohatgi reports that with the increase in volume percentages of fly ash, hardness value increases in Al–fly ash (precipitator type) composites. He also reports that the tensile elastic modulus of the ash alloy increases with increase in volume percent (3-10) of fly ash. Aghajanian, etc have studied the Al_2O_3 particle reinforced Al MMCs, with varying particulate volume percentages (25, 36, 46, 52 and 56) and report improvement in elastic modulus, tensile strength, compressive strength and fracture properties with an increase in the reinforcement content. The interface between the matrix and reinforcement plays a critical role in determining the properties of MMCs. Stiffening and strengthening rely on load transfer across the interface. Toughness is influenced by the crack deflection at the interface and ductility is affected by the relaxation of peak stress near the interface.

A contribution to efforts aimed at the development of Aluminium Matrix Composites (AMCs) with high performance indices at reduced cost. The well acknowledged good performance in service and consequent high demand for AMCs is attributed to its excellent combination of properties such as high specific strength and stiffness, low thermal coefficient of expansion, good wear, corrosion and high temperature resistance among others. These property combinations are very useful for the design of a wide range of components and parts utilized for automobile and aerospace applications. For example, use of AMCs with high specific strength and stiffness for engine components can contribute significantly to the reduction of the overall weight and fuel consumption of automobiles and aircrafts. Particulate ceramic materials such as silicon carbide (3.18 g/cm3) and alumina (3.9 g/cm3) have been widely utilized as reinforcement in AMCs. These reinforcements are however, denser than Aluminium (2.7 g/cm3) and thus result in increase in the weight of Aluminium based composites depending on the weight percent of the reinforcing phase. Synthetic reinforcements such as silicon carbide (SiC) and alumina (Al_2O_3) despite their apparent wide spread use, are not produced in most developing countries. The reliance on importation from abroad and the high foreign currency exchange involved implies that the synthetic reinforcements are purchased locally at relatively high cost. A low cost option currently explored by composite materials researchers from developing countries is the consideration of ashes obtained from the controlled burning of agro-wastes such as baggage, rice husk, coconut shell, bamboo leaf and ground nut shell as particulates reinforcement for the development of AMCs . These agro-waste ashes often contain a high percentage of silica (SiO_2) with a distribution of other refractory oxides such as Al_2O_3 and hematite (Fe_2O_3). The agro-waste ashes are characterized with densities far lower than that of SiC (3.18 g/cm3) and Al_2O_3 (3.9g/cm3); but the strength levels achieved using these ashes as reinforcement in aluminium matrices is marginal even for high volume percents of the reinforcement . This is due largely to the presence of SiO_2 which is the Predominant constituent of agro-waste ashes.

Stir casting process of application

Aluminium-matrix composites are not a single material but a family of materials whose stiffness, strength, density, thermal and electrical properties can be tailored. The matrix alloy, reinforcement material, volume and shape of the reinforcement, location of the reinforcement and fabrication method can all be varied to achieve required properties. The aim involved in designing metal matrix composite materials is to combine the desirable attributes of metals and ceramics.

In stir casting process, the reinforcing phases are distributed into molten matrix by mechanical stirring. Stir casting of metal matrix composites was initiated in 1968, when S. Ray introduced alumina particles into aluminium melt by stirring molten aluminium alloys containing the ceramic powders. Mechanical stirring in the furnace is a key element of this process. The resultant molten alloy, with ceramic particles, can then be used for die casting, permanent mould casting, or sand casting. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement.

The melting was carried in a tilting oil-fired furnace in a range of 760 ± 10^{0}C. A schematic view of the furnace has been shown in Figure 1.

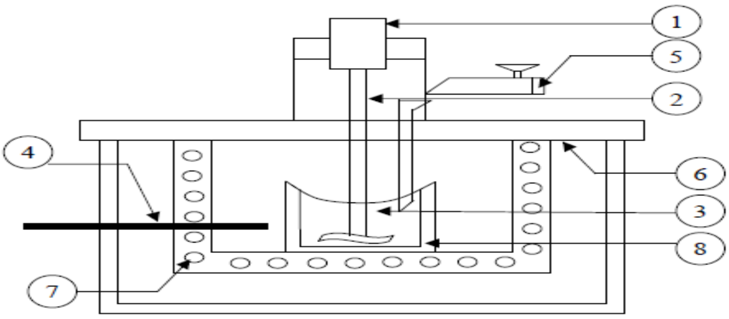
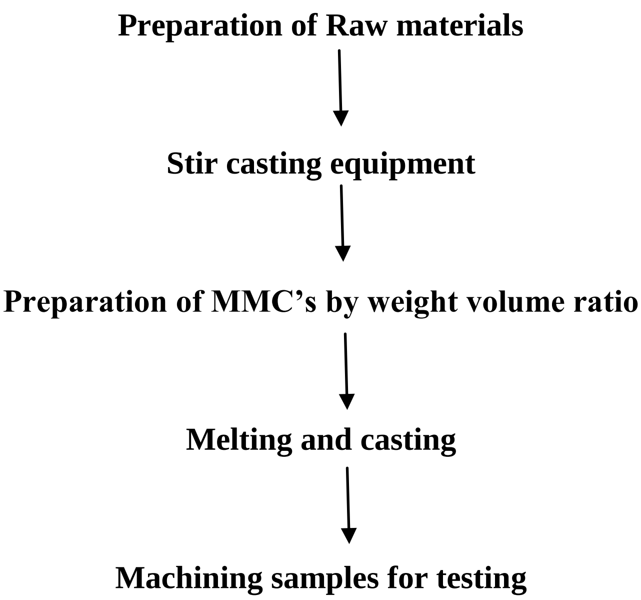


Fig. 1. Schematic view of setup for Fabrication of composite

1. Motor
2. Shaft
3. Molten aluminium
4. Thermocouple
5. Particle injection chamber
6. Insulation hard board
7. Furnace
8. Graphite crucible

EXPERIMENTAL WORK



Experimental set up

RULE OF MIXTURES BY WEIGHT/ VOLUME RATIO

Metal Matrix Composite: Al SIC +Fly ash + Husk

Total Volume of the Composite: 16cm X 4cm X 3cm =192 cm^3

S.No.	Composition of Material	% by Volume	Volume Occupied (cm^3)	Density (gm./cm^3)	Mass (gm.)
1	Al SIC	76%	147.84	2.9	428.73
2	Fly ash	12%	15.36	1.02	15.66
3	Husk	3%	3.84	1.42	5.45
4	Al_2O_3	3%	5.76	3.97	22.87
5	Mg	2%	3.84	1.47	5.64
6	Hexachloro methene	4%	7.68	1.2	9.22

Metal Matrix Composite: Al 6061 + Fly ash

Total Volume of the Composite: 16cm X 4cm X 3cm =192 cm^3

S.No.	Material Constituents	% by Volume	Volume Occupied (cm^3)	Density (gm./cm^3)	Mass (gm.)
1	Al 6061	74%	142.08	2.74	389.30
2	Fly ash	6%	11.52	1.01	11.63
3	Al_2O_3	3%	5.76	3.97	22.87
4	Mg	2%	3.84	1.47	5.64
5	Hexachloromethene	4%	7.68	1.2	9.22

Metal Matrix Composite: Al 6061 + Fly ash+ Husk

Total Volume of the Composite: 16cm X 4cm X 3cm =192 cm^3

S.No.	Material Constituents	% by Volume	Volume Occupied (cm^3)	Density (gm./cm^3)	Mass (gm.)
1	Al 6061	73%	140.16	2.71	379.83
2	Fly ash	8%	15.36	1.01	15.51
3	Husk	6%	11.52	8.908	102.62
4	Al_2O_3	3%	5.76	3.97	22.87
5	Mg	2%	3.84	1.47	5.64
6	Hexachloromethene	4%	7.68	1.2	9.22

Metal Matrix Composite: Al Sic + Fly ash

Total Volume of the Composite: 16cm X 4cm X 3cm =192 cm^3

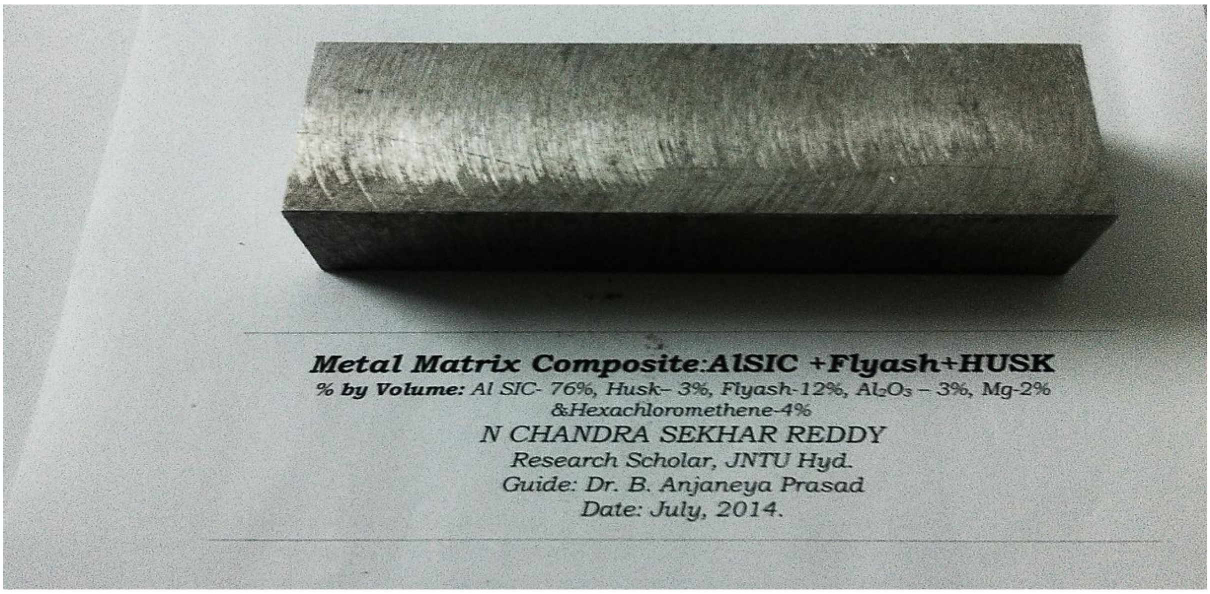
S.No.	Material Constituents	% by Volume	Volume Occupied (cm^3)	Density (gm./cm^3)	Mass (gm.)
1	Al Sic	80%	153.6	2.9	445.44
2	Fly ash	11%	23.04	1.01	23.27
4	Al_2O_3	3%	5.76	3.97	22.87
5	Mg	2%	3.84	1.47	5.64
6	Hexachloromethene	4%	7.68	1.2	9.22

Metal Matrix Composite: Al Sic + Fly ash + *TiB2*

Total Volume of the Composite: 16cm X 4cm X 3cm =192 cm^2

S.No.	Material Constituents	% by Volume	Volume Occupied (cm^3)	Density (gm./cm^3)	Mass (gm.)
1	Al Sic	77%	147.84	2.9	428.73
2	TiB_2	6%	23.04	4.52	104.14
3	Fly ash	8%	15.36	1.01	15.51
4	Al_2O_3	3%	5.76	3.97	22.87
5	Mg	2%	3.84	1.47	5.64
6	Hexachloromethene	4%	7.68	1.2	9.22

Results


Metal Matrix Composite:AlSIC +Flyash+HUSK
% by Volume: Al SIC- 76%, Husk- 3%, Flyash-12%, Al2O3 – 3%, Mg-2%
&Hexachloromethene-4%
N CHANDRA SEKHAR REDDY
Research Scholar, JNTU Hyd.
Guide: Dr. B. Anjaneya Prasad
Date: July, 2014.


Metal Matrix Composite: Al 6061 + Flyash+ Husk
% by Volume:Al 6061- 77%, Flyash- 8%, Husk – 6%, Al2O3 – 3%, Mg-2%
&Hexachloromethene-4%
N.CHANDRA SEKHAR REDDY
Research Scholar, JNTU Hyd.
Guide: Dr.B. Anjaneya prasad
Date: July, 2014.


Metal Matrix Composite: Al 6061 + Flyash
% by Volume: Al 6061- 79%, Flyash-12%, Al2O3 – 3%, Mg-2% & Hexachloromethene-4%
N CHANDRA SEKHAR REDDY
Research Scholar, JNTU Hyd.
Guide: Dr.B.Anjaneya Prasad
Date: July, 2014.


Metal Matrix Composite: AlSIC + Flyash
% by Volume:AlSIC- 80%, Flyash-11%, Al2O3 – 3%, Mg-2% &Hexachloromethene-4%
N.CHANDRA SEKHAR REDDY
Research Scholar, JNTU Hyd.
Guide: Dr.B. Anjaneya prasad
Date: July, 2014.


Metal Matrix Composite: AlSIC + TiB2 +Flyash
% by Volume:Al AlSIC- 77%, TiB2 – 6%, Flyash – 8%, Al2O3 – 3%, Mg-2% &Hexachloromethene-4%
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Tensile samples with tubes machining

Conclusions

By taking volume weight ratios in to consideration it is easy to mix the volume ratios of alloy matrix and stir casting is one of the prominent processes of matrix fabrication because of its stirring capacity . The blade velocity will give good mixing and molecular bonding will give an excellent casting than normal casting process.

1. From the study it is concluded that we can use fly ash for the production of composites and can turn industrial waste into industrial wealth. This can also solve the problem of storage and disposal of fly ash.

2. Fly ash upto 10% by weight can be successfully added to Al by stir casting route to produce composites.

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