Industrial Science
ISSN 2347-5420
Impact Factor : 1.5015(UIF)
Volume - 1 | Issue - 12 | Aug - 2015

Development and characterization of Al-Cu-Mg alloy/TiC metal matrix composites

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ABSTRACT

To meet the ever increasing demand of man's needs and comforts composites are versatile materials used for various engineering and industrial applications.Among the various Metal matrix composites, aluminium alloy based composites are widely considered by the researchers because of their high strength-lightweight combination along with good corrosion resistance. As a result, Aluminium metal matrix composites are increasingly finding their application in the fields of electronics, aerospace and automobile etc .Al-Cu-Mg is used as matrix material reinforced with hard ceramic particles like TiC. Stir casting Technique is used by varying weight percentage (wt. %) of reinforcement. To develop challenging composite material.

KEYWORDS :Stir casting process, Metal matrix, Density.

INTRODUCTION :

Over the past few years, researchers have emphasized on production of light and strong materials. Aluminium based metal matrix composites are the advanced materials with superior properties which are actively being sought for engineering applications. In recent years, Al based composite materials have gained significance in aero- space, automotive and structural applications due to their enhanced mechanical properties and good stability at high temperature. The necessary characteristics of advanced materials include high specific modulus, stiffness, strength, hardness, ductility, corrosion resistance, low heat expansion coefficient and so on [1].

Fibers or particulate types are widely used as reinforcement phases in Metal Matrix Composites (MMCs). There are many processing techniques which have been developed for fabricating Metal Matrix Composites (MMCs). Such techniques are Powder Metallurgy (PM), liquid metal infiltration, composting, squeeze casting method, stir casting and spray decomposition method etc[2,3].

Among the fabrication techniques of MMC, stir casting (for particulate or discontinuous reinforced MMCs) is generally preferred. Its advantages are its simplicity, flexibility and applicability to large quantity of production. It is also attractive because of minimized final cost of the product. In the stir casting method, there are several factors that need considerable attention, including the difficulty of achieving a uniform distribution of the reinforcement one of thing .During these conventional processes, the major difficulties are improper wetting due to oxidation which exhibit interface binding between matrix and ceramic phases. Improved wetting must be achieved to obtain a good bond between the matrix and reinforcement[3-4]

Various types of reinforcements are used in matrix of Aluminium like SiC, TiC, Al_2O_3, B_4C, TiB_2, TiN, etc. Among these, TiC is a relatively new reinforcement in metal matrix composites and has good properties such as wettability, thermal stability and distribution in Aluminium metal matrix [5-6].

2. EXPERIMENTAL PROCEDURES

2.1 Selection of Matrix Material and their properties

Al-Cu-Mg (2618) alloy is selected as a matrix material because of excellent physical and mechanical properties.

Al is soft, durable, ductile and malleable metal and has good specific mechanical properties.Excellent corrosion resistance properties.Aluminum is 100% recyclable. Easily machined, cast, drawn, extrudedand is a good thermal and electrical conductor and capable of being superconductor.

Table 1.Composition of Al2618 alloy

Component	%Composition
Aluminium	93.7
Copper	2.30
Magnesium	1.60
Iron	1.1
Silicon	0.18
Titanium	0.07

2.2 Selection of Reinforcement (TiC)

To developing new composite aluminum(2618) is used metalmatrix, Titanium carbide is selected as reinforcement Because of Very high strength,High resistance,Corrosion and wear resistance. Good surface finish.

Table 2: chemical composition of TiC

Component	%Composition
Titanium	79.91
Carbon	20.3

2.3 preparations of composites

The composites were developed by stircastingas shown inFig1.Al-Cu-Mg base alloy is used in there quired quantity wastaken in agraphitecrucible andmelted inanelectric furnace.The temperature of meltwas raisedto750°C.This molten metal was stirred manually using agraphite impellerata speed of 200rpm.The impellerblades were designed in such way tha the lpsinvortex formation.Ti Cparticles of finegrade(44μm) were taken separately.Defined ratioof fine Ti Cparticles keeping total percentage upto1wt.% were taken.Tic powder was preheated at 300°Ctodriveoff themoisture. After the formation of vortex in themelt, the TiC powder was pouredin sideth evor texintothemelt with the help offunnel keptonto pof vortex.The vortex methodisone ofthe better known approaches used to createand maintaina good distribution of there inforcement materialin them atrixalloy. Stirring of melt was continued for a not her 5min.even after the completion of particle feeding to ensure homogeneous distribution of the Ti Cparticles.The molten mass was finely poured in to the metal mouldand allowed to solidifyatroom temperature. Inthefirstbatch of casting there wasone weight percent TiC(44μm) particles where taken in these condbatch composite preparation two weight percentfine TiC particles weretaken and repeated the above procedure for different weight percentage of of TiC particle.

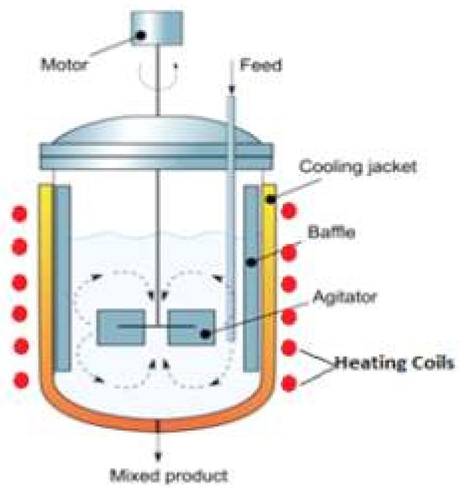


Fig 1 .stir casting process

2.4Tensile test

Specimens are prepared ASTM-E8-04 as shown in fig 2. Specimens are placed in the grips of a Universal Test Machine as shown in fig3.A specified grip separation and pulled until failure. For ASTM-E8-04 the test speed can be determined by the material specification or time to failure (1 to 10 minutes). A test speed for standard test specimens is 5 mm/min. An extensometer or strain gauge is used to determine elongation and tensile modulus. Depending upon the reinforcement and type, testing in more than one orientation may be necessary.

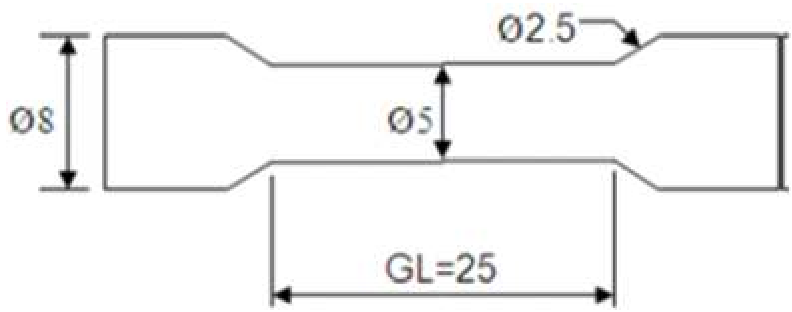


Fig2.Schematic of tensile specimen (alldimension in mm).

Fig3. Universal testing machine

2.5 Hardness test procedure

The Brinell hardness test method was conducted as per ASTM standard consists of indenting the test material with a 10 mm diameter hardened steel or carbide ball subjected to a load of 3000 kg. For softer materials the load can be reduced to 1500 kg or 500 kg to avoid excessive indentation. The full load is normally applied for 10 to 15 seconds in the case of iron and steel and for at least 30 seconds in the case of other metals. The diameter of the indentation left in the test material is measured with a low powered microscope. Hardness is determined by taking the mean diameter of the indentation (two readings at right angles to each other) and calculating the BHN by dividing the applied load by the surface area of the indentation. Since the degree of accuracy attained by the Brinell test can be greatly influenced by the surface finish of the specimen. Brinell hardness can be calculated by the formula given below. The BHN is calculated according to the formula given below in eq-1.

$$BHN = 2P/(\pi D(D-\sqrt{D^2-d^2})) \quad \text{---------------} \quad (1)$$

Where,
P = Load Applied
D = Dia of Ball Indenter
d = Dia of Indentation

2.6 Compression Test

A compression test determines the characteristics of materials under crushing loads. The sample is compressed and deformation at various loads is noted. Compressive stress and strain was calculated and plotted as a stress-strain diagram which is used to determine elastic limit, proportional limit, yield strength and yield point. When a compressive load is applied on a specimen, the deformation may take place: for brittle materials it may be crushing or fracture and for ductile material it may be due to elastic or plastic.

3. RESULTS AND DISCUSSIONS

3.1DENSITY

Theoretical density was calculated using rule of mixture the Figure 4 effect of weight percentage on density , it is observed that as the weight percentage of reinforcement increases density of the composite increased .According to Rule of Mixture of composite materials are estimated as follows. Density of the al-cu-mg metalmatrixcompositesimprovedfrom2.62 to 2.6683 thisimpliesan increment of 1.85 % density.

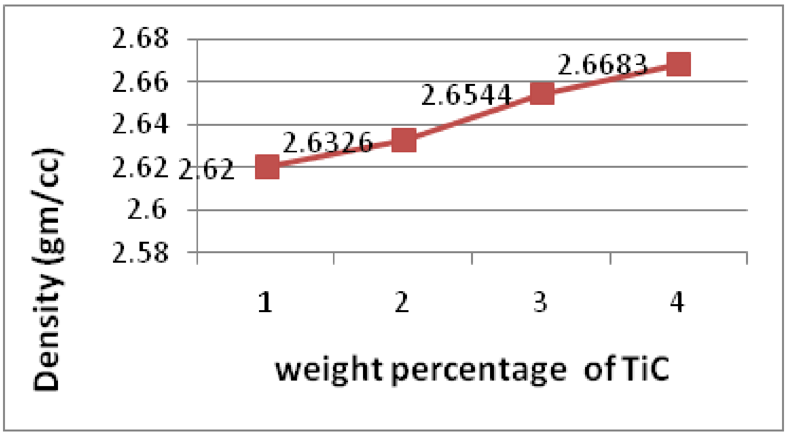


Fig 4.Effect of Wt% of TiC on Density

Density $dc = dm \times Vm + df \times Vf$

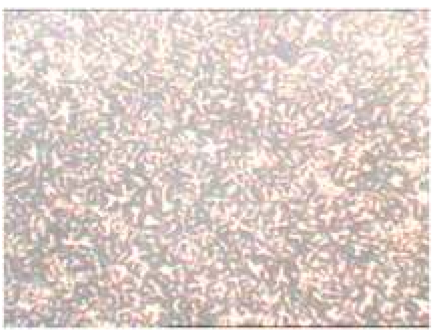
Where,

dc, dm, df– densities of the composite, matrix and dispersed phase respectively;

Vm, Vf– volume fraction of the matrix and dispersed phase respectively.

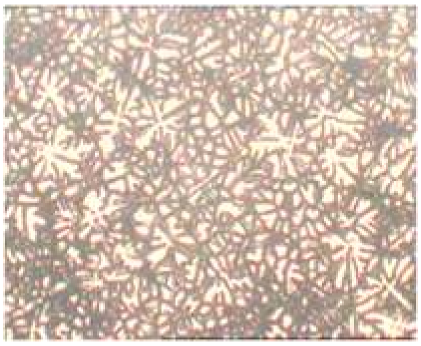
3.2 MICROSTRUCTURE ANALYSIS

Microstructure of Al-2618 base alloy and composite with3wt% TiC is shown in the Fig 5(a,b) respectively. The sample is roughened with belt polish and fine polished with various emery papers from 80,120,400, 600 and fine polished using Lavigated Alumina powder.The Microstructure showed nearly uniform distribution of the reinforcement particles with base alloy.

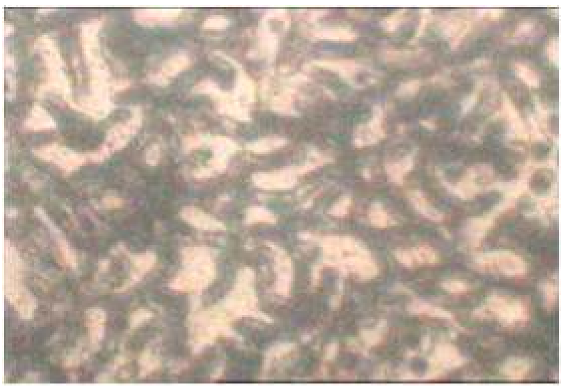


a)100X

b)400XFigure 5 (a): Microstructure of base alloy



a)100X



b)400X Fig5(b). Microstructure of Al –Cu-Mg /3% of TiC

3.3 HARNESS TEST RESULTS

Hardness test was conducted according to ASTM –E10-93, specimen was cut into ASTM –E10-93. The hardness of the composite specimen is significantly increased with increase in reinforcement content. Thetestresultsshowsthatwith the presenceof hardceramic particles, hardnessof the al-cu-mg metalmatrixcompositesimprovedfrom62.1BHN to 69.1 BHN thisimpliesan increment of 7%.Figure 6 represent effect of weight percentage of titanium carbide on hardness.

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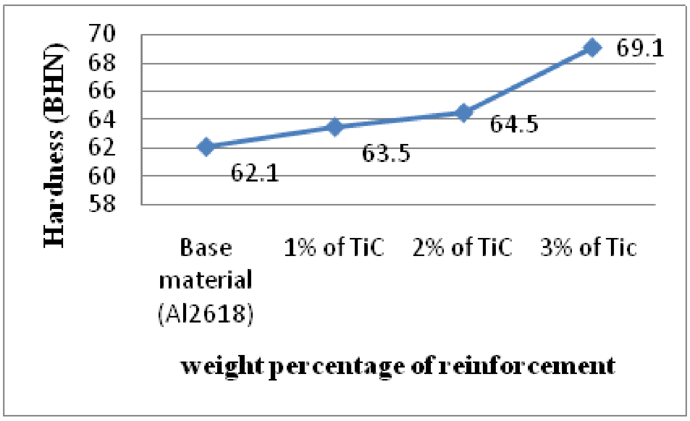

Figure 6:Effect of hardness on Al-Cu-Mg wt% TiC composite

3.4TENSILE TEST RESULTS

3.4.1 Yield strength

The specimen is prepared according to ASTM E8-04. The ultimate tensile strength was estimated using computerized uni-axial tensile testing machine .The yield strength of Al-cu-mg alloy is 124.85 MPa and composite with 3%TiC is 238 MPa, thisimpliesan increment of 90 % yield strength as shown in Figure7.

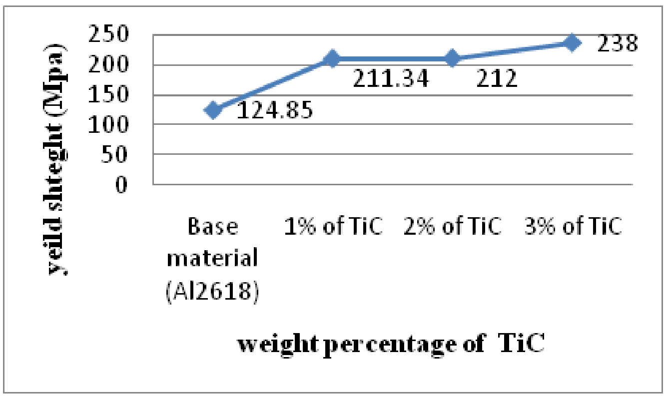

Figure 7.Effect yield strength on Al-wt.% TiC composites

3.4.2. Ultimate tensile strength

The ultimate tensile strength was estimated using computerized uni-axial tensile testing machine .The ultimate tensile strength of Al-2618 base allaoy is 130.536 MPa and composite with 3%TiC is 249.91MPa, thisimpliesan increment of 91 % ultimate strength as shown in figure 8.

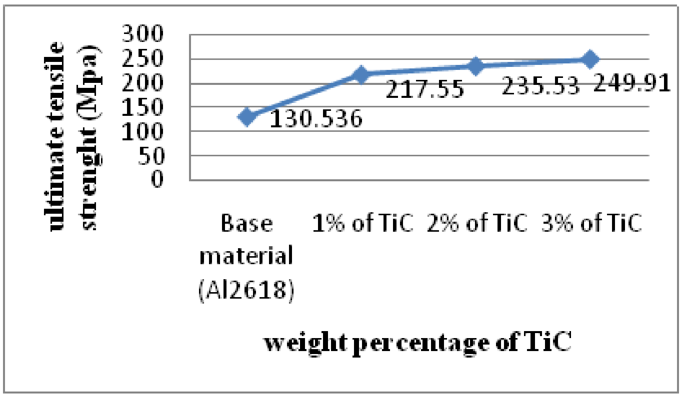

Fig 8.Effect ofultimate Tensile strength on Al and wt.% TiC composites

3.4.3 Percentage of elongation

The percentage of elongation of Al-cu-mg alloy is 5.68 and composite with 3%TiC is 15, thisimpliesan increment of 9.32% as shown in figure9.

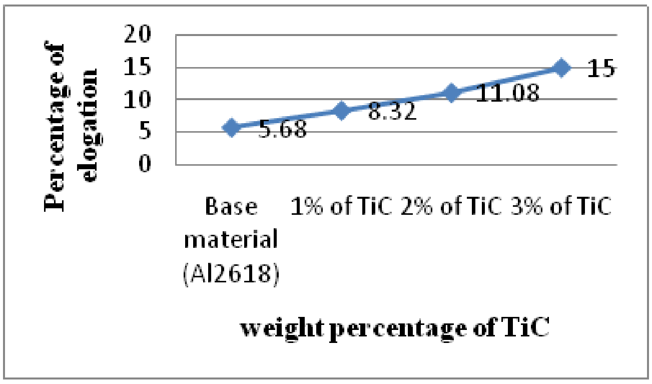

Figure 9.Effect of hardness on Al-wt.% TiC composites

3.5 COMPRESSION TEST RESULTS

According To ASTM E9 standard the compression test was carried out. The compression strength is increased with increase in reinforcement because TiC particulates being very hard resist the forces in all direction to some maximum load and suddenly fractures when it reaches the limit.Compressive strength of Al-cu-mg alloy 71.68 MPa and composite with 3% TiC is 79.50MPa. Thisimpliesan increment of 10.9% hardness of composite .The effect of compressive strength as shown in figure 10

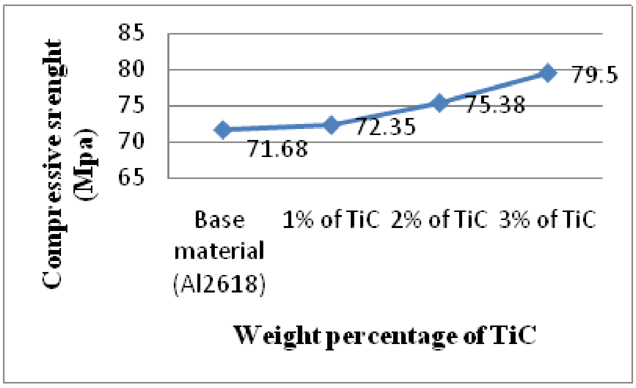

Figure 10: Effect of Wt% of TiC reinforcement on compressive strength

- 4. CONCLUSIONS
- Successful fabricationofAl2618 metalmatrixcompositeswithreinforcement ofTitanium carbide (TiC) usingstir casting method.
- The micro structure study revealed uniformdistribution ofparticles TiC in Al-cu mg alloy isrequiredforachievingbetter mechanical properties.
- Yieldstrengthhave been increased by theincorporation ofTitanium carbide reinforcement. Yield strength is increase 90% after addition of 3 weight percentage of Titanium carbide particle.
- Ultimate tensilestrength has been increased by theincorporation ofTitanium carbide reinforcement. Ultimate tensile strength is increase 91% after addition of 3 weight percentage of Tic particle.
- Withtheaddition oftitanium carbide reinforcement the hardness andcompression strengthvalueshaveimproved by 7% and 10% after addition 3 weight percentage of Titanium carbide respectively.
- Tensile strength, compression and hardness of Al-Cu-Mg 3wt%TiC MMCs fabricated in the present investigation indicated improvements of material properties.

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