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Fabrication and Mechanical Properties of Al8081, TiB_2 and Graphite by Stair Casting

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ABSTRACT

This study investigates the production of various reinforced and non-reinforced composite materials using in suit method. It presents the new approach into optimize the mechanical properties of hybrid composites (Al-gr-Tib_2) produced with stir casting process. AL 8081 powders are used as the matrix material and Tib_2 and Gr powders are used as the reinforcement materials. These extruded samples were subjected to T6 heat treatment. The composite materials produced are examined in terms of density, hardness, transverse rupture strength, and wear resistance. Furthermore, optical microscopy, scanning electron microscopy, In this study, high density Al AL 8081/ Tib_2 /gr hybrid composite materials were successfully produced. After extrusion, some micro particles were found to crack Compositions

KEYWORDS: Suit method, hybrid composites, stir casting, transverse rupture strength, optical microscopy,

1. INTRODUCTION

Composites are man made materials consisting of one or more discontinuous phases having intimate contact with each other, with are cognizable interface between them. These are multifunctional materials systems that provide characteristics not obtainable from individual phases. Further, composites are tail or made to cost effective, property effective and application oriented. In general, the discontinuous phase is harder and stronger than the continuous phase and is called the 'reinforcement'; whereas continuous phase is termed as the 'matrix'. The matrix holds reinforcement to form the desired shape and bears the major portion of an applied load, while the reinforcement improves overall mechanical properties of the matrix. Reinforcement increases the strength, stiffness, wear resistant and the temperature resistance capacity and lowers the density.

CLASSIFICATION OF COMPOSITES

In general, composites are classified according to the type of matrix material and then nature of reinforcement at two distinct levels. The first classification includes ceramic matrix composites (CMCs), organic matrix composites (OMCs) and metal matrix composites (MMCs). The term organic-matrix composite is generally assumed to include polymer Matrix composites (PMCs) and carbon matrix composites. The second classification refers to there in for cement form; particulate reinforcements, whiskers, continuous fiber, laminated composites and woven composites.

2. REALATED WORK

Depending upon the application in-service, a variety of composites with different combinations of matrix materials and reinforcements are being produced

through different fabrication methods. Briefs various systems and processing routes Proper mixing method to minimize the agglomeration of their enforcement and settling of the particle scan minimized by the quick pouring and employing chill casting technique. Secondary processing like rolling, forging, and extrusion gives better distribution of reinforcements.

Though there are many applications with MMCs; fabrication, secondary processing compatibility between the matrixes are enforcement and characterization are still the major problems in the manufacturing of these composites. Tib2 in various forms has been the most widely used reinforcement, in aluminum alloy. Other reinforcements are A12O3, SiO2, TiC, TiO2, ZrO2, TIB2, borate whiskers, quartz, diamond, graphite, fly ash etc. Among the variousmetal matrix composites (MMC), aluminum alloy metal matrix composites have successfully demonstrated their potential for even high-volume applications.

As concluded from many previous search studies, the strengthening of aluminum alloys with a dispersion of fine ceramic particulates strongly increases their potential in wear resistance and structural applications. In the current work, it is justified that B 4 c significantly improves the mechanical properties of the aluminum alloy based MMCs. AA2024- B 4c composites and AA2024-Tib2-gr hybrid composites have potential applications in automotive industry sectors. Conventional monolithic materials have limitations with respect to achievable combinations of strength, stiffness and density. In order to overcome these short comings and to meet the ever- increasing engineering demands of modern technology, metal matrix composites regaining.

Decrease of the elementary, distribution, some crystalline and Nano crystalline intermediate phases are produced inside the particles involving chemical changes. For the present research, the parent materials aluminum. The most important attributes of mechanical alloying are the following. Production of fine dispersions of second-phase particles. Extensions of solid solubility limits. Refinement of grain sizes down to nano meter range. Synthesis of novel crystalline and quasi- crystalline phase Development of amorphous (glass) phase Disordering or ordered inter metallic Fabrication of materials with precise composition and controlled micro structure Possibility of alloy in elements difficult to combine by conventional melting methods Inducement of chemical reaction sat low temperature Scalable process Velocity and frequency of the balls as follows

$$I=MV\ (F/P)\ M$$

3. PROPOSED WORK

MECHANICAL PROPERTIES OF AL 8081

Aluminum 8081 Matrix material the need for engineering materials in the areas of aerospace and automotive industries had led to a rapid development of metal matrix composites (MMC). Researchers are turning to particulate-reinforced aluminum metal matrix components (AMC) because of their relatively low cost and isotropic properties. In Al 8081 one constituent is aluminum/aluminum alloy termed as matrix phase. The other constituent is embedded in this aluminum/aluminum alloy matrix and serves as reinforcement. Mostly ceramic materials such as Sic, Al2O3, TIB2, etc. are used reinforcement. The major advantages of Al 8081's compared to unreinforced materials are, it gives greater strength, improved stiffness, reduced density (weight),improved high temperature properties, improved abrasion and wear resistance and enhanced and tailored electrical performance, etc. Aluminum 8081 is an aluminum alloy, with zinc as the primary alloying element. It has excellent mechanical properties and exhibits good ductility, high strength, toughness, and good resistance to fatigue.

MECHANICAL PROPERTIES OF GRAPHITE

Graphite is a crystalline form of the element carbon with its atoms arranged in a hexagonal structure. The principal types of natural graphite are Crystalline, Amorphous graphite, Lump graphite, highly ordered pyrolytic graphite and graphite fiber. The uses of natural graphite are Refractories, batteries ,steel making, brake linings, foundry facings and lubricants

,pencils and some special purpose applications also graphite is used. Properties of Graphite are modulus of elasticity, compressive strength, flexural strength and coefficient of thermal expansion

PROCESSING OF AL8081

Primary processing for manufacturing of AMCs can be classified into two main groups.

a) Liquid state process includes stir casting, squeeze castings, and ultrasonic assisted castings,

b) Solid state process include powder blending followed by consolidation (Powder metallurgy), high energy ball milling, and friction stir process.

LIQUID STATE PROCESS

Stir casting process is a liquid state process, in this process the aluminum alloy is matrix phase and ceramics are reinforcement phase. The aluminum alloy is heated in liquid state and reinforcing phases (usually in powder form) are distributed into molten Aluminum alloy by mechanical stirring. The key element in this process is Mechanical stirring in furnace. Squeeze casting process is the combination of gravity die casting and closed die forging. In this process, pressure is applied on the solidifying liquid metal. The steps involved in this process are: (i) pouring of metered quantity of liquid metal with adequate super heat in to the die cavity, (ii) application of pressure on the liquid metal and maintaining the same till the solidification is complete and (iii) removal of the casting and preparation of the die for the next cycle.

Ultrasonic Assisted Casting is combines solidification processes with ultrasonic cavitation- based dispersion of nano particles in metal melts has been developed. Ultrasonic cavitation can produce transient (in the order of nanoseconds) micro ‚hot spots' that can have temperatures of about 5000ºC, pressures above 1000atms, and heating and cooling ratesabove1010 K/s.

PROPERTIES OF ALL COMPOSITESMATERIALS

The factors that determine properties of composites are, micro structure, volume fraction isotropy and homogeneity of the system and these are strongly influenced by proportion sand properties of the matrix and the reinforcement

PHYSICAL PROPERTIES

Density is a physical property of matter, as each element and compound have a unique density associated with it. Density defined in a qualitative manner as the measure of the relative "heaviness" of objects with a constant volume. Density play very important roles in the composite material study. These materials using in space crafts and automotive industry, they must be light weight. So, the density should be reduced by adding some reinforced material like Al2O3, Sic, TIB2, etc., in Aluminum salloy. In a composite, the volume fraction (v), which is commonly used in property calculation. Density can be calculated by dividing the mass of specimen by the volume displaced by that specimen in the water beaker.

MATERIALS AND METHODS

Aluminium8081

8081 aluminum alloy can be further improved by how it is strengthening using a process known as heat treatment. Tempering method can use high heat (300-500 C) to reconfigure metal's crystal structure to strengthen its overall mechanical properties, and can literally make-or-break a material. There are many methods of tempering 8081 aluminum, but simplify this article, we will highlight T6tempered 8081 aluminum alloy.8081-T6 is a common temper for aluminum plate and bar stock. However, it is important to know that each tempering process gives 8081 aluminum its own distinct values and characteristics. [1]

TUNGSTEN DIBORIDE (TIB_2)

Tungsten diboride is known as a robust material having extremely high hardness (about 9.5 up to 9.75on hardness scale), high cross section for absorption of neutrons. Good shielding properties against neutrons), stability to ionizing radiation and most chemicals. Its Vickers hardness (38GPa), Elastic Modulus (460GPa) and fracture toughness (3.5 MPa· m) approach the corresponding values for diamond (1150 GPa and 5.3 MPa·m). Semiconductor properties are Tungsten diboride is a semiconductor, with electronic properties dominated by hopping-type transport. The energy band gap depends on composition as well as the degree of order. The band gap is estimated at 2.09 eV, with multiple mid-band gap states which complicate the photo luminescence spectrum. The material is typically p-type. [2]

Matrix Material

AA8081 alloy was selected because of its low specific weight and high strength to weight ratio and fatigue and also its excellent Mach inability, formability and weld ability. This alloy is widely used in automotive industry, aircraft industry anddefense industries.

Table 1:List of compositions

s.no	Compositions	Sample name
1	AL 8081+2% Tib2+2% gr	ATG22
2	AL 8081+4% Tib2+2% gr	ATG42
3	AL 8081+6% Tib2+2% gr	ATG62
4	AL 8081+8% Tib2+2% gr	ATG82

METHODS STIRCASTING

Stir casting is a type of casting process in which a mechanical stirrer is introduced to form vortex to mix reinforcement in the matrix material. It is a suitable process for production of metal matrix composites due to its cost effectiveness, applicability to mass production, simplicity, almost shaping and easier control of composite structure

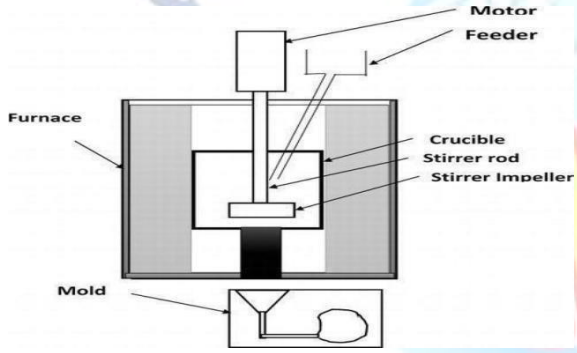


Figure 1: Schematic of stir casting setup

Stir casting setup as shown in Figure consist of a furnace, reinforcement feeder and mechanical stirrer. The furnace is used to heating and melting of the materials. The bottom poring furnace is more suitable for the stir casting as after stirringof the mixed slurry instant poring is required to avoid the settling of the solid particles in the bottom the crucible. The mechanical stirrer is used to form the vortex which leads the mixing of the reinforcement material which are introduced in the melt. Stirrer consist of the stirring rod and the impeller blade. The impeller blade may be of, various geometry and various number of blades. Flat blade with three numbers is the preferred as it leads to axial flow pattern in the crucible with less power consumption. This stirrer is connected to the variable speed motors; the regulator attached with the motor controls the rotation speed of the stirrer. Further, the feeder is attached with the furnace and used to feed the reinforcement powder in the melt. A permanent mold, sand molder lost-wax mold can be used forpouring the mixed slurry. [2]

HEAT TREATMENT

Heat treatment is a process that is used to alter the physical properties of a material in a beneficial way. During a heat treatment process, a material is typically heated to a target temperature at which its physical properties change. The metal being heat-treated must be considered heat treatable for any effect to occur. To harden a material.

4. RESULTS

DENSITY

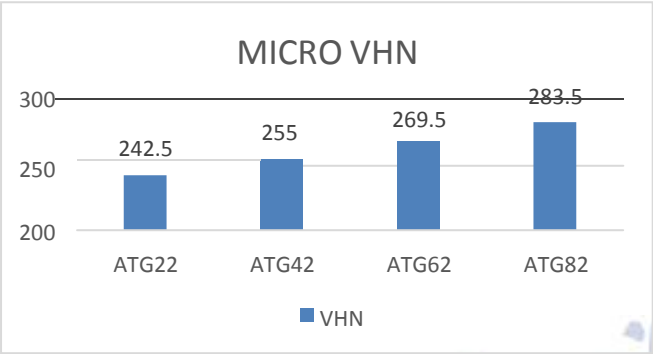
Mass of a unit volume of a material substance. The formula for density is $d = M/V$, where d isdensity, M is mass, and V is volume. Density is commonly expressed in units of grams per cubic

Table2: Density test results

compositions	Weight inair	Weight inwater	density	Avg density
ATG22	11.694	7.094	2.531	2.583
	7.124	4.361	2.578	
	4.329	2.698	2.641	
ATG42	9.865	5.985	2.542	2.568
	10.816	6.246	2.581	
	9.505	5.824	2.582	
ATG62	9.98	6.1	2.572	2.556
	9.58	5.83	2.554	
	10.48	6.359	2.543	
ATG82	10.016	7.026	2.510	2.552
	10.354	6.354	2.588	
	10.273	6.257	2.558	

Hardness

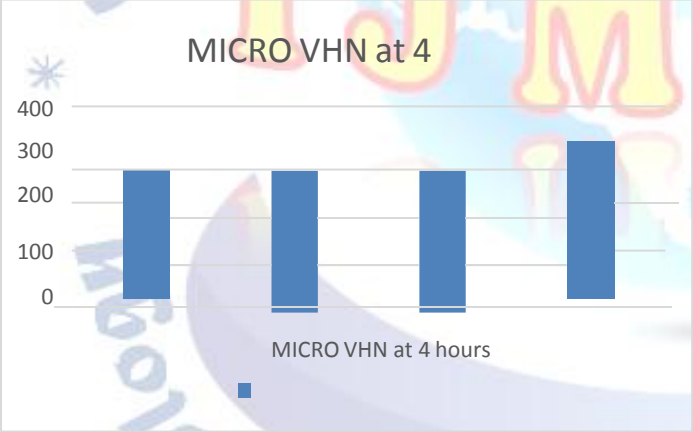
It a measure of how much a material resists changes in shape. Ability of material to resist wear, tear, scratching, abrasion cutting is called Hardness. Harder materials are more difficult to cut and shape than softer ones. They are also usually more brittle which means they do not bend much but can shatter.



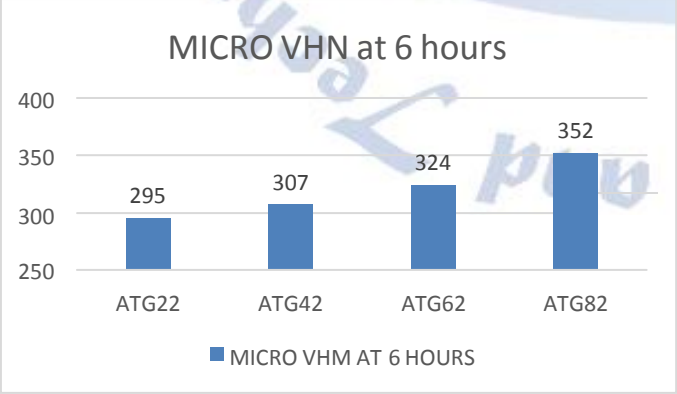
graph:1 Hardness test graph

HEAT TREATMENT

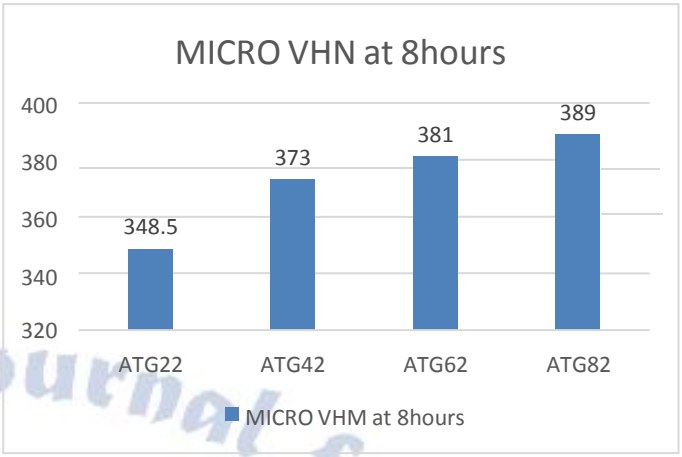
For this process, a material is heated above a certain temperature. The material is then rapidly quenched by a media such as water or oil. This rapid quenching will create a harder, stronger material when performed on a frequently hardened through heat treatment to resist wear and indentation. Metals that require ductility and toughness, such as structural steels, may need to be annealed or normalized if they are subjected to cold



Graph 2: Heat treatment graph at 4hours



Graph 3: Heat treatment graph at 6hours



Graph 4: Heat treatment graph at 8hours

COMPRESSIVE TEST

Compressive strength or Compression strength is the capacity of a material or structure to withstand loads trending to reduce size, as opposed to Tensile strength which withstands loads tending to elongate. In other words, Compressive strength resists being pushed together, whereas tensile strength resists tension (being pulled apart). In the study of strength of material, tensile strength, compressive strength, and shear strength can be analyzed independently. Some materials fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load

Table 3: Compressive test results

S,no	Sample name	Load (Kn)
1	ATG22	56
2	ATG42	65
3	ATG62	78
4	ATG82	89

WEAR TEST

Wear test is carried out to predict the wear performance and to investigate the wear mechanism. Two specific reasons are as follows: – From a material point of view, the test is performed to evaluate the wear property of a material so as to determine whether the material is adequate for aspecific wear application

Table 4: Wear test results

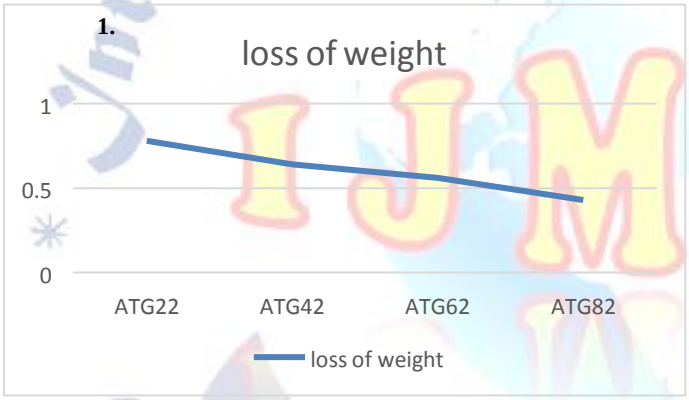
Sample name	Initial weight	Final weight	Loss of weight	Percentage (%)

ATG22	2.98	2.97	0.0072	0.72
ATG42	3.53	3.52	0.0071	0.71
ATG62	3.53	3.52	0.0069	0.69
ATG82	3.14	3.13	0.0068	0.68

CORROSION

Table 5: corrosion test results

Sample name	Initial weight	Final weight	Loss of weight	Percentage (%)
ATG22	3.70	3.62	0.078	7.8
ATG42	3.68	3.62	0.064	6.4
ATG62	3.84	3.78	0.056	5.6
ATG82	3.76	3.72	0.043	4.3



Graph 5: loss of weight graph

SCANNING ELECTRON MICROSCOPY (SEM)

Accelerated electrons Nan SEM carry significant amounts of kinetic energy, and this energy is dissipated as a variety of signals produced by sample interactions when the incident electrons are decelerated in the solid sample. These signals include secondary electrons (that produce SEM images), backscattered electrons (BSE), diffracted backscattered electrons (EBSD that are used to determine crystal structures and orientations of minerals), photons (characteristic X-rays that are used for elemental analysis and continuum X-rays), visible light (cathode luminescence --CL), and heat. Secondary electrons and backscattered electrons are commonly used for imaging samples: secondary electrons are most valuable for showing morphology and to photography on samples and back scattered electrons are most valuable for illustrating contrasts in composition in multi phase samples (i.e. for rapid phase discrimination). X-ray generation is produced by in elastic collisions of the incident electrons with electrons in discrete orbital's (shells) of atoms in the sample. As the excited electrons return to lower energy states, they yield X-rays that are of a fixed wavelength (that is related to the difference in energy levels of electrons in different shells for a given element). Thus, characteristic X- rays are produced for each element in a mineral that is "excited" by the electron beam. SEM analysis is considered to be "non-destructive"; that is, x-rays generated by electron interactions do not lead to volume loss of the sample, soit is possible to analyze the same materials repeatedly. Performed the SEM test for the deformed compression test pieces for the samples ATG 22 and ATG 82 at different positions and magnifications , the following results are discribed below

ATG22

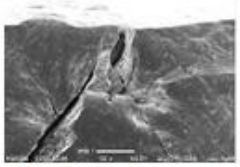


Figure 2:Top of specimen

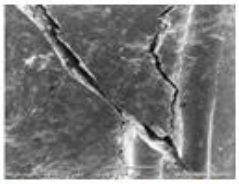


Figure 3:Middle of specimen

Figure 4:Bottom of specimen

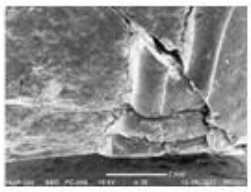


Figure 5:Different magnification

ATG82

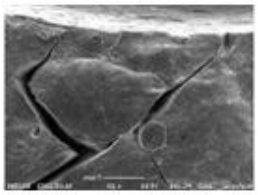


Figure 6:Top of Specimen

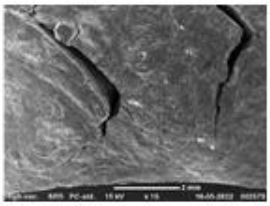


Figure 7:Middle of specimen

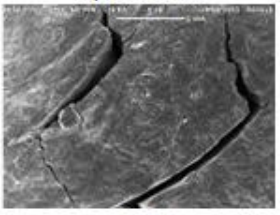


Figure 8:Bottom of specimen

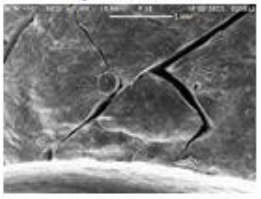


Figure 9:Different magnification

5. CONCLUSION

The following conclusions are obtained from the above work. By using stir casing method successfully fabricated aluminum composite. As the percentage of Tib2 increases hardness of the composite increases due that extreme By the heat treatment process the hardness of compete is increased The AL8081-TIB2-Graphite nano metal matrix composite materials have been fabricated by stir casting method followed by extrusion process.The nano TIB2 particulates are evenly dispersed in the matrix alloy. The micro hardness of AL8081-TIB2- Graphite nano metal matrix composite material is superior to the matrix material. The micro hardness increases by 12.2% by the addition of 2 wt. % of TIB2 nano particulates in aluminum (AL 8081) matrix alloy.The inclusion of TIB2 nano particulates in AL 8081 matrix alloy significantly enhanced the ultimate tensile strength and yield strength of the AL8081-TIB2- Graphite metal matrix composite materials. The 8 wt.% of TIB2 reinforced aluminum AL8081-TIB2 nano composite shows 54.11% increase in the ultimate tensile strength as compared to ultimate tensile strength of LM 13 alloy. The ductility of AL8081-TIB2-Graphite nano metal matrix composite material decreases as compared to matrix alloy. The ductility decreases by 32.72% with the inducing of2 wt. % of TIB2 nano particulates in aluminum (AL 8081) matrix alloy. The compression strength increases as the fraction of reinforcement enhances in the matrix material. The 8 wt.

% of TIB2 reinforced as-cast aluminum (AL8081-TIB2-Graphite nano composite.Fracture toughness increasesas the reinforcement substance amplifies in the matrix material. The fracture toughnessincreases by 130% by the addition of 2 wt. % of TIB2 nanoparticulates in AL 8081 matrix alloy.The wear resistance increases as the wt. $^{O}/_{o}$ of reinforcement substance amplifies in the matrix material. The wear resistance of aluminium (AL8081-TIB2-Gr) wt. % nano .

Conflict of intrest statement

Authors declare that they do not have any conflict of intrest .

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