EXPERIMENTAL INVESTIGATION OF METAL MATRIX COMPOSITES FOR BICYCLE FRAMES

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ABSTRACT

The objective of this research is to produce metal matrix composite (MMC) for bicycle frames by stir casting technique and investigates the material characterization of Al, SiO₂ used Metal Matrix Composite materials in this three material compositions are chosen (Al88%-SiO₂12%) (Al94%-SiO₂6%) and (Al99%-SiO₂1%), The reinforced particles size of SiO₂ is 400 mesh respectively these three compositions material characterizations find out through Tensile testing, Hardness testing, Impact analysis and flexural analysis in this combinations (Al94%-SiO₂6%) get the better results and this combination are suggested for manufacturing bicycle frames.

Keywords: Bicycle frames, Al, SiC, B₄C, Tensile test, Hardness Test, Stir casting method

1. INTRODUCTION

A bicycle frame is the main component of a bicycle, onto which wheels and other components are fitted. The modern and most common frame design for an upright bicycle is based on the safety bicycle, and consists of two triangles: a main triangle and a paired rear triangle. This is known as the diamond frame. Frames are required to be strong, stiff and light, which they do by combining different materials and shapes.

A frameset consists of the frame and fork of a bicycle and sometimes includes the headset and seat post.[2] Frame builders will often produce the frame and fork together as a paired set.
Aluminum alloys are an important engineering material for mechanical and wear applications. Because it is have low density, improved machinability, high specific strength, superior wear resistance, and low thermal conductivity.

Aluminium alloys are mostly used in automobile, aerospace, marine and mineral processing industries. Hard ceramic phase to a relatively soft matrix alloy, commonly aluminium, improves the strength, creep performance, and wear resistance of the alloy [1, 2]. Aluminum alloy 6061-T6 is widely utilized in aircraft, defence, automobiles and marine areas due to its good strength, light weight and better corrosion properties. But, it exhibits inferior tribological properties in extensive usage [3, 4]. Additions of reinforcement such as sic and Al2O3 ceramic particles in the aluminium based composite becomes brittle nature [5]. As a result of these the aluminium composite materials are used in mechanical components such as gears, cams, wheels, impellers, brakes, clutches and bushes and bearings [6, 7]. Many techniques were developed for producing particulate reinforced MMCs, such as powder metallurgy [8], in situ [9], and squeeze casting [10]. From all the above three methods, stir casting technique is the simplest and the most economical process for fabricating particulate reinforced MMCs.

Pre-aging at various retrogression temperatures improves the tensile properties, electrical resistivity and hardness of the AA7075 aluminium alloy [12]. The hardness of aged AA7075 alloy increases [13]. The hardness of the specimen measured before the wear test by Rockwell hardness test machine at room temperatures. The magnitude of hardness increases by increasing volume fractions of SiC and B4C reinforcement particles [14]. Aluminium alloy 6061-T6 reinforced with hybrid composites [(SiC + Gr) and (SiC +Al2O3)] using friction stir casting techniques. The wear properties of these HMMC are increased. Presence of hard ceramic particles like sic and Al2O3 increases micro hardness value [15]. The wear resistance of the al7075-sicb4c composites is increased by increasing sic ceramic particles. The coefficient of friction the specimen decreases with increasing volume content of reinforcements [16]. The mechanical properties such as tensile strength, flexural strength and hardness of the aluminium alloys are increased by adding alumina Al2O3 and boron carbide B4C [17]. AA6061- fly ash composites in T6 condition have exhibited better wear behavior compared to the matrix alloy at room temperatures. This is due to the uniform distribution of hard fly ash particles [18].AA6061 alloy reinforced with SiC and B4C have better tribological properties. Hybrid composite with different volume fraction (5 to 15 wt. %) has marked effect on wear rate. By increasing the volume fraction of reinforcements the wear rate and coefficient of friction decreases [19]. The mechanical and wear properties of AA7075 reinforced with 0-8 wt. % of the Al2O3 and 5 wt. % of graphite particles. From this composition the ultimate tensile strength increases with increasing Al2O3 particles. The mechanical strength increased by adding Al2O3 particle and decreased due to addition of graphite particle.

2. MATERIALS

Aluminium 6061

Al-6061 is a precipitation hardened aluminium alloy, containing magnesium and silicon as its major alloying elements. Originally called "Alloy 61S", it was developed in 1935. It has good mechanical properties and exhibits good weld ability. It is one of the most common alloys of aluminium for general-purpose use.

It is commonly available in pre-tempered grades such as 6061-O (annealed), tempered grades such as 6061-T6 (solutionized and artificially aged) and 6061-T651 (solutionized, stress-relieved stretched and artificially aged).
Silica Powder is a granular, vitreous, porous form of silicon dioxide made synthetically from sodium silicate. Silica gel is tough and hard. It is more solid than common household gels like gelatin or agar. It is a naturally occurring mineral that is purified and processed into either granular or beaded form.

Silicon dioxide, also known as silica, is an oxide of silicon with the chemical formula SiO₂, most commonly found in nature as quartz and in various living organisms. In many parts of the world, silica is the major constituent of sand. Silica is one of the most complex and most abundant families of materials, existing as a compound of several minerals and as synthetic product. Notable examples include fused quartz, fumed silica, silica gel, and aerogels. It is used in structural materials, microelectronics (as an electrical insulator), and as components in the food and pharmaceutical industries.

3. EXPERIMENTAL METHODS

Stir Casting Furnace

In a 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 aluminum melt by stirring molten aluminum 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 mold casting, or sand casting. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement.

The cast composites are sometimes further extruded to reduce porosity, refine the microstructure, and homogenize the distribution of the reinforcement. A major concern associated with the stir casting process is the segregation of reinforcing particles which is caused by the surfacing or settling of the reinforcement particles during the melting and casting processes. The final distribution of the particles in the solid depends on material properties and process parameters such as the wetting condition of the particles with the melt, strength of mixing, relative density, and rate of solidification. The distribution of the particles in the molten matrix depends on the geometry of the mechanical stirrer, stirring parameters, placement of the mechanical stirrer in the melt, melting temperature, and the characteristics of the particles added.

Figure 1 Stir Casting Furnace
TENSILE TEST
The most common type of test used to measure the mechanical properties of a material is the Tension Test. Tension test is widely used to provide basic design information on the strength of materials and is an acceptance test for the specification of materials. The major parameters that describe the stress-strain curve obtained during the tension test are the tensile strength (UTS), yield strength or yield point (σy), elastic modulus (E), percent elongation (ΔL%) and the reduction in area (RA%). Toughness, Resilience, Poisson’s ratio(ν) can also be found by the use of this testing technique.

HARDNESS TEST
Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a compressive force is applied. Some materials, such as metal, are harder than others. Macroscopic hardness is generally characterized by strong intermolecular bonds, but the behavior of solid materials under force is complex; therefore, there are different measurements of hardness: scratch hardness, indentation hardness, and rebound hardness.

IMPACT TEST
The impact test is a method for evaluating the toughness and notch sensitivity of engineering materials. It is usually used to test the toughness of metals, but similar tests are used for polymers, ceramics and composites. Metal industry sectors include Oil and Gas, Aerospace, Power Generation, Automotive, and Nuclear.

FLEXURAL TEST
Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. A flexure test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to the top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is the flexural strength of that particular sample.
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4. RESULTS AND DISCUSSION

**Figure 3** Tensile Test, Flexural Test, Impact Test, Hardness Test Specimens

**Figure 4** Tensile Strength for Different Composite Materials

**Figure 5** Flexural Strength for Different Composite Materials
5. CONCLUSION
From the experimental analysis of Al+SiO₂ hybrid composite material was prepared by using stir casting furnace method with the three different compositions for tensile test, flexural test, impact test and hardness from the test comparisons Al94%-SiO₂6% was obtained very high tensile strength, flexural strength, hardness value and Impact energy the material properties are used for validate the bicycle frame strength, in conventional Al6061-T6 bicycle frame materials.
REFERENCES


