ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

FABRICATION AND CHARACTERISATION OF Al6063 METAL MATRIX NANOCOMPOSITES

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DOI: 10.5281/zenodo.290187

ABSTRACT

Nanotechnology is spreading vastly in the various demanding fields of engineering and medicines like aerospace, defence, automobiles, electronics, materials, chemistry, energy, environment, information & communication, consumer goods and biotechnology. Aluminium alloys are widely used in many applications due to their low density and good mechanical properties, better corrosion and wear resistance, low thermal coefficient of expansion as compared to conventional metals and alloys. The aim involved in designing metal matrix composite materials is to get desirable attributes of both metals and ceramics. In this fabrication and characterization of aluminium Al6063 with reinforcement nano γ-alumina(Al_2O_3) metal matrix composites produced by stir casting process and various test specimens produced with different wt%(0.5%,1%,2%,3) of reinforcement material. Specimens after casting, ageing process is done for better tensile strength and hardness to find the mechanical properties of specimens are subjected to micro structure analysis, tensile test and hardness test.

KEYWORDS: Al6063 alloy, nano Al_2O_3, Stir casting, ageing, optical microscope.

INTRODUCTION

Composite Material:

Composite material is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the other one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fibers, particles, or flakes. The matrix phase materials are generally continuous. Examples of composite systems including concrete reinforced with steel and epoxy reinforced with graphite fibers, etc.

Metal Matrix Nano composites (MMNC):

Metal matrix nano composites (MMNC) refer to materials consisting of a ductile metal or alloy matrix in which some nano sized reinforcement material is implanted. These materials combine metal and ceramic features, i.e., ductility and toughness with high strength and modulus. Thus, metal matrix nano composites are suitable for production of materials with high strength in shear/compression processes and high service temperature capabilities. They show an extraordinary potential for application in many areas, such as aerospace, automotive industries and other Metal Matrix Nano composites include Al/Al_2O_3, Al/SiC, Fe-Cr/ Al_2O_3, Ni/ Al_2O_3, Co/Cr, Fe/MgO, Al/CNT, Mg/CNT etc [1].

The sizes of the reinforced particles have a strong effect on the failure mode, strength and ductility of Al – based composites [2].Addition of Al_2O_3 to aluminium matrix results in an improvement of mechanical properties, such as Hardness, Strength and Wear resistance [3]. Reinforcement of Al matrix material with nano size alumina particles yields the superior properties which are very important for today's requirement [4]. Low strength matrices may benefit more from brittle reinforcement particles than high strength matrixes [5]. MMC's can produce various process that powder metallurgy, casting and metal alloying, among that casting is attractive process due to easy processing and low cost [6]. The mechanical and tribological properties of the MMNC's improved by reinforcing various material ranging from very soft materials like graphite, talk etc, to high hardened ceramics like SiC,Al_2O3[7].

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MATERIALS AND METHODS

Al6063 alloy:

A medium strength aluminium-magnesium-silicon alloy for intricate extruded sections. Forms well in T4 temper. High corrosion resistance, good surface finish its nature. General applications are furniture and architectural extrusions**.**

Table.2.1. Table showing the composition of Al6063 chemical composition

ELEMENT	Si	Fe	Cu	Ni	Mn	Mg	Al
%	0.48	0.22	0.00	0.001	0.01	0.74	98.549(REMINDER)

Nano Alumina (Al_2O_3):

Nano- γ-Al_2O_3 is with small size, high activity and low melting temperature; it can be used for producing synthetic sapphire with the method of thermal melting techniques. The g-phase nano- Al_2O_3 with large surface area and high catalytic activity, it can be made into Micro porous spherical structure or honeycomb structure of catalytic materials. Al_2O_3 – Nano powder, gamma Particle shape: spherical, elongated Average particle size: ca. 40 nm; Specific surface: > 40 m2/g, Purity: > 99.9 %; X-Ray analysis: γ- Al_2.

Stir Casting:

Stir casting is liquid state method of composite materials fabrication, in which ceramic particles is mixed with molten matrix metal by means of mechanical stirring.

Table.2.2. Table showing the composition and nomenclature used for the composites

S .No	Composition used
1.	Al 6063(PURE)
2.	Al 6063+0.5 wt% γ-Al_2O_3
3.	Al 6063+1 wt% γ-Al_2O_3
4.	Al 6063+2 wt% γ-Al_2O_3
5.	Al 6063+ 3 wt% γ-Al_2O_3

Ageing:

age hardening, is a heat treatment technique used to increase the yield strength and compressive strength of malleable materials, including most structural alloys of aluminium, magnesium, nickel, titanium, and some steels and stainless steels.

Fig.2.1 before Ageing

Fig.2.2 after Ageing

RESULTS AND DISCUSSIONS

Microstructure Analysis:

Micro structural analysis, these specimens are surface finish by emery paper of sizes 1/0, 2/0, 3/0, 4/0. Then specimens are polished by Disc Polishing Machine. After disc polishing these samples are etched with Keller's Reagent for 30 minutes. Microstructure analysis is done is done under electron microscope and the following image of composites are obtained.

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Fig.3.1 optical microscope unit

Before Ageing | After Ageing

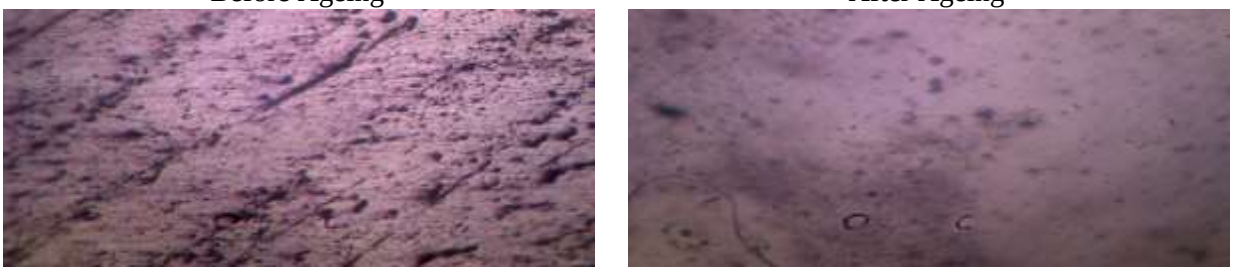

Fig3.2. Image of Pure ALUMINIUM 6063(magnification factor 100X)

Fig3.3. Image of ALUMINIUM 6063 ALLOY +0.5 wt% γ- AL_2O_3, (magnification factor 100X)

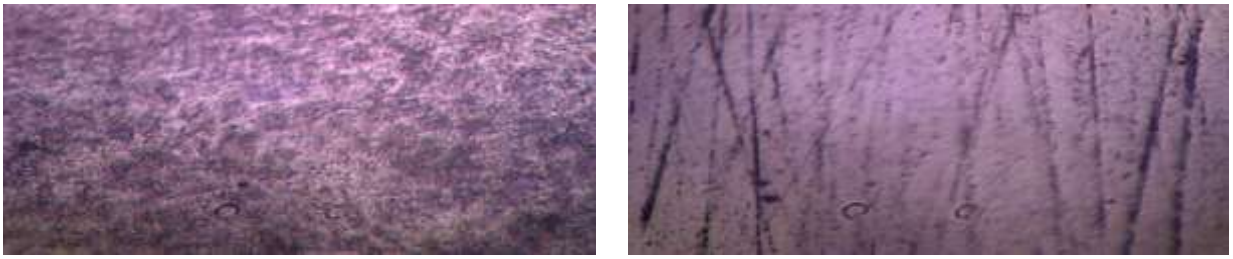

Fig3.4.Image of ALUMINIUM 6063 ALLOY +1 wt% γ- AL_2O_3, (magnification factor 100X)

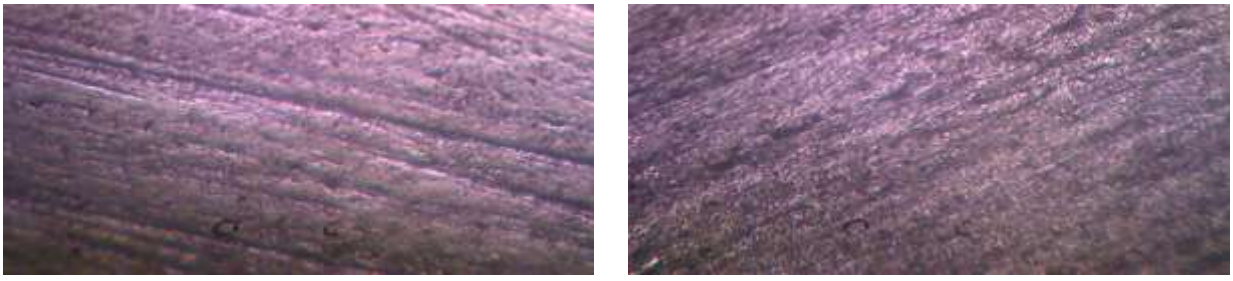

Fig3.5.Image of ALUMINIUM 6063 ALLOY +2 wt% γ- AL_2O_3, (magnification factor 100X)

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Fig3.6.Image of ALUMINIUM 6063 ALLOY +3 wt% γ- AL_2O_3, (magnification factor 100X)

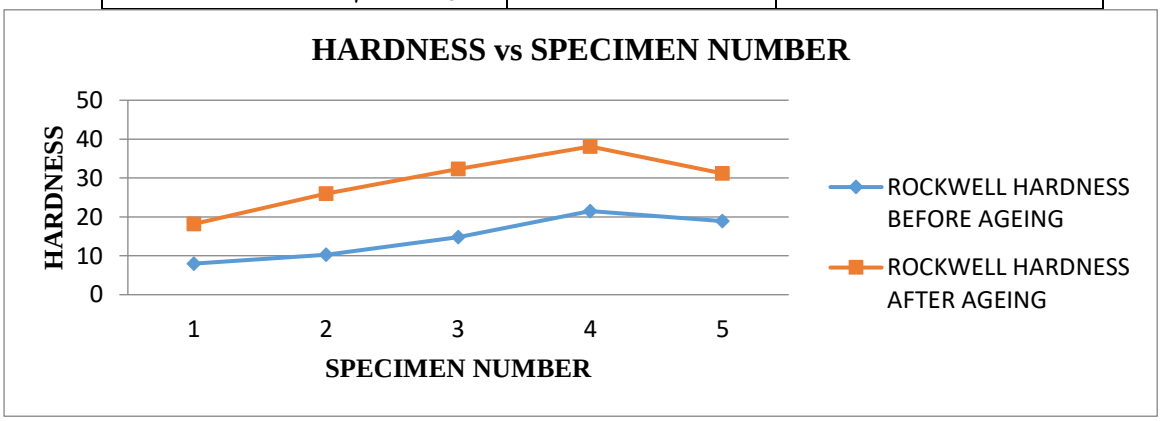
2) Hardness Test:

a) Rockwell's Hardness Test:

In this hardness of material can be calculated. In this samples are placed below the point of indenter and load is applied. As aluminum Alloy the readings are noted in B-scale.

Table 3.1 showing the Rockwell's Hardness Test values:

CHEMICAL COMPOSITION	ROCKWELL HARDNESS (B - SCALE)	
	BEFORE AGEING	AFTER AGEING
AL 6063	8	18.2
AL 6063 + 0.5 wt% γ- AL_2O_3	10.3	26
AL 6063 + 1 wt% γ- AL_2O_3	14.8	32.3
AL 6063 + 2 wt% γ- AL_2O_3	21.5	38.1
AL 6063 + 3 wt% γ- AL_2O_3	18.9	31.2



Graph 3.1 Hardness vs Specimen

b) Vickers Hardness Test:

Micro hardness of all the samples was measured under a load of 1kg for a dwell time of 5 seconds. As a result of the indenter's shape, the impression on the surface of the specimen was a square. The length of the diagonals of the square was measured through a microscope fitted with an ocular micrometer.

Table.3.2 Showing the Vickers Hardness Test Values

CHEMICAL COMPOSITION	VICKERS HARDNESS (HV)	
	BEFORE AGEING	AFTER AGEING
Al 6063	46.86	65.39
Al 6063 + 0.5 wt% γ- Al_2O_3	55.687	79.54
Al 6063 + 1 wt% γ- Al_2O_3	68.04	87.32
Al 6063 + 2 wt% γ- Al_2O_3	81.484	108.17
Al 6063 + 3 wt% γ- Al_2O_3	68.829	89.91

ISSN: 2277-9655
Impact Factor: 4.116
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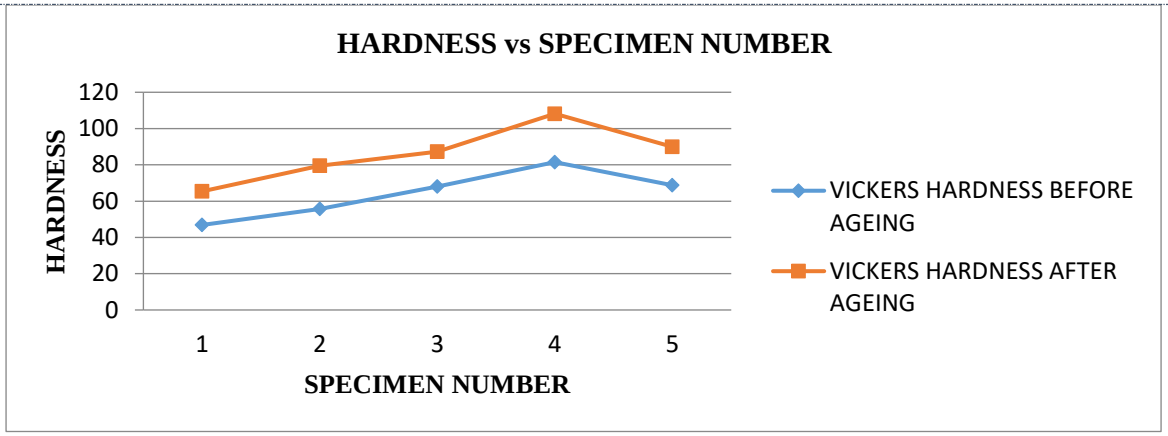


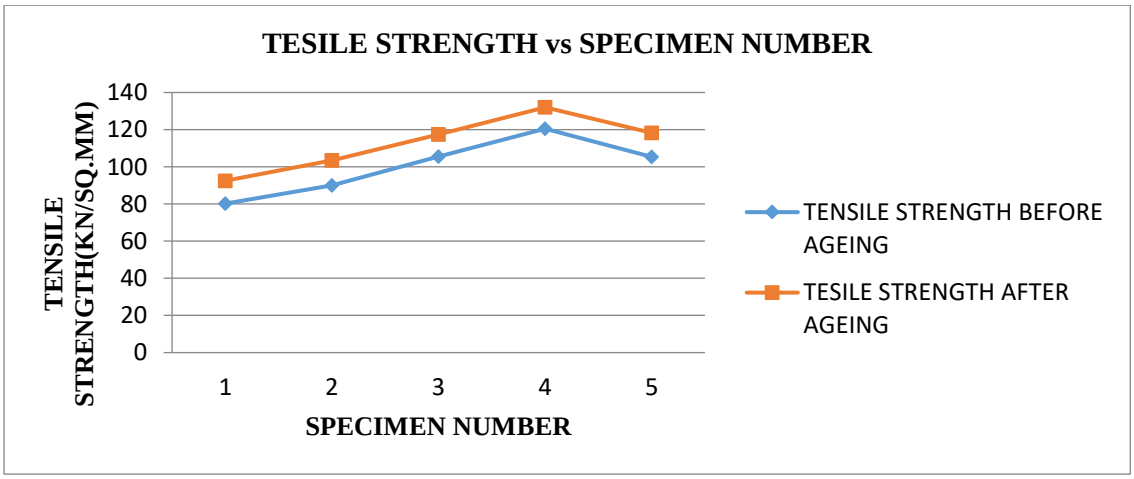
Graph 3.2 Hardness vs Specimen

3. Tensile Test:

A tensile test, also known as tension test, is probably the most fundamental type of mechanical test you can perform on material. Tensile tests are simple, relatively inexpensive, and fully standardized. By pulling on something, you will very quickly determine how the material will react to forces being applied in tension. As the material is being pulled, you will find its strength along with how much it will elongate. The universal testing machine (UTM) is used.

Table 3.3 shows the tensile strength test values

CHEMICAL COMPOSITION	TENSILE STRENTH (N/Sq. mm)	
	BEFORE AGEING	AFTER AGEING
Al 6063	80.2	92.5
Al 6063 + 0.5 wt% γ- Al_2O_3	90.1	103.5
Al 6063 + 1 wt% γ- Al_2O_3	105.6	117.5
Al 6063 + 2 wt% γ- Al_2O_3	120.5	132
Al 6063 + 3 wt% γ- Al_2O_3	105.3	118.3



Graph 3.3 Tensile Strength vs Specimen

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CONCLUSION

In the present investigation, the mechanical properties along with micro structure, hardness and tensile strength performances of the Nano particles reinforced Al-Al_2O_3 matrix composites were investigated. The composites were fabricated via stir casting process with different wt% (0.5%, 1%, 2%, 3%) of reinforce material (nano alumina). The following are the conclusions drawn from the present study.

- Fabrication is done successfully and seems to be alright with reasonable porosity.
- The micro structure gives the proper mixing of nano Al_2O_3 in Al6063.
- Nano composite exhibited better property after ageing than before ageing. The hardness was higher for the Nano composite probably due to the grain refinement observed in the Nano composite
- The higher Rockwell's hardness value from lower wt% to 2% wt % of nano alumina, maximum 38.1 is obtained at 2% nano alumina after ageing specimen.
- The higher Vickers hardness value from lower wt% to 2% wt % of nano alumina, maximum 108.17 is obtained at 2% nano alumina after ageing specimen
- Maximum Tensile strength among all different specimen of composite is 132 N/mm^2 is found for 2% nano alumina specimen after ageing.

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