CHARACTERISATION OF NEWLY DEVELOPED ALUMINIUM (A_{356}) BASED NANO COMPOSITE

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ABSTRACT

Metal matrix nanocomposites were fabricated with Aluminium alloy (A_{356}) as matrix material and Nano-Aluminium oxide (Al_2O_3) as a reinforcement material through powder metallurgical process. Six different aluminium composite specimens with varying percentage of Nano-Al_2O_3 particle varying from 1% to 3% in volume were evaluated for various density conditions. The micro structure of Metal matrix Nano composites was examined using optical microscope for 100x & 200x resolutions. In addition to that Compression test, vicker's hardness test, Brinell Hardness test, Density tests were carried out to evaluate the mechanical properties of Nano Aluminium (A_{356}) composites. The results have indicated that, a significant improvement in hardness and compressive strength for specimen with 3% of Nano- Al_2O_3 concentration, which Is result of oxide addition and higher concentration Nano Particles.

Keywords: Nano Aluminium (A_{356}) composites, powder metallurgy, mechanical properties.

I. INTRODUCTION

Aluminium matrix nanocomposites can also be defined as reinforced metal matrix composites. This type of composites can be classified as continuous and non-continuous reinforced materials**.** These Nano composite materials have potential properties such as High strength even at elevated temperatures, High stiffness (modulus of elasticity) , Low density, High thermal conductivity and Excellent abrasion resistance. As shown in literature survey [1], Aluminium A356 alloy and Al2O3/SiC nanoparticles are used as the matrix alloy and the reinforcements, respectively. Nanoparticles are injected into the molten alloy and dispersed by ultrasonic cavitation and acoustic streaming. The microstructure and mechanical properties of the cast nanocomposites have been investigated. [2]. For the purpose of accomplishing post *in-situ* reaction ultrasonic treatment, the *in-situ* formed Al-4.4Cu/2TiB2 micro composite was remelted and subjected to high-intensity ultrasonic waves for various length of time. The results shows that the improved mechanical property of nanocomposite has been attributed to the presence of TiB2 particles of nanometre size and robust interfaces with the aluminium alloy. [3]. In this study, the hot extrusion process was applied to stir cast aluminum matrix–SiC composites in order to improve their microstructure and reduce cast part defects. The particle size of the milled powders and the amount of released heat from the reaction between the carrier agent and molten aluminum are inferred as two crucial factors that affect the resultant part tensile properties and microhardness. [4]. In this work, the fabrication and characterization of bulk Al–B4C nanocomposites were investigated. It is found that the wear resistance of the nanocomposites increased significantly by increasing the B4C content. Dominant wear mechanisms for Al–B4C nanocomposites were determined to be formation of mechanical mixed layer on the surface of samples. [5]. The reinforcing effects of carbon nanotubes (CNTs) are investigated for aluminum matrix composites. It is found that a composites containing 4.5 vol% multiwalled CNTs exhibits a yield strength of 620 MPa and fracture toughness of 61 MPa_mm1/2, the values of which are nearly 15 and seven times higher than those of the corresponding starting aluminum, respectively. [6]. In this research, the effects of electromagnetic stirring and 1.5 wt% SiC nanoparticles on the solidification microstructure and mechanical properties of alloy Al A357 were studied at three different frequencies (10, 35, and 60 Hz). [7]. In this study, dry sliding wear behavior of ZA27 alloy matrix hybrid nano composites has been investigated. Results showed that the increasing of alumina nano-particle content can positively influence improving the tribological behavior of the hybrid nanocomposites. [8]. The aluminium nanocomposites containing different wt. % of B4C nanoparticles and Al-B4C-h-BN hybrid nanocomposites are prepared using stir and ultrasound assisted casting method. The prepared hybrid and nanocomposites are characterized using X-ray diffraction, Atomic Force Microscopy, Scanning Electron Microscopy and Energy Dispersive Xray Analysis. The wear properties of the hybrid nanocomposites, containing 4 wt% B4C and 2

wt. % h-BN, exhibit the superior wear resistance properties compared to the unreinforced aluminium matrix and nanocomposites.

II. EXPERIMENTAL PROCEDURE

Initially the required materials are procured as per the need and homogenously mixed to prepare Nano A_{356} composites in the laboratory through ball milling process for 04 hours and sufficient cooling time is provided to avoid overheating which will results in micro aggregation. The chemical composition of A_{356} is shown in Table 01.

(Al)	(Cu)	(Fe)	(Mg)	(Mn)	(Si)	(Ti)	(Zn)
91.25	0.2	0.2	0.40	0.1	7.5	0.25	0.1

Table 01.

Six number of specimens were fabricated with various combinations of Nano-Al_2O_3 & A_{356} as shown in Table 02 & 03.

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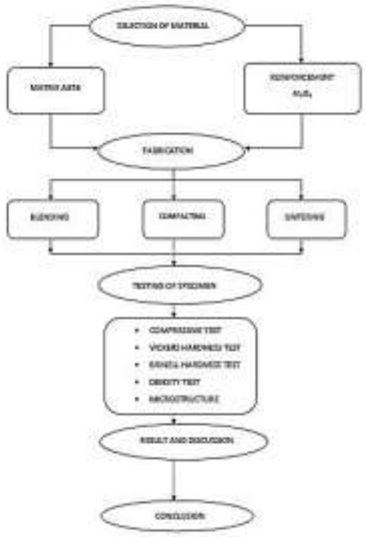

Figure. 01

Six number of specimens were fabricated with various combinations of Nano-Al_2O_3 & A_{356} as shown in Table 02 & 03. The prepared powder is compacted in the UTM to fabricate the required size of specimen.

Table 02.

Material	Weight in (%)	Weight in (g)
A356	98	56.84
Al2O3	2	1.16
Total	100	58

Table 03.

Material	Weight in (%)	Weight in (g)
A356	97	58.2
Al2o3	3	1.8
Total	100	60

Die-setup is placed in base of UTM. The 57g amount of powder is dropped into the die hole. Then the die punch is placed above the dropped powder over the die. Then the load is applied gradually up to 250KN and the load is kept constant for 15 min similar procedure is followed for all sets. The compacted material is then subjected to sintering process in which the material is kept at muffle furnace at elevated temperatures for the required period of time. After successful fabrication of composite material, they are subjected various tests to find out mechanical properties i.e. Compression test, vicker's hardness test, Brinell Hardness test, Density tests.

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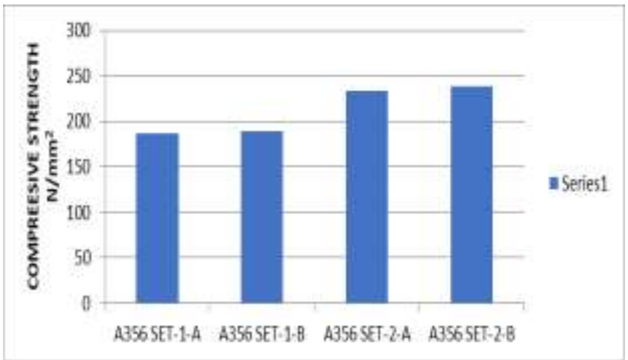
III. RESULTS & DISCUSSIONS

3.1 Microstructure Analysis

The microstructure of A356/3% Al2O3 composite is composed of an aluminium matrix containing aluminium oxide. In general, the aluminium oxide is uniformly distributed and tends to be connected at inter-dendritic boundaries. Fig shows the microstructure of A356/3% Al2O3 composite in the power methodology condition formed. It can be seen that the aluminium oxide is uniformly distributed and most of aluminium particles at the grain boundaries due to the low given loaded.

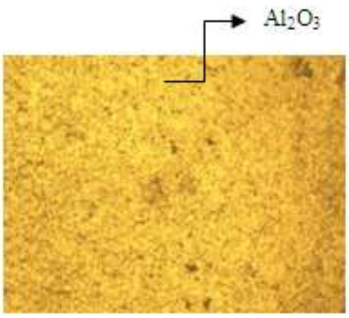
3.2 Compressive Strength



Graph 1: compressive strength of various composition

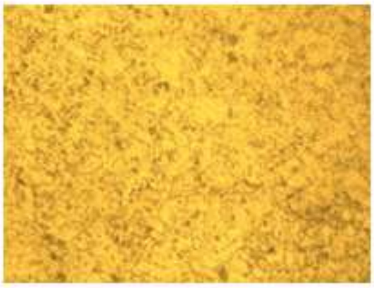
The result of compressive tests is shown in Fig. It can be understood from these results that by decreasing the Al2O3 content, the compressive strength increased continuously. Although the porosity content of the samples decreased by decreasing Al2O3 content, so compressive strength increased.

A356 100X SET-1-A



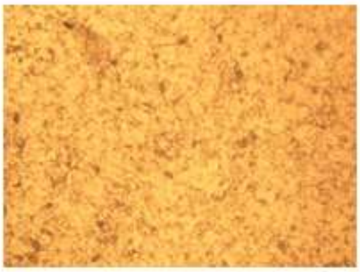
A356 100X SET-1-B

A356 100X SET-2-C



A356 200X SET-1-A

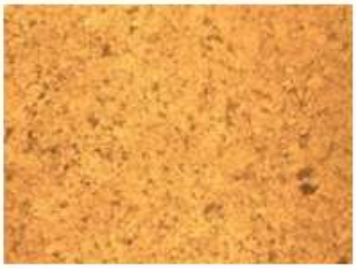
A356 200X SET-1-B



A356 100X SET-2-C

A356 200X SET-2-A

A356 200X SET-2-B



A356 200X SET-2-C

Figure. 01 Micrographic Views for Set 01 & Set 02 for 100x & 200x resolution

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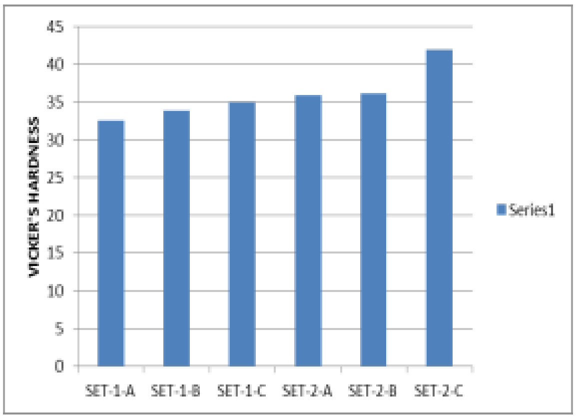
3.3 Vicker's Analysis



Graph 2: Vicker's hardness of various compositions

Vickers micro hardness measurements were performed on the aluminium A356 alloy and A356/Al2O3 foam composite prior to and subsequent to the application of the normal loads. The vicker's micro hardness as a function of applied indentation load for both the unreinforced A356 aluminium alloy and aluminium oxide foam are given in fig. As the A356 aluminium alloy plastically deforms during the wear process, a phenomenon of work hardening results creating a hardened sliding surface. In this study conducted on wear properties of aluminium alloys established an increase of hardness in the wear track area as compared to the unworn areas.

3.4 SEM Analysis

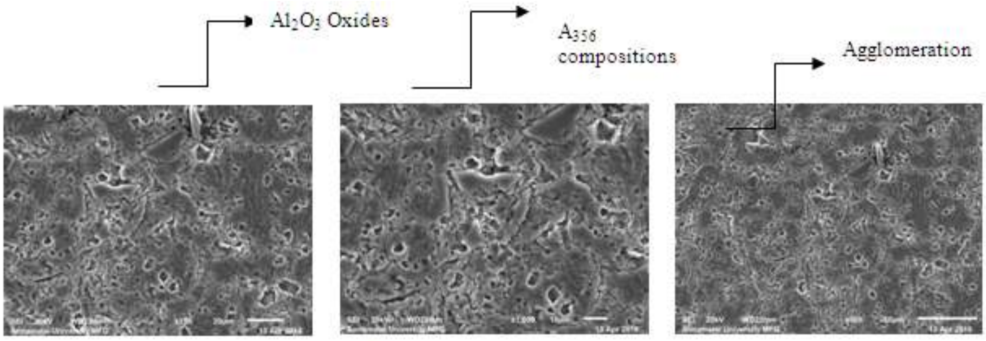


Figure. 02 SEM images for Set – A Specimen

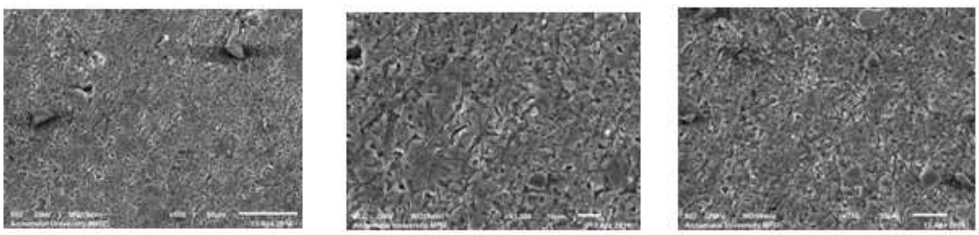


Figure. 03 SEM images for Set – B Specimen

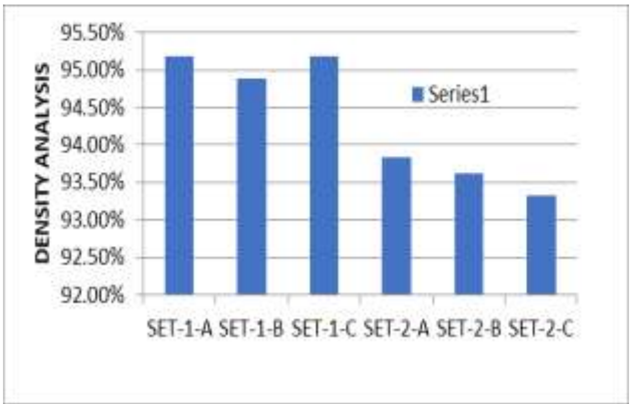
The SEM images were observed in the High Vacuum 10.00kv and magnification of 10000x with the micron sized level is 1μm. Fig. 8.12 shows the SEM analysis of casted composites with various volume fraction of Micron and Nano Al2O3. As a result of SEM observations of the microstructures showed that, spreading of the micro was more uniform sizes while Nano particles lead to the agglomeration and segregation of the particles, and porosity. The reason for the separation of particles is proposed as follows.

3.5 Density Testing Analysis

The measured density of the power methodology composites and reinforcing Nano particles content. The results of the measured densities demonstrate that by increasing reinforcing Nano particles content, density decreased because of higher possibility of agglomeration at higher percentages of Nano particles.

In short, by decreasing Nano scaled reinforcements, porosity content decreased. This result is confirmed by porosity content vs. amount of Al2O3 Nano particles.

Graph 4: Density of various compositions



$$\rho_{2.0} = 2.68*0.98 + 3.9*0.020 \quad = 2.7044$$

$$P_{3.0} = 2.68*0.97 + 3.9*0.030 \quad = 2.71$$

IV.CONCLUSION

The process of preparation of different weight fraction Al2O3 particulate reinforced A356 composites were done through the powder metallurgy route. The microstructure and mechanical tests like hardness and compressive strength were evaluated and the following observations were drawn:

1. All composite samples show the hardness and compressive strength values more than those of monolithic matrix aluminium. This is due to produce a lot of mismatches into the boundary of particle/matrix.
2. The mechanical properties such as hardness and compressive strength have improved. A356/3% Al2O3 (in Nano size) proves the higher hardness and also exhibits the higher compressive strength due to the
3. combined effect of oxide addition and the higher Nano particle concentration.
4. The Nano composite having 60nm Al2O3 Nano particulates showed better room and elevated compressive properties than those containing 200nm Al2O3 Nano particulates.

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