Microstructure And Hardness Of A356 Reinforced With Micro And Nano Al_2O_3 Particles Produced By Powder Metallurgy Technique

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Abstract- *Al_2O_3 miniaturized scale and nano particles delivered by arrangement ignition strategy are fortified with Aluminium compound to create smaller scale particulate and nano particulate composites by powder metallurgy technique.Al_2O_3 fortifications of various rates by weight divisions are utilized to set up the examples. A356 compound is appropriate where great consumption protection joined with warm properties are required. Nano powders have properties like great hardness, wear safe, warm conductivity, high quality and firmness proportion. The microstructure and hardness tests are performed on sintered composite examples. The microstructure uncovered great agglomeration and interfacial bond amongst lattice and n-Al_2O_3. Increment in n-Al_2O_3 particles enhanced mechanical properties. These composites discover applications in the nourishment, compound, marine, electrical and car parts chamber pieces and heads, and other motor and body parts.*

Keywords- Al_2O_3 Nanoparticles, A356 alloy, Powder metallurgy, Hardness, Microstructure.

I. INTRODUCTION

Significance of metal matrixnano composites (MMNC's) as designing material are expanding in most recent three decades, because of astounding improvement in mechanical properties, for example, microstructure, hardness, Young's modulus and wear properties. Aluminum amalgams are very alluring to their low thickness, their great consumption protection, high warm and electrical conductivity and high damping limit. The vital assembling systems for aluminum based composites are strong state and fluid state and vapor testimony methods. Powder metallurgy is an investigation of creating metal powders and making completed/semi-completed items from blended or alloyed powders with or without the expansion of nonmetallic constituents.

Ventures in powder metallurgy are powder generation, compaction, sintering and auxiliary operations.

1.1 Powder Metallurgy Technique:

The first step in powder metallurgy is production of metal powders. The raw materials for powder production are pure elements or alloys. The different methods for making powders are atomization,reduction of compounds, electrolysis etc.Powders alongside combination added substances, fortifications and ointments (to encourage simple launch of conservative and to limit wear of hardware) are mixed. A portion of the ointments utilized are waxes, metallic stearates, graphite and so on. At that point blended powder is framed into a conservative. The predominant combination process includes squeezing in an inflexible toolset, involving a bite the dust, punches and, potentially, mandrels or center bars. This takes after Sintering. It is the way toward solidifying either free total of powder or a green smaller under controlled states of temperature and time. It is to expand trustworthiness and quality which includes warming of the material, in a defensive air, to a temperature that is beneath the dissolving purpose of the significant constituent.

II. MATERIALS AND METHODS

2.1 Matrix material and Reinforcement

In this present investigation commercially available A356 powder is used as matrix material. μ –Al_2O_3 of 50-70 μm and n-Al_2O_3 of 10 to 30 nm particles areadded as reinforcements in varying parentages (2%, 4%, 6 % and 8% weight fraction) to produce micro particulate composites and nanoparticulate composites respectively.

The Al A356 chemical composition is given in the Table 2.1.

Table 2.1: A356alloy composition

Cu	Mg	Mn	Si	Fe
0.20	0.25–0.45	0.1	6.5-7.5	0.2
Sn	Zn	Ti	Pb	Al
0.05	0.1	0.2	0.05	Bal

2.2 Determination of Particle size of n-Al_2O_3 by XRD technique.

X-ray beam diffractometer comprises of three essential components: a X-beam tube, an sample holder, and a X-beam identifier. n-Al_2O_3 powder is put in the sample holder. X-beams are created in a cathode beam tube by warming a fiber to deliver electrons, quickening the electrons towards an objective by applying a voltage, and assaulting the objective material with electrons. At the point when electrons get adequate vitality to unstick inward shell electrons of the objective material, trademark X-beam spectra are delivered. Indicator records and procedures this X-beam flag and changes over the flag to a tally rate on PC screen. For run of the mill powder designs, information is gathered at 2θ from ~5° to 70°, edges.

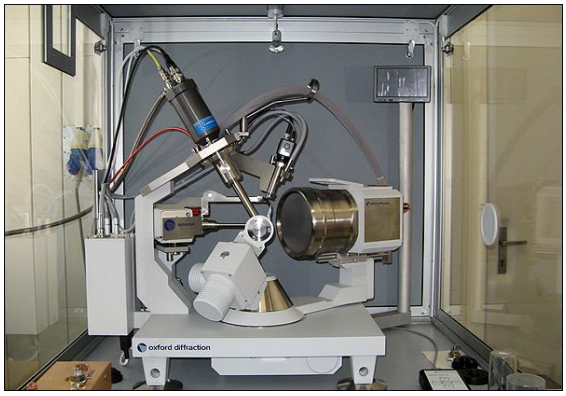
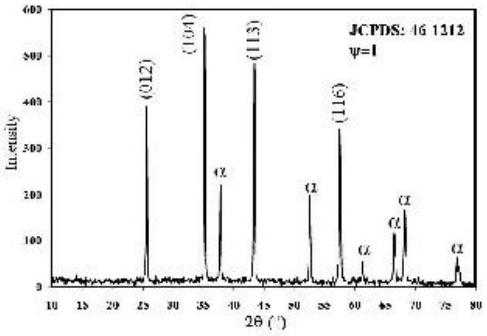
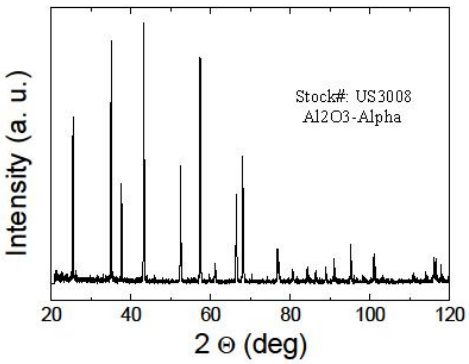


Fig 2.1: X-ray diffractometer



(a)



(b)

Fig 2.2: Standard Al_2O_3 XRD pattern for a) micro particles b) nano particles

2.3 Fabrication of Al-Al_2O_3 micro and nano composites

The production of micro and nano reinforcements mixed with the Al-Si alloy involves powder metallurgy techniques to prepare green compaction and sintering.

2.3.1Blending of powders: The fine powders are mixed thoroughly using ball milling process as shown in the fig2.3 for better mixing of the particles and to obtain good bonding. The samples were ball milled and were mixed thoroughly at a speed of 150rpm for 6-8hrs without a lubricant. The samples were composed of μ-Al_2O_3 and n-Al_2O_3 for 2%, 4%, 6% and 8% by weight.

(a)

(b)

(c)

Fig 2.3: Ball milling of powders a) ball mill equipment b) cross sectional view of ball mill c) ball bearings for ball mill.

2.3.2 Compaction: The blended powder is removed from the ball milling process. Then the powder is transferred to the die and cold compaction is done at190kN to 215kN force. Then the samples are ejected slowly from the die with the help of a plunger and samples are tested for external crack and surface damages. The process and equipment used for compaction is shown in fig.2.4.

(a)

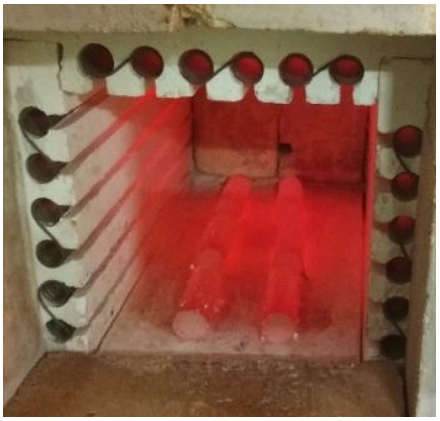
(b)

(c)

Fig 2.4: Compaction process a) 200 ton UTM for compaction b) split pattern plunger c) tools used for compaction

2.3.3 Sintering: The compacted mass samples free from surface cracks and damages are kept in the muffle furnace and are sintered at a high temperature around 650^{o}C in a furnace for 2 hrs as shown in the fig 2.5. Then the samples are removed from the furnace and allowed to cool at room temperature.

(a)



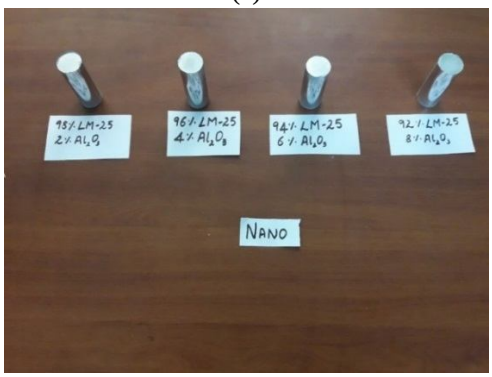
(b)

(c)

Fig 2.5: Heat Treatment a)muffle furnace b) samples during heat treatment c) samples after heat treatment in the muffle furnace

2.3.4 Machining and finishing operation: Machining is done on sintered samples to 20mm diameter and 50mm length samples are prepared to obtain fine finishing surface on the samples without any surface roughness are shown in fig 2.6.

(a)



(b)

Fig 2.6: Samples prepared by powder metallurgy techniques a) micro samples b) nano samples

2.3.5 Microstructural analysis and Hardness testing:

Microstructure investigation of Al-Al_2O_3 micro and nanocompositeswas completed utilizing high-determination scanning electron microscopy (HRSEM-HITACHI TM3000). Vicker's hardness tests were performed as shown in fig 2.7to assess the hardness of Al-Si alloy for various percentage ranges of micro and nanoAl_2O_3reinforcements.

(a)

(b)

Fig 2.7: Vicker's Hardness Test a) hardness Equipment b) loaded sample

Vickers Hardness test

The Vickers hardness test is directed utilizing precious stone pyramid indenter with a square base. The point between the characteristics of pyramid is 136^0. The Vickers Hardness Number (VHN) of materials is acquired by separating the connected power P, in kgf, by the surface of the pyramidal dejection.

$$VHN = \frac{2P\sin(136/2)}{d^2} = \frac{1.8544F}{d^2} \quad (2.1)$$

Where,

d - average length of diagonals in mm.
5kgf test load is selected for the experiment.

Microstructure: An examining electron magnifying lens (SEM) is a sort of electron magnifying lens that produces pictures of a specimen by checking the surface with an engaged light emission. The electrons communicate with molecules in the specimen, delivering different signs that contain data about the example's surface geography and piece. The electron shaft is checked in a raster examine design, and the pillar's position is joined with the distinguished flag to create a picture. SEM can accomplish determination superior to 1 nanometer. Tests for before warm treatment and after warmth treatment are measured for microstructure for different rates of small scale and nano Al_2O_3.

Fig2.8: SEM equipment

III. RESULTS AND DISCUSSION

3.1 XRD Results

Crystallite size from XRD data is calculated using Scherrer equation

$$D_p = \frac{0.94\lambda}{\beta_{1/2}\cos\theta} \quad (3.1)$$

Where,

Dp = Average crystallite size,
β = line broadening in radians, θ = Bragg angle,
λ = X-ray Wavelength

Using Scherrer equation for Dp Calculator

Wavelength:	1.54056	Ang
Peak Width:	0.3	degrees
Peak Position:	23.3	degrees
Crystallite size:	27.02	nm
Lattice Strain:	0.0063	

β= 0.32519°, $2\theta=23.3^0$, θ = 11.65°, λ = 0.154nm

From Scherer equation, crystal size is given by

L = (0.9*0.154*10^-9)/(0.3*(π / 180) * cosine (11.65))
L= 27.02nm

3.2 Microstructural analysis results:

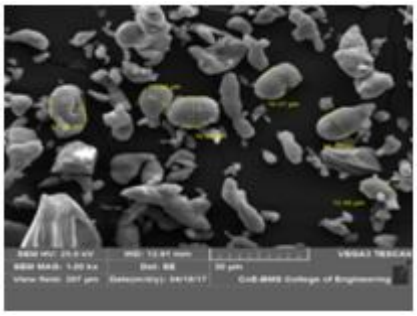
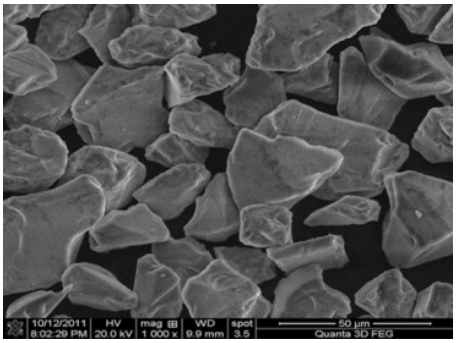
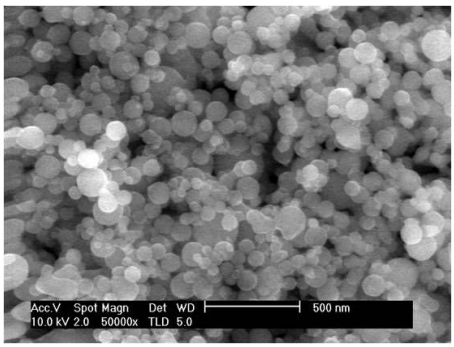


Fig3.1:Microstructureof A356 Specimen

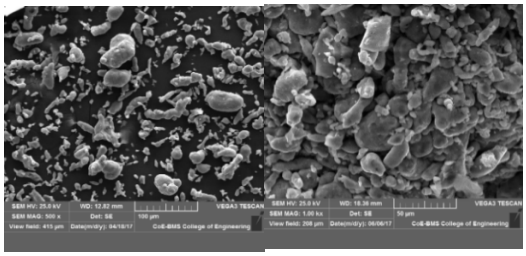


(a)

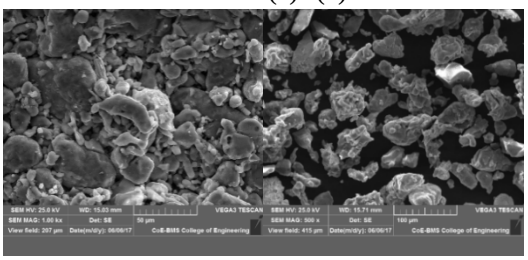


(b)

Fig 3.2: SEM image of Al_2O_3 powders for a) micro at 1KX and b)nano at 50KX



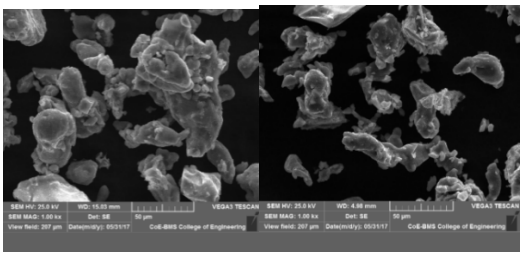
(a) (b)



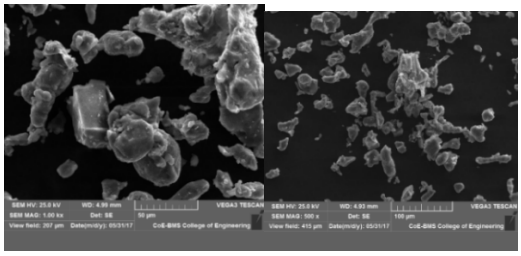
(c)(d)

Fig 3.3:SEM micrographs ofa)2% b)4% c)6% and d)8% µ-Al_2O_3 reinforced withAl-Si alloy

The figure3.3 shows SEM images of Aluminium alloy micro composites. The reinforcements are uniformly distributedin the matrix. For 4% micro Al_2O_3 alloy composite the particle dispersion is more uniform andmechanical inter locking due to atomic bonding between matrix and reinforcement is more effective compared to other percentages of micro reinforcements.



(a) (b)



(c) (d)

Fig 3.4:SEM micrographs of a)2% b)4% c)6% and d)8% n-Al_2O_3 reinforced withAl-Si alloy

The fig3.4shows SEM images of Aluminium alloy nano composites. The reinforcements are uniformly distributed in the matrix. For 4% nanoalloy composite the particle dispersion is moreclearly visible and mechanical inter locking due to atomic bonding between matrix and reinforcement is more effective compared to other percentages of nanoreinforcements.

3.3 Hardness Test Results:

The hardness results of A356alloy reinforced with micro and nano Al_2O_3composites are shown in fig.3.5 and fig.3.6.

VHN results ofA356 micro and nanocomposites

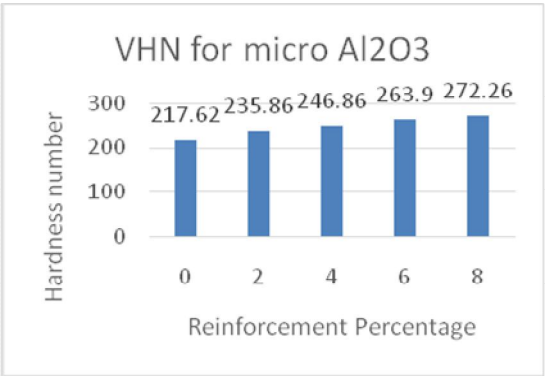


Fig 3.5: Hardness number for micro Al_2O_3

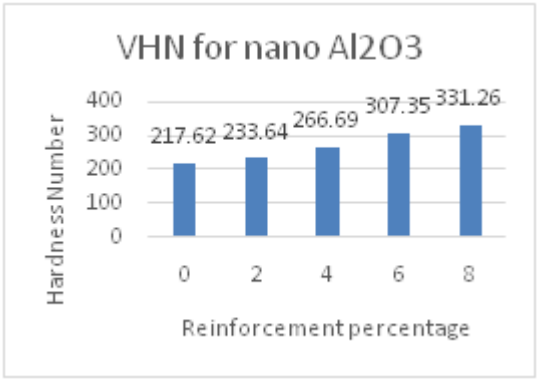


Fig 3.6: Hardness number of nano Al_2O_3

Increment in level of micro and nano Al_2O_3particles in the A356 amalgam increase the hardness of the composites.

IV. CONCLUSION

miniaturized scale and nano strengthened in A356 enhanced mechanical properties. Ball milling processing for 8 hours has given best outcome for the specimens. Uniform distribution of atoms bonding in the lattice which is seen in SEM pictures. The particle dispersion is clearly seen where the bonding is more effective. The best results of microstructure were obtained for 4% micro Al_2O_3 and 4% nano Al_2O_3 particles. The hardness of Al-Si composites increases with increase in µ- Al_2O_3 and n- Al_2O_3 reinforcements.

V. ACKNOWLEDGEMENT

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