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Study of Microstructure And Mechanical Properties Of Sintered Aa5083 Aluminium Alloy Composite Reinforced With Al_2o_3 Nano And Micro Particles

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Abstract - The utility of Nano composite is increasing in many applications with especially automotive and aerospace. The usage of Nano composite is not up to the mark comparing with its tremendous properties. The difficulty such has poor machinability and lack of its details such as physical and mechanical properties of aluminum alloy AA5083 matrix composites reinforced with micron (10% wt – 5% wt) and nano-particles (1% wt – 5% wt) of Al2O3 were to be fabricated through powder metallurgy method. Optimum amount of reinforcement were determined by evaluating mechanical properties like micro-hardness, compressive strength and microstructure of composites. The results are to be detailed and analysed elaborately. This will be useful for metallurgical people and manufacturing engineers.

I. INTRODUCTION

Composite materials are engineered materials made from at least two or more constituent materials with significantly different physical or chemical properties. These materials remain separate and distinct on a macroscopic level within the finished structure.

The different materials work together to give the composite unique properties. This new properties are different to the properties of the individual elements. But within the composite you can easily tell the different materials apart – they do not dissolve or blend into each other.

II.METHODOLOGY

To find out best reinforcement for aluminium matrix composite, the composites are fabricated by powder metallurgy process. Then the density, compressive strength, hardness and micron structure of the fabricated composites are found. The results are compared and discussed. The figure shows chart of

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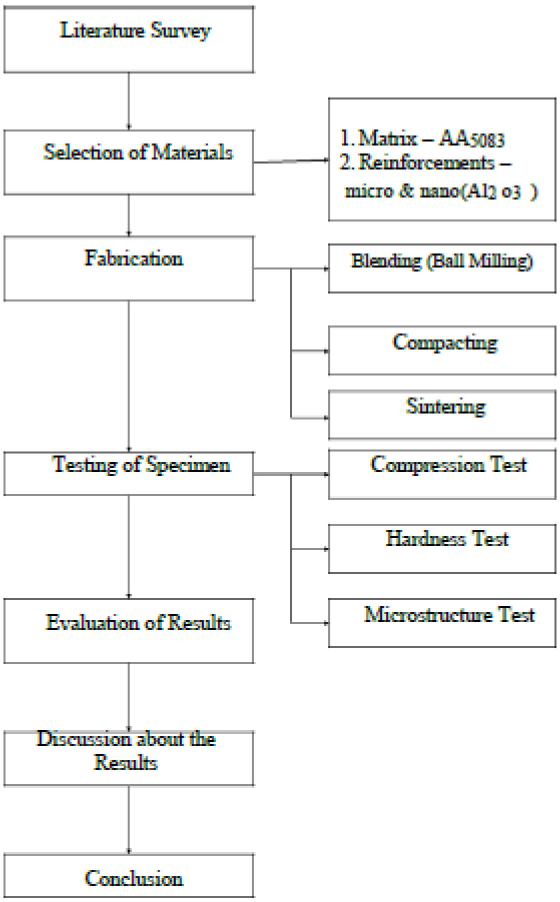
methodology.



Flow Chart Methodology

III. MATERIAL SELECTION

A. MATERIALS

This project is concerned with fabrication of metal matrix composite as aluminium alloy as matrix material and micron and Nano size of alumina as reinforcing material.

- Matrix: AA5083(Aluminium alloy)
- Reinforcement: Al2O3 (Aluminium Oxide) (micron & Nano Size)

B. COMPOSITION OF MATRIX: AA5083

Table 1 Composition of Matrix AA5083

Sl. No	Component	Density (ρ) g/cm^3 (Actual)	Weight Percentage	Density (ρ) g/cm^3 (Weight %)
1	Aluminium (Al)	2.70	93.4	2.52
2	Chromium (Cr)	7.19	0.15	0.0107
3	Copper (Cu)	8.94	0.1	0.0089
4	Iron (Fe)	7.87	0.4	0.0314
5	Magnesium (Mg)	1.73	4.45	0.0769
6	Manganese (Mn)	7.40	0.7	0.0518
7	Silicon (Si)	2.32	0.4	0.0093
8	Titanium (Ti)	4.50	0.15	0.0067
9	Zinc (Zn)	7.14	0.25	0.0178
			Total =100	$\rho_{Theoretical}$ = 2.73

C. MATERIAL PREPARATION

Aluminium alloy (AA5083) is prepared by mixing of aluminium powder (size of 60 -110 μm) with fine powders of Cu, Cr, Fe, Mg, Mn, Si, Ti and Zn in Ball mill. The machine is operated 4 hours.

D. BLENDING RATIO

Table 2 Blending ratio

	Aluminium alloy (AA5083) (Weight %)	Alumina Al2O3 (micron size) (Weight %)	Alumina Al2O3 (Nano Size) (Weight %)
SET – I	100	0	0
SET – II	90	10	0
SET –III	90	9	1
SET-IV	90	8	2
SET-V	90	7	3
SET-VI	90	6	4
SET-VI I	90	5	5

IV.TESTING OF FABRICATED SPECIMEN

A. COMPRESSION TEST

The compressive strength of the fabricated specimens are found in UTM. Seven samples from each set of material have undergone compressive test. The average ultimate compressive stress for each set of material.

B. VICKER'S HARDNESS TEST:

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Seven sample sets are taken and kept in a Micro Vickers Hardness Tester to find out the average hardness number by giving 0.5kg space load.

C. MICROSTRUCTURE

Seven sample sets are taken and kept in a Optical Trinocular Metallurgical microscope to find out microstructure using kellar reagent solution as an etchant with the magnification of 100X lens.

V. RESULTS

A. *Compressive Strength*

Figure shows the response of process parameters with respect to the accuracy of the drilled hole dimension. From the Figure 6.1 it is observed that maximum speed of 1625 rpm and the maximum feed rate of 1mm/min show the significant results. So that the further analysis of in process tool condition monitoring using vibration signal is carried out using the optimized parameters.

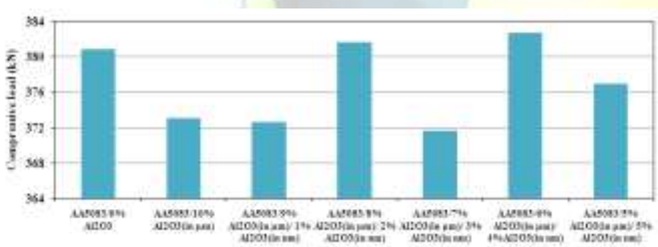

FIGURE 1: Compressive strength of various compositions

B. *Tool wear estimation*

The Micro-hardness tests were carried out on the prepared composite samples in micro vickers hardness tester (Wilson Wolpert – Germany). The tests were conducted at constant loading of 0.5 kg load for 30 seconds at 25ºC. In an each sample, four trails were made and the mean value was taken to avoid the higher deviation of results and it is observed that the result deviation was not exceeding 2% of the mean value.It was observed from the Fig.2 the hardness value of specimens seems varies significantly with variation of reinforcements of nano & micro particles for the prepared samples. Among the 7 samples AA5083/6% Al2O3 (in µm) 4% Al2O3 (in nm) micro hardness and the hardness values witnessed the less deviation in the samples 2,34,5 and 6.

The above observation is due to inhomogeneous blending and non-uniform distribution of reinforcements in matrix phase that results in lack of isotropic behavior among prepared samples. Also, from the microstructure it is found that the poor intermetallic bonding in between the matrix and reinforcing phase during the sintering. Whereas the AA5083/6% Al2O3 (in µm) 4% Al2O3 (in nm) shows the highest hardness value due to the good compatibility in between the matrix and reinforcement phase. From the microstructure graphs, it is also observed that the 6% Al2O3 (in µm) 4% Al2O3 (in nm), sample made a remarkable change in the reinforcements. In general lesser porosity (not more than 2.5%) was identified on the prepared samples. The black dots in the microstructure indicate the Al2O3 reinforcements in the white colored aluminum matrix phase.

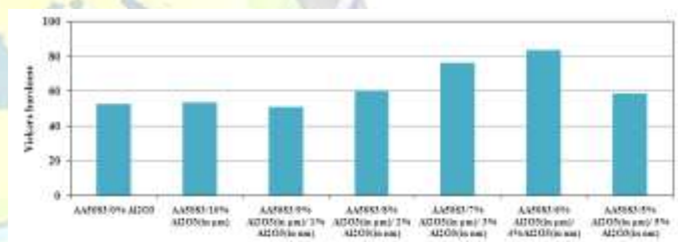

FIGURE 1: Hardness of various compositions

C. **Microstructure Analysis**

The microstructure studies were made on the etched surface samples with HF solution. From the micrographic analysis Al-Si precipitates in the matrix phase. From the Fig.3 Voids and porosity are observed in all the 7 samples that results the inhomogeneous distribution of reinforcement and poor bonding occurred due to the aggregation of reinforcements in some selective regions. The micrograph of sample 4 exhibits the well distribution compared all other 6 samples.

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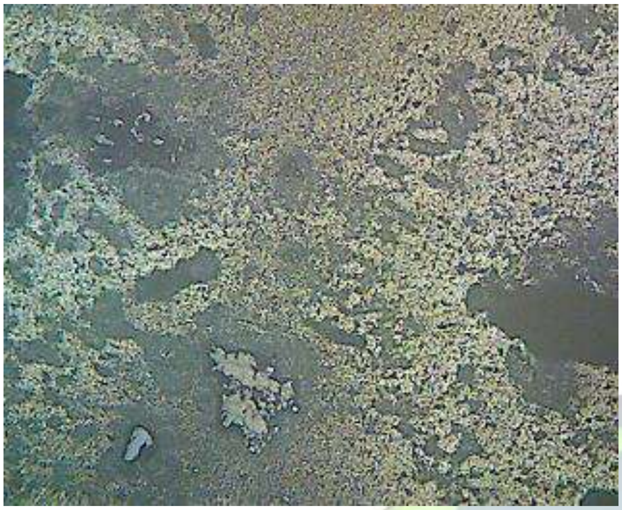
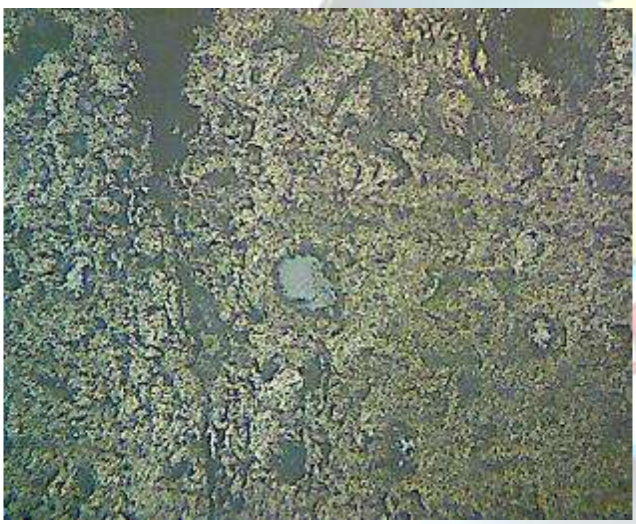


a) AA5083/0% Al2O3



b) AA5083/10% Al2O3(in µm)

c) AA5083/9% Al2O3(in µm)/ 1% Al2O3(in nm)

d) AA5083/8% Al2O3(in µm)/ 2%Al2O3(in nm)

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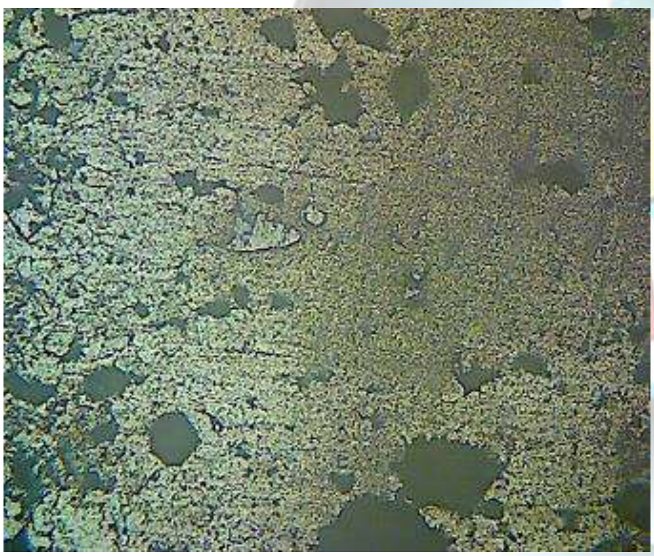
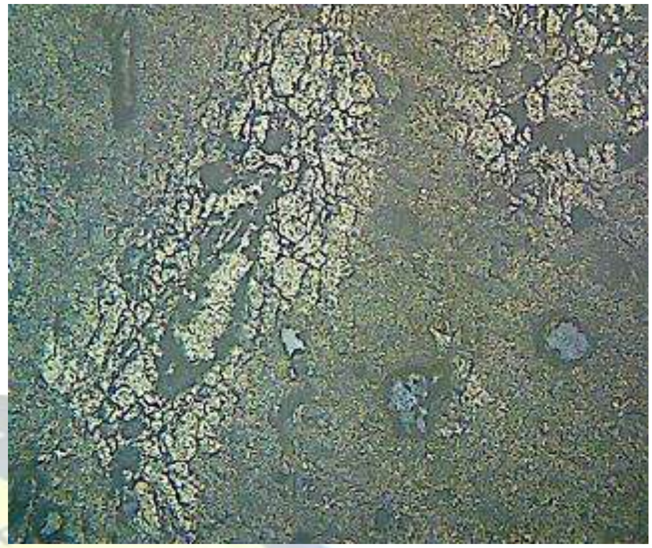
e) AA5083/7% Al2O3(in μm)/ 3% Al2O3(in nm)



f) AA5083/6% Al2O3(in μm)/ 4% Al2O3(in nm)



g) AA5083/5% Al2O3(in μm)/ 5% Al2O3 (in nm).

Fig 1.17. Micrographic views of samples

CONCLUSION

The process of preparation of different weight fraction Al2O3 particulate reinforced AA 5083 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. Al AA5083 MMCs reinforced with different sizes and weight percentages of Al2O3 particles (up to 10 wt. %, size micron - nano) was successfully fabricated by powder metallurgy route which starts from blending of samples of interested weight fractions, compacting of composite samples by applying the 25 ton compressive loading in universal testing machine. Then it was sintered in the furnace for 2 hours at the temperature of 450°C in the presence of argon gas environment that prevents the excessive growth of grains and followed by 2 hour soaking and furnace cooling, then the samples surface were sprayed over by molybdenum di sulphate (Mo S2) to avoid oxidation.
2. The characterization and microstructure was made by optical micrograph. The observations of the microstructures showed that the nano particles distribution in Al matrix is more uniformly, while the coarser particles led to agglomeration and segregation of particles results in porosity.
3. The mechanical properties such as hardness and compressive strength have improved. AA5083/6% Al2O3 (in μm) 4% Al2O3 (in nm) proves the higher hardness and also exhibits the higher

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compressive strength due to the combined effect of oxide addition and the higher nano particle concentration.

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