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"HARDNESS BEHAVIOUR OF SI_3N_4 INCORPORATED ALUMINIUM METAL MATRIX COMPOSITES "

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ABSTRACT

This Paper deals with hardness behaviour behavior of Aluminum metal powder composite reinforced with Si3N4 particles has been evaluated experimentally prepared by Powder Metallurgy route. Four number Cylindrical preforms (Si3N4-0 wt. %, 3wt. %, 5 wt. % and 7 wt. %) at a compaction pressure of 120 KN were prepared using a die and punch assembly on a Universal Testing Machine. Sintering at different temperatures of 450°C, 470°C and 490°C has been carried out using Electrical Muffle Furnace. Hardness is measured using Rockwell's Hardness machine at 100 kg load applied at ball point. The microstructural characterization done by Scanning Electron Microscopy (SEM) to investigate the grain structure. Densification and hardness of specimen are increased with the increase of Si3N4 percentage and sintering temperature.

Key Words: *Aluminum (Al); Silicon Nitride (Si3N4); sintering temperature; hardness, density, porosity, SEM analysis.*

I. INTRODUCTION

Composites are the materials having superior mechanical properties and light in weight. Epoxies and polyester commonly serves as a matrix material. The reinforcing fibers are usually graphite, glass, boron, etc. New developments concerns are in metal matrix and ceramic composite materials. Ceramics-matrix cutting tools are being developed, made of silicon carbide reinforced alumina, with greatly improved tool life. A composite material contains more than one component. The compound materials are amalgamated into the composites so as to take the advantage of their attributes, thus providing an improved version of the material. Cohesive structures form by physically combining the two or more than two compatible materials. Reinforced fibre composites are materials prepared heterogeneously by associating and bonding the material in a single structure possessing different properties. Due to the complementary properties generated by the forming of two or more materials develops additional and superior properties in it. Thus these materials became the ideal material for the application where requiring high strength to weight and stiffness to weight ratios. These material develops anisotropic properties. Commonly used fibres for composites materials are glass, boron and graphite for producing amorphous structures, ceramic and metallic for single crystals and as for poly crystals as well, carbon and boron produces multiphase structures and organic materials for macromolecular structures.

II. POWDER METALLURGY

Powder Metallurgy is a process where metallic shapes are manufactured from metallic powders. In powder metallurgy, the metal or alloy is solid at the start and remains solid at the end of the process. Now-a-days powder metallurgy becomes an important aspect in fabrication industry. Powder Metallurgy helps us to deals with the materials like

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refractory materials which are difficult to machine like *sintered carbides* etc.

III. Literature Review

M. A. Salem et al. (2017) analyzed the impact of the Al lattice, SiC sizes and the SiC volume part on the microstructure development, mechanical properties of the composites. They worked on Al-SiC MMCs by taking different sizes, and volume parts were manufactured using ball milling machine and powder metallurgy. Al and Al-SiC composites of various volume fractions were processed for 120 hours and then, the Al and Al-SiC composites were compact under 125 MPa and then sintered at 450 °C. Then he measured the thermal conductivity, electrical resistivity and micro hardness analysis of the prepared composite samples. He conclude as we decrease the size of Al-SiC particle and increases the volume of Al-SiC will decrease the properties of the MMC's. On the other side micro hardness was increased when we took the small particle size of Al-SiC and increases their volume fraction.

Ashok Kumar Mishra and Rajesh Kumar Srivastava (2016) he studied the wear resistance and coefficient of friction on Aluminum Al-6061 reinforced with SiC particles of 150 and 600 mesh size and taking the weight fraction varying from 5%,10%, 15%, 20%, 25%, 30%, 35%, 40%. The tested the dry sliding wear properties using pin on disk wear tester using velocity at 2m/s and sliding distance of 2000m with applied load of 10, 20 and 30KN. He commented that wear increases with increase in load and sliding distance and coefficient of friction decreases with increases in weight percentage of reinforcement. He also said that wear will reduce till 35% weight fraction only. He analyzed the wear surfaces by optimal microscopy. And he obtained the best result with 35% SiC having 600 mesh size.

Smrutiranjan Pradhan et al. (2016) analyses the wear and friction behavior of Al-SiC MMC under three different condition i.e. dry, aqueous and alkaline medium. The pin on disc apparatus where specimen is sliding under Alumina disc and varying speed. So as the load increases; wear increases. It seems that maximum wear occurs in alkaline medium, followed by aqueous and dry conditions. The microstructural analysis and worn analysis done by SEM & EDS. And he conclude that minimum wear occurs in dry medium is dominated by adhesive and abrasive wear whereas in aqueous and alkaline medium mechanical and corrosive wear will responsible for the same.

Babalola et al. (2014), he reviewed the development of Aluminum matrix composites with SiC as an additive via fabrication through solid state and liquid state process. Then he quoted that Aluminum matrix composites can easily be prepared when combined it with non-metallic reinforcing materials like SiC, B4C, Si3N4, AIN, TiC, TiB2, TiO2 and etc. After adopting the cost effective techniques like stir casting for manufacturing the samples and comparison is done with the powder metallurgy samples and results shows that stir casting samples have high hardness then the powdered one.

IV. Experimentation

DIE & PUNCH PREPARATION

For preparing the samples of the composite material, first the well-defined combination of powder preforms a die and punch has been manufactured by turning the die steel on lathe then tempered the punch for withstanding the high load applications. The pin on disc machine has a pin holder of capacity varying from 6 mm to 12 mm. As the powder preforms should have sufficient contact area with the disc the pin diameter was decided as 10 mm. The figure below shows the photograph of the die and punch.

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Table 1 Sample selection

T1 (450°C)	T2 (470°C)	T3 (490°C)	T2 (500°C)
T1 (0% Si3N4)	T2 (0% Si3N4)	T3 (0% Si3N4)	T2 (0% Si3N4)
T1 (3% Si3N4)	T2 (3% Si3N4)	T3 (3% Si3N4)	T2 (3% Si3N4)
T1 (5% Si3N4)	T2 (5% Si3N4)	T3 (5% Si3N4)	T2 (5% Si3N4)
T1 (7% Si3N4)	T2 (7% Si3N4)	T3 (7% Si3N4)	T2 (7% Si3N4)

V. RESULTS & DISCUSSION

HARDNESS COMPARISON AT DIFFERENT SI3N4 %'S

For T1 temperature (Where T1 = 450°C)

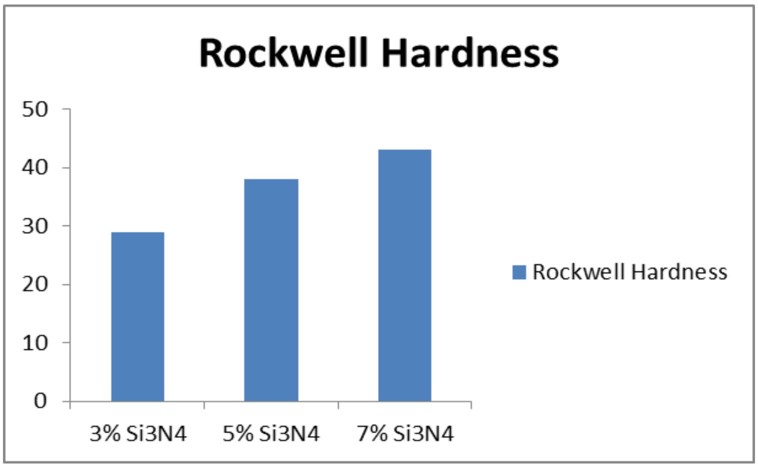

Figure 1 Rockwell Hardness at 450^{0}C

For T2 temperature (Where T2 = 470°C)

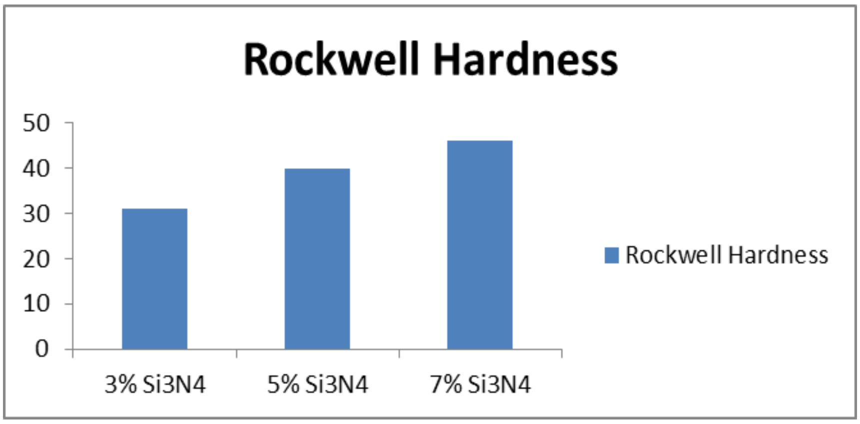

Figure 2 Rockwell Hardness at 470^{0}C

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For T3 temperature (Where T3 = 490°C)

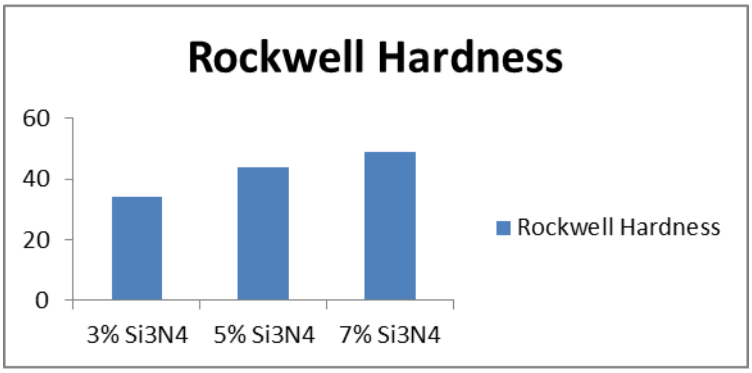

Figure 3 Rockwell Hardness at 490^{0}C

VI. CONCLUSION

In this work, hardness of Al- Si3N4 composite is investigated at a load of 100 Kg. Result shows the hardness is always the function of percentage incorporation of the ceramic or second phase particle in the metal matrix. Specimens of the composite material when tested for hardness results at sintering temperature of 450°C, 470°C, and 490°C, at every sintering temperature, higher incorporation percentage of the silicon nitride exhibited the improved hardness as compared to its lower counter parts.

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