Journal of Material Science and Mechanical Engineering (JMSME)
Print ISSN: 2393-9095; Online ISSN: 2393-9109; Volume 2, Number 1; January-March, 2015 pp. 54-56

http://www.krishisanskriti.org/jmsme.html

Characterization of Hybrid (Al/Sic/Tic) Nano Composite by Powder Metallurgy Method

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Abstract—*The growing interest in hybrid nano composites (Al/nano SiC/TiC) could be realized for the past decades because of its superior mechanical and physical properties such as high specific stiffness, high specific strength, and low density. The addition of one more particle in composite is trends exhibit new properties. Hybrid nano composites are fabricated by powder metallurgy method. Aluminium material used as matrix and TiC and SiC particles used as reinforcements. The distribution of nano SiC and TiC particles in the aluminium matrix is evaluated by scanning electron microscope. The mechanical properties of hybrid composites are evaluated by compressive test and micro hardness test.*

Keywords: *Aluminium, Nano SiC, TiC, Powder metallurgy, SEM*

1. INTRODUCTION

The increasing needs for metal matrix composite to be cost effective and at the same time have an optimum level of performance have led to PRMMCs receiving considerable attention in recent years. PRMMCs have excellent mechanical properties such as high specific stiffness and high specific strength and low weight. The particulate reinforced composites are relatively isotropic compared to the whisker and fiber reinforced composites. The failure and mechanical properties of PRMMCs are strongly affected by the fabrication method, volume fraction, shape and size of particles, and distribution and properties of constituents [1].

The PRMMCs are fabricated by several methods such as liquid state, semi-solid state and solid state. The first two methods are induced some chemical reactions between matrix and reinforcement. Its affect the mechanical properties of composite materials. The uniformity of particles in the matrix is also very difficult[2].There are many researchers focused on the synthesis of silicon carbide/ aluminium composites using different routes, such as stir-casting, squeeze casting, in-situ, semi-solid powder densi- fication and spray co-deposition. However, powder metallurgy method is almost used to fabricate the metal matrix composites because of its low manufacturing temperature, which avoids strong interfacial reactions and minimizing undesired reactions between the matrix and the reinforcement. An additional advantage of powder metallurgy is the particles are distributed uniformly in the matrix [3]. This uniformity of particles in the matrix improves mechanical properties such as high specific strength, high stiffness and wear resistance[4].

The use of a single reinforcement in an aluminium matrix may sometimes compromise its physical properties. However, the consequent increase in SiC content in composites makes machining difficult [5].Thus, it is essential to identify ways to retain the advantageous influence of SiC while simultaneously addressing the problems of machining SiC-reinforced composites. However, the Hybrid composites are prepared by reinforcing with a mixture of two or more different types of particles which com-bines the individual properties of each type of particle [6]. Essamet al. fabricated hybridcomposite via FSP and exhibited high hardness and superiorwear resistance than the matrix material. Using the nano sized reinforcement which it disperse throughout the matrix uniformly, hence the Metal matrix nanocomposites (MMNCs) attract great deals of attentions nowadays due to their great mechanical properties and also their further applications in advanced industries. The effects of nano-sized reinforcements on the mechanical properties have not been thoroughly studied.An increase in strength can be obtained with decreasing particle size, owing to a greater number of particles for the same volume fraction, whilst at the same time ductility is preserved because, below a critical size, particles no longer fracture [7]. Meanwhile, reinforcing nanoparticles in the matrix enhances wide spectrum of properties including yield and tensile strength at room temperature, creep and fatigue resistance at higher temperatures, hardness, compressive strength, and thermal shock resistance [8].

The aim of the present study is to investigate the effects on mechanical properties of the nano sized reinforcement to the matrix phase. The Al/SiCp/TiCp hybrid composites were fabricated using powder metallurgy (PM) route. The effects of nano sized SiC / TiC particulates reinforcement in the matrix were analyzed by mechanical test and micro structural analysis.

2. EXPERIMENTAL PROCEDURE

Pure aluminium powder is used as a matrix material with purity of 99.8%. The aluminium powders having the size of 200 mesh i.e. 74 microns. The SiC/TiC ceramic particulates were used as reinforcement. The reinforcements of SiC/TiC particulates having 60 nm in sizes. Both the SiC and TiC were dispersed in the Al matrix with vol.2% using conventional PM route as follows: The Al matrix and SiC/TiC particulates in addition to 1 wt.% Acrawax were blender, mechanically mixed until a homogeneous mixer is achieved, and then placed into containers. Performance of dry powder lubricant is of vital importance since metal powders in forming process of powder metallurgy (P/M) should be admixed with one of lubricant powders, such as zinc stearate, lithium stearate, Acrawax C, EBS wax or Wspecial wax, and then poured into a die cavity to press a green compact of metallic part. The mixer of matrix and reinforcements Al/SiC/TiC were cold compacted in a tool steel die shown below schematically in fig.1. The powders were then compacted using universal testing machine having a capacity of 400KN. The compaction pressure applied was about 400MPa.The Al/SiC/TiC hybrid composites produced from the cold compaction step were subject to sintering at 600^0C for 90 Mins. The sintering process was performed in muffle furnace having the maximum capacity of 1100^0C. The final Al/SiC/TiC compostes samples had cylindrical shape of 26mm and about 32mm length. For microstructural examinations, evaluated using the scanning electron microscopes (SEM). Mico hardness test measurements were carried out using a load of 500g. A minimum of three readings were taken for each side of the sample and the average value was determined.

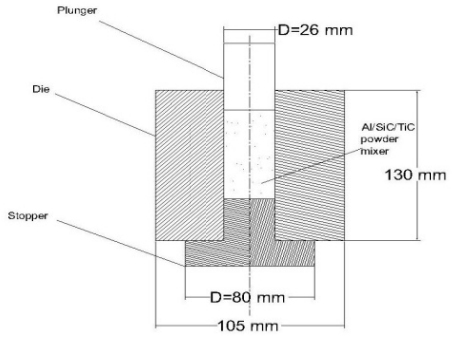

Fig. 1: Schematic illustration of the cold compaction Die setup for preparation of Al / nano SiCp /TiCp composites

3. RESULT AND DISCUSSIONS

In the present work, the materials handled in the process were in solid state. The composite has been investigated through SEM micrographs, the further magnification of the specimen of Al/SiC/TiC are clearly visible that the dispersion of the particles are homogeneously dispersed throughout the spcimen. The uniform distribution of particles has been achieved by appropriate time of mixing. Also found that the internal porosity occurs as black points in the SEM image are formed during the PM process.

There is a high-density dislocation in the Al matrix near SiC particles, and the metal matrix was bonded well with the reinforcement SiC particles through a very thin and clean interface layer by diffusion bonding. The SiC/Al interface shows polycrystalline structure, and no interfacial reaction products have been found [11].

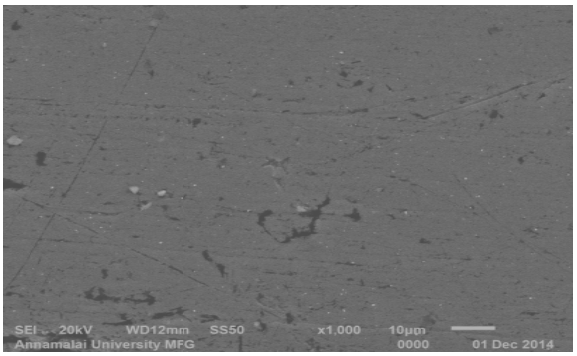

Fig. 2: SEM image of pure Aluminium

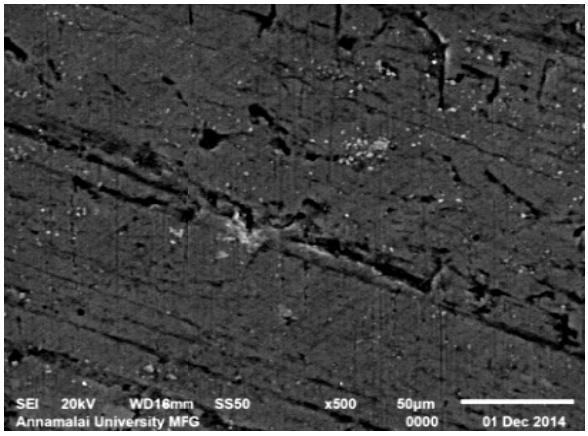

Fig. 3: SEM image of Al / 1% SiC/1% TiC

3.1 Microhardness Test

The micro hardness evaluation was carried out to understand the influence of nano particles in the Al matrix. The prepared specimens were polished and micro hardness values are measured on the specimens. The values are taken at different location to understand the influence of nano particles on the mechanical behavior of composites. The results of micro hardness test have been plotted in Fig. 4. The test results revealed that hardness of Al / Nano compisutes higher that the aluminium alloy. The aluminium materials is soft material and dispersion of nano particles in the Al matrix being contributed the improving the hardness strength of composite materials.

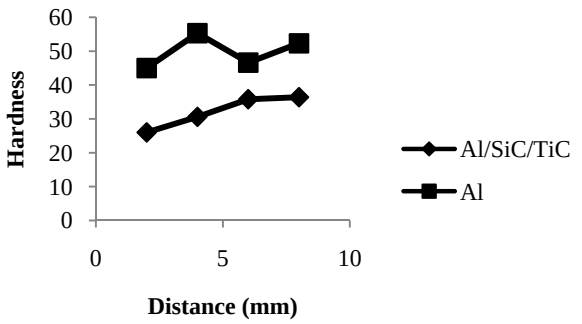

Fig. 4: Micro hardness values of Al/Nano SiCp composites

3.2 Compression Test

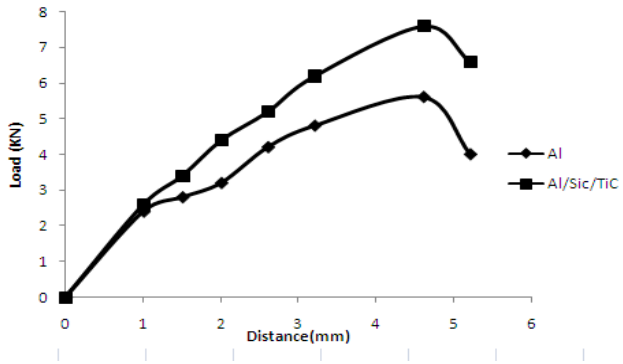

Fig. 5: Compressive values of Al/Nano SiCp composites

Compression test are made on Servo controlled Universal Testing Machine. As the result obtained from the compression test, the Al Alloy has the low compressive strength when compared to Al / Nano SiCp and TiCp composites Fig. 5. The presence of Nano particles (SiCp and TiCp) in the matrix basically brittle properites. Therefore, these nano particles restricted the flow matrix materials. Hence, compresisve strenth is very high.

4. CONCLUSION

The hybrid nano composite was fabricated by powder metallurgy route and mechanical properties, microstructure examination evaluations were carried out by compressive test, micro hardness test and SEM analysis. The results revealed that the uniform dispersion of the particles with matrix material increased the hardness strength. The compressive strength is also increased.

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