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Evaluation of Mechanical Properties and Microstructure of a CNT Coated Ceramics Reinforced in an Aluminium Alloy

M.Sangeetha*, S.Prakash

Department of Mechanical Engineering, Sathyabama University, Chennai, India

Abstract : At the present time the steel and other metals are replaced by composite materials in the field of automobiles due to less weight and less corrosiveness. In this experiment aluminium alloy is used as the matrix element. Ceramics are coated with carbon nanotubes (CNT). The coated ceramics are reinforced in the aluminium alloy. The ceramics are coated for two reasons, abrasiveness of ceramics and due to the poor bonding between the matrix and ceramics. To avoid the abrasiveness of the ceramics it is coated with CNT. Because of coating there is a good interfacial bonding between the matrix and reinforcement. The ceramics are coated by the process called Sonication. The coated ceramics are reinforced in the aluminium alloy by stir casting process. The prepared specimen is subjected to mechanical testing. The mechanical properties of coated ceramics in the aluminium alloy show the improved mechanical properties compared to the properties of aluminium alloy and uncoated ceramics in aluminium alloy. The microstructure of the prepared specimen is analyzed. There is an equal distribution of ceramics on the base alloy. The porosity of coated ceramics in the alloy is avoided and it is verified by Scanning Electron Microscope (SEM).
Keywords : Carbon Nano Tubes; Ceramics; Microstructure; Stir casting; Scanning Electron Microscope.

1.0 Introduction

Aluminium reinforced with ceramics are replaced instead of aluminium alloy in the field of automobile parts such as brakes, cylinders, connecting rod, valves, etc. Metal matrix composite is suitable for automotive components compared to polymer composites[1].

The author Kang Pyo So, proved in the paper that by adding 0.84% is powder and 1% CNT with Al tensile strength improved by 15% and young's modulus increased to 79%[2].

The author tested the Multi Wall Carbon Nano Tubes with Al and shows that the porosity is low and the mechanical property is high, such as hardness (110HV) and there is a uniform distribution of MWCNT in Aluminium matrix compared to SWCNT and DWCNT [3].

K.K. Alaneme proved that the hardness, ultimate tensile strength and percent elongation of the hybrid composites decreased with increase in bamboo leaf ash content and the fracture toughness of the hybrid composites was observed to be superior to that of the single reinforced Al - 10 weight%[4].

Rashad.R.M tested the MWCNT with A 356 and shows the ultimate tension is 200MPa and there is an equal distribution of CNT for 1.5% of MWCNT and it is decreased by further increasing the percentage of MWCNT of about 2% and the ultimate tensile strength is 165MPa.[5]

M.Vamsi Krishna studied from the microstructure of hybrid metal matrix composites

(Al6061/SiCp/Graphite) that there is an equal distribution of reinforcement of the matrix element with improved mechanical properties[6].

The author Michael Oluwatosin Badurin proved that the mechanical and tribological properties of hybrid metal matrix composites are good when compared to aluminium alloy[7].

The novelty of this paper is the coating process. In this paper the abrasive ceramic is coated by CNT by Sonication process.

2.0. Experimental

2.1 Materials

2.1.1. Aluminium Alloy/Ceramics/Carbon nano tubes

Aluminium alloy is selected due to their application in the field of automobile and aerospace components. Tensile property and elongation of aluminium is good. The hardness of the alloy is low. Ceramics are added to aluminium alloy to overcome its less hardness property. Ceramics are abrasive with large hardness value. By mixing ceramics with aluminium the hardness value improved, but there is a poor interfacial bonding between the ceramics and the reinforcement. The coarse ceramic is not bonded properly with the base metal. CNT is added with ceramics in order to treat the surface of the ceramics resulted in good bonding between the reinforcement and the base metal [8,9].

2.2 Methods

2.2.1 Sonication / Stir Casting

Sonication is the process in which the ceramic powder and CNT powder with poly vinyl alcohol is subjected to a vibration process for 30 minutes and this mixture is dried in the hot air oven for about 10 minutes to get the dry powder. After Sonication process the microstructure of the coated powder is analyzed for proper coating.The stir casting process is one in which the coated ceramics are mixed with the molten aluminium alloy at 600°C for 8 minutes. The aluminium alloy is heated in the furnace at 700°C and the coated ceramics are preheated in the separate furnace and both are stirred. The mixed components are poured in a die of square shape. The micro structure of cast specimen is taken to analyze the proper distribution of coated ceramics on the aluminium alloy. Figure 2 shows the ceramics are properly distributed in the base metal without any agglomeration.

3.0 Results and Discussions

3.1 Results of Sonication

In Sonication process 10% of ceramics, mixed with 1.1%, 1.6% and 2.1% of CNT. This mixture is subjected to vibration in the presence of poly vinyl alcohol resulted in the proper distribution of nano sized CNT over the micron sized ceramics. Figure 1 shows the CNT coated equally over the entire surface of ceramics.

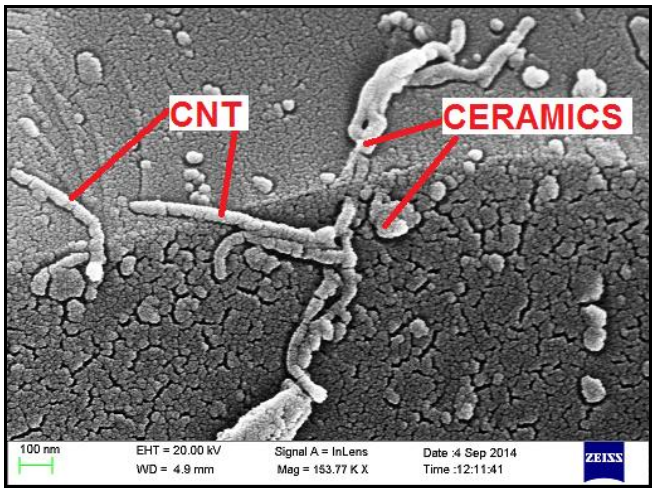

Figure. 1. Microstructure of CNT coated ceramics

3.2 Results of Stir Casting

In stir casting process molten cast aluminium alloy is mixed with different proportions of coated ceramics and different plates are obtained. The specimens fabricated by stir casting are aluminium alloy, uncoated ceramic reinforced composites and three samples of coated ceramic composites.

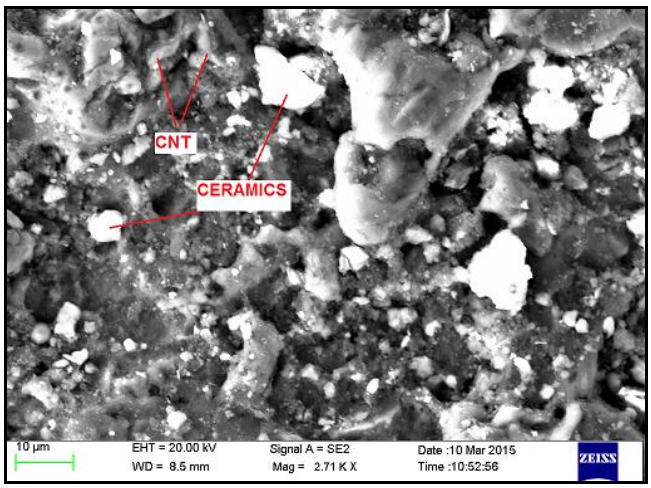

Figure. 2. Microstructure of coated ceramics in aluminium alloy

3.3 Mechanical Testing

Mechanical testing is conducted over five samples. Mechanical properties such as tensile strength, elongation and hardness are tested and their results are plotted in the graph. Figure 3 explains that the tensile strength is increased by adding ceramics to aluminium alloy and it further increased by adding CNT up to 1.6%. When the percentage of CNT increased beyond 2.1%, the mechanical properties get affected. In the graph 1 along axis represents aluminium alloy, number 2 represents aluminium and ceramics, number 3 represents Al/ceramics / 1.6% CNT and number 4 represents Al/ ceramics/ 2.1% of the CNT [10,11].

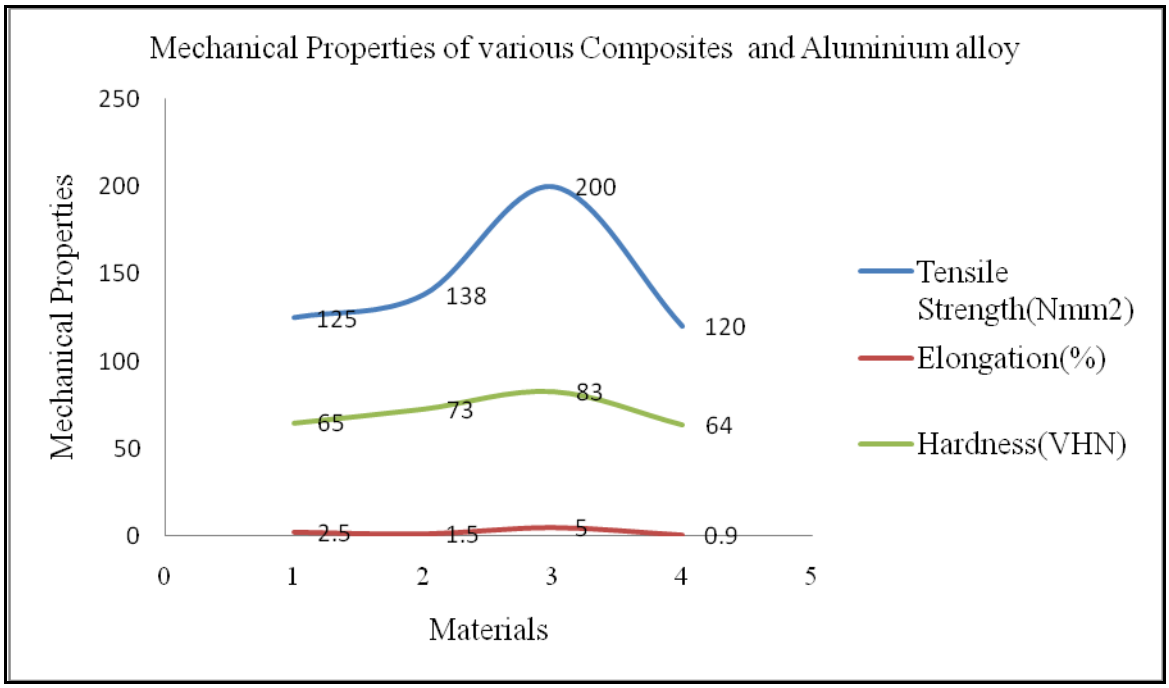

Figure. 3. Mechanical properties of various materials

4 Conclusion

- The microstructure of the coated ceramics shows the equal distribution of CNT over the ceramics.
- Microstructure of coated ceramics, mixed with the aluminium alloy shows the proper distribution of coated ceramics with the aluminium..
- Improved mechanical properties of composites are obtained in 1.6% of the CNT.

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