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Study on mechanical properties of hot extruded az31-mwcnt composites fabricated by powder metallurgy

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ABSTRACT

Magnesium alloys attract great attention for their excellent properties such as light weight, high specific strength.Mg alloy based MMCs (metal matrix composites) among other MMCs are widely used in various applications in aerospace, automobiles, and sports equipment's because of its low density and better mechanical properties. The main aim of the project is study and fabrication of AZ31-MWCNT composite. Multiwall carbon nanotubes (MWCNTs) reinforced Mg alloy AZ31 Nano composites were fabricated by mechanical alloying and powder metallurgy technique. The reinforcement material MWCNTs were blended in three weight fractions (0.33%, 0.66%, and 1%) with the matrix material AZ31 (Al-3%, zinc-1% rest Mg) and blended through mechanical alloying using a high energy planetary ball mill. Specimens of AZ31 and AZ31-MWCNT composites will fabricated through powder metallurgy technique. After fabrication of AZ31-MWCNT it goes for hot extrusion which arranged CNT in unidirectional. The microstructure, density, hardness, porosity, ductility, and tensile properties of AZ31 and AZ31-MWCNT Nano composites will characterized and compared

Keywords— **AZ31-MWCNT composites, hot extrusion, Planetary ball mill, Powder metallurgy.**

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I. INTRODUCTION

In the past decade. Initial work on MMCs (Metal Matrix Composites) was stimulated by the high performance needs of the aerospace and automobile applications which placed performance ahead of cost, at least in developmental programs. MMCs have been produced using a wide range of matrices which include magnesium alloys, copper alloys, iron based alloys, magnesium alloys, and nickel based super alloys, titanium alloys and lead alloys.[1]

Mg alloy based MMCs and Other MMCs are widely used in various applications in Aerospace, automobiles, and sports equipment's because of its Low density and better mechanical properties. It having very high weight to strength ratio CNTs Reinforced Mg composites are becoming more popular, as Compared to fiber reinforced Mg composites, due to their increased production rate, reduced reinforcement costs and Easier fabrication processes. Micrometer-size sic, Al_2O_3 Particles are commonly chosen as a reinforcement in Mg Because of their low cost and easy availability. The Microstructure and mechanical properties were significantly improved with the micro size particulate reinforcements and It is founded by various authors that Nano size reinforcement Will further improve the properties if the nanoparticles are Homogeneously reinforced into the matrix material. However, only few attempts have been made so far to reinforce CNTs through mechanical Alloying using high speed planetary ball milling into AZ31 matrix system which was carried out in this work.[3]

CNTs are the more exciting nanostructured materials of the 20th century with superior mechanical properties discovered by Iijima. CNTs are discovered to have young's modulus and tensile strength in the range of 3 TPa and 2 GPa, respectively, and density in the range of 2.0 g/cm3. The properties CNTs could be an ideal reinforcement for AZ31 as matrix material. Recent researches producing AZ31 matrix composites reinforced with CNTs has been limited, looking to the problem of agglomeration of CNTs due to Wander wall forces but were largely focused on polymer matrix composites Among the various processes powder metallurgy is the easiest and cheapest method to fabricate the particulate reinforced composites. Goh et al. have developed Mg- CNT Nano composites through powder metallurgy route and the results of mechanical behavior characterization revealed that an increasing volume fraction of CNTs in the magnesium matrix lead to an improvement in 0.2% YS, ductility, and work of fracture. An increase in the ductility was observed up to 0.18 wt. % of CNTs in Mg, but further increase in amount of CNTs reduces the mechanical properties due to agglomeration of CNTs.[1,3]

II. PROBLEM STATEMENT

It is important to develop lightweight and high-strength materials for improving energy-efficiency through the weight reduction for transportation carriers. Magnesium alloys have attracted lots of attentions, since the density of magnesium is approximately two thirds of that of aluminum and one fifth of steel. As a result, AZ31 offer a very high specific strength among conventional engineering alloys. AZ31 having good damping capacity, excellent cast ability, and superior machinability. However, compared to other structural metals, AZ31 have a relatively low mechanical strength, especially at elevated temperature. At high temp. Magnesium is goes for oxidation. The need for high-performance and lightweight materials for aerospace applications has led to extensive efforts in the development of AZ31 matrix composites and cost-effective fabrication technologies. They are proved to have good mechanical properties through an incorporation of structural filler (e.g., ceramic whiskers such as silicon carbide whisker and others, aluminum oxide, graphite and other particles, carbon fibers and carbon nanotubes: CNTs). We are use MWCNT for increasing mechanical properties of AZ31.

III. OBJECTIVE

1) The main objective of this research is to fabricate AZ31 Nano composites reinforced with higher weight fraction of MWCNTs through mechanical alloying and powder metallurgy process to study the mechanical properties. Three weight fractions of MWCNTs 0.33%, 0.66%, and 1% were added to the matrix of AZ31 and blended through high energy planetary ball mill to improve the homogeneity of the reinforcement material and to reduce the agglomeration.

2) The homogeneity of MWCNTs has been successfully achieved through mechanical alloying process using high energy planetary ball milling. Similar process has not been previously applied on AZ31-MWCNT system and found effective in reinforcing the MWCNTs up to 1wt% CNTs with reduced agglomeration.

3) The specimens of AZ31 and AZ31-CNT composites were characterized for the microstructure and mechanical properties and compared for the effect of increasing weight fraction of CNTs, mixing medium, cold compaction, sintering temperature, and hot extrusion.

MATERIALS

TABLE I

Properties of Mutiwalled Carbon Nano Tube

Properties	**Value**
Purity	>95%
OD*ID*L	10-30 nm×2-6nm×15-30*10-3m
Melting Point	3652 – 3697^{0}C
Density	2.0 g/cm^3
Surface Area	90-350 m2/g

IV. METHODOLOGY

1)Powder metallurgy process can be use to synthesize bothAZ31 alloy and AZ31-CNT composites

2)The reinforcement material MWCNT with three weight fractions of 0.33%, 0.66%, and 1% will add to the matrix of AZ31 alloy and blended through mechanical alloying using a high energy ball mill for 2 h at a speed of 300 RPM.

3) Tungsten carbide balls should be used with ball to powder weight ratio of 1: 15and there will be no binder or inert gas used during the milling process.

4) The homogeneously blended powders in different variations of CNTs will compacted into cylindrical billets of 30mm diameter in a die with a load of 15 tons using a 100 ton hydraulic press under ambient conditions.

5) The compacted specimens of AZ31 and AZ31-CNT should kept in a seal tubular container to avoid oxidation and sintered at 650∘C for 2h in a tubular sintering furnace.

6) The sinter specimens then extruded using an extrusion die at 450∘C.

7) Microstructure investigations of the samples can be carried out using SEM (scanning electron microscope).

8)Density measured using Archimedean principle at room temperature using Xylene as auxiliary liquid.

9)Porosity calculated from theoretical and experimental densities.

10) Hardness can measured using Vickers hardness tester with a load setting of 5KN and dual time of 15 sec. Hardness was measured at 5 places in each sample and the average value will taken.

Fig. 1 ball milling

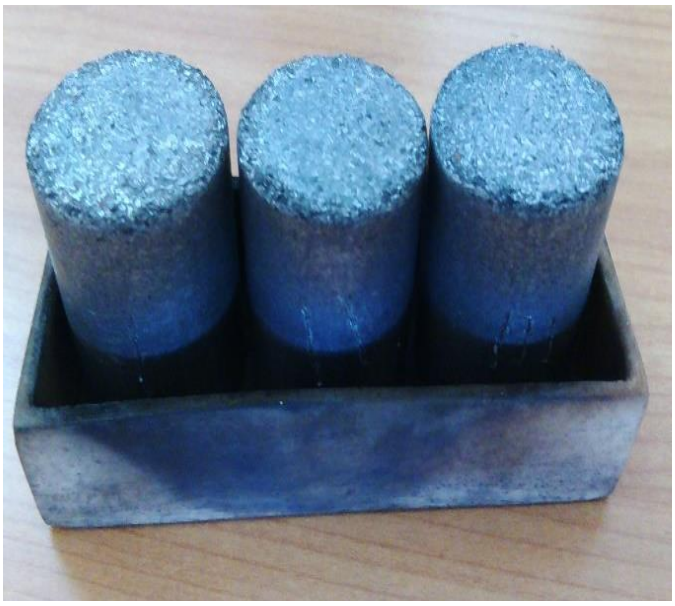

Fig. 2 sintered sample

Fig.3 Extruded sample

V. RESULTS & DISCUSSION

A. MICROSTRUCTURE

Mechanical alloying using ball milling technique is very effective in dispersing CNTs on the Surface of the particles at the beginning of milling, and within the particles after few hours of ball milling. The microstructures of the ball milled samples are shown in Figure as shown below. Mechanical alloying using ball milling technique is very effective in dispersing CNTs on the Surface of the particles at the beginning of milling, and within the particles after few hours of ball milling. The microstructures of the ball milled samples are shown in Figure 1. It is observed from the images that during the process of ball milling the powders collide with the Tungsten carbideballs creating high pulverization energy responsible for introducing lattice Defects that cause the powder particles to deform plastically. The particle get homogeneous size by ball milling. As the process continues, the powder particles fracture and the reinforcement particles are cold welded to the matrix particles and this occur at the atomic scale. Further milling leads to the enlargement of the forming particles with reinforcement as an intermediate phase appearing inside or at the surface of these particles. The particles get elongated after 2 hr ball milling. It is found that the particles are fractured again into submicron matrix particles with fine dispersion of the reinforcement phase.

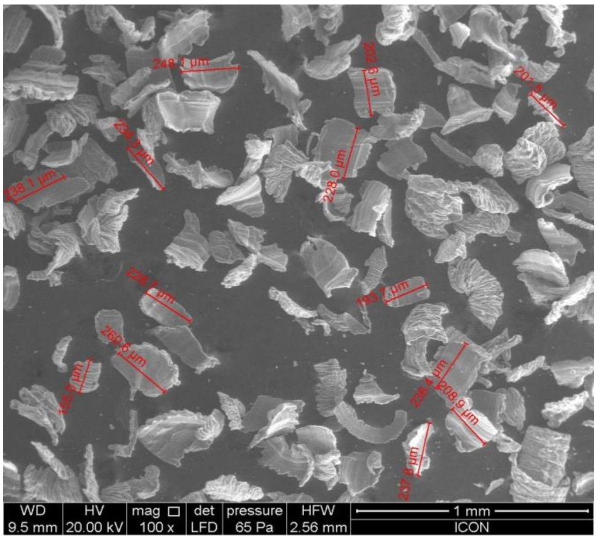

Fig. 4 AZ31-MWCNT(0.33%) 1hr ball milling sample

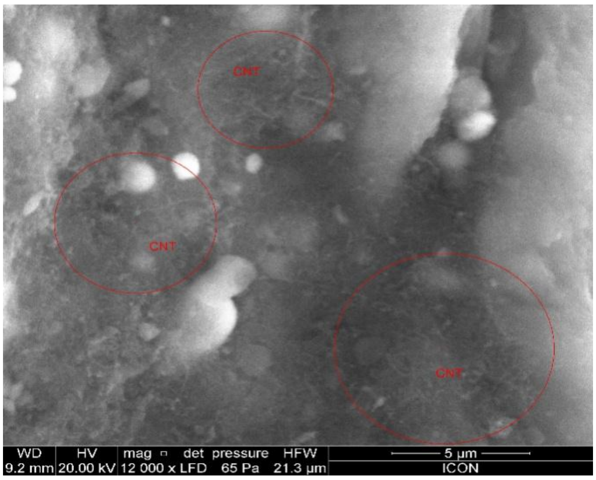

Fig 5 AZ31-MWCNT(0.33%) 1hr ball milling sample

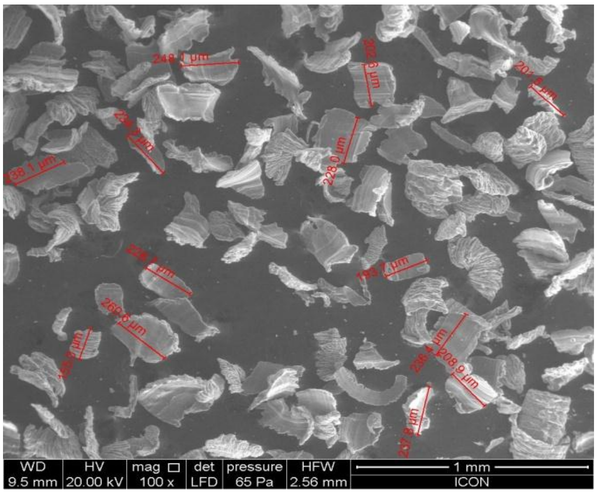

Fig. 6 AZ31-MWCNT(0.33%) 2hr ball milling sample

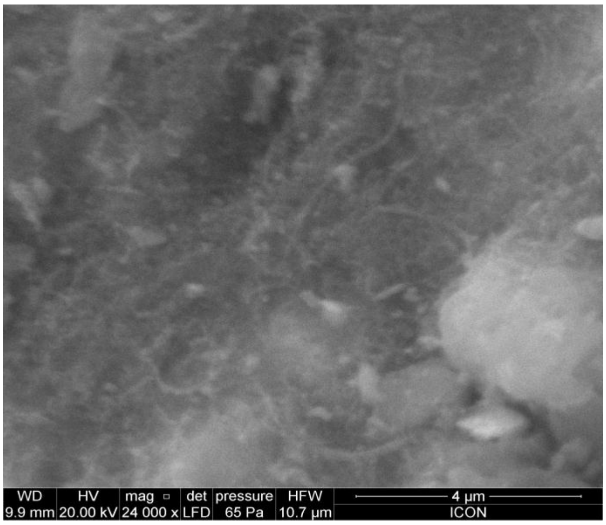

Fig. 7AZ31-MWCNT (0.66%) 1hr ball milling sample

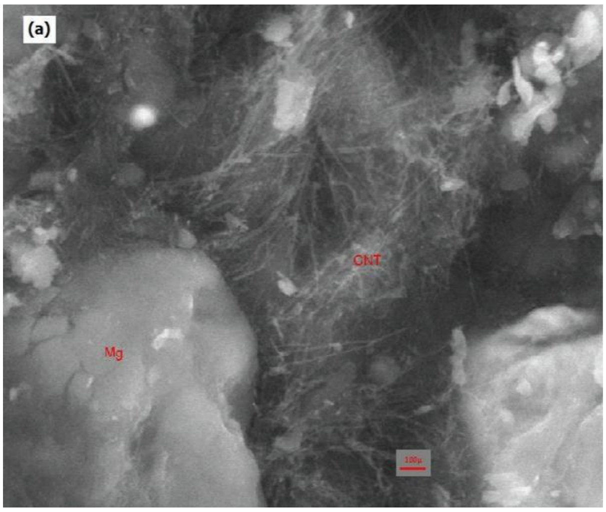

Fig.8AZ31-MWCNT (1%) 1hr ball milling sample

B. DENSITY

It is observed that the density of the Nano composites decreases with increasing weight percentages of CNTs.The reason for the decrease in the density is due to the addition of light weight and high volume CNTs compared to the matrix material. This is calculated by theoretically.

TABLE II

Density of AZ31 and AZ31 - MWCNT

Composite	Density
AZ31	1.729
AZ31-0.33%MWCNT	1.723
AZ31-0.66%MWCNT	1.714
AZ31-0.99%MWCNT	1.700

C. HARDNESS

As the CNTs increases the hardness increases because carbon percentage increases.

TABLE II

Hardness of AZ31 and AZ31 – MWCNT

Composite	Hardness (BHN)
AZ31	50
AZ31-0.33%MWCNT	52
AZ31-0.66%MWCNT	54
AZ31-0.99%MWCNT	57

VI. CONCLUSIONS

1) From microstructure we can observed that up MWCNT properly mixed with AZ31 and the particle get homogeneous size .The MWCNTs are reinforced in the AZ31 matrix.

2) The results of mechanical behavior characterization revealed that an increasing weight Fraction of MWCNTs in the AZ31 matrix lead to decreases in density.

3) As the percentage of CNTs increases the hardness is also increases.

4) AZ31-MWCNT Mixing properly in ball milling.

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