STUDY ON MECHANICAL BEHAVIOUR OF Mg-CNT COMPOSITE MATERIAL FABRICATED BY STIR CASTING

S. L. Waranghuse[1], R. L. Mankar[2]

[1] *PG Student, Department of Mechanical Engineering, JCOE Kuran , SPPU Pune*

[2]*Guide, Department of Mechanical Engineering, JCOE Kuran , SPPU, Pune*

[1]soma.waranghuse@gmail.com

[2]raj.mankar217@gamil.com

***Abstract*— This paper presents the study of pure metal (Mg) and composite metals (Mg +CNT), have fostered the way to improved composite materials and their properties. CNTs have been introduced into pure mg materials reinforcement by stir casting process with varying percentage. Till now other materials have vastly been studied for that purpose, including metals. Today, many use of CNT reinforced composites are there but CNT reinforced metals are still rare and only found in very few applications. Several reasons can be identified but the still increasing demand for lighter and stronger metals build the way to more useful research on the topic of metal matrix composites (MMCs) reinforced by CNT. This review will describe the state of the art in this field and highlights the promising and excellent mechanical properties of CNT reinforced MMCs.**

***Keywords*—CNT, MMC, AMC, composite, stir casting.**

I. INTRODUCTION

Now a days the modern development needs in advanced engineering materials for various applications goes on increasing. To meet such requirements metal matrix composite is one of the reliable sources. Composite materials are one of the reliable solutions for such demands. In composites, materials are combined in such a way that to enable us to make superior use of their parent material while reducing some extent the effects of their deficiencies. The simple term 'composites' gives indication of the combinations of two or more different material in order to improve the properties. In the past few years, materials development has shifted from conventional to composite materials for adjusting to the need for reduced weight, low cost, quality, and high performance in structural materials. Driving force for the utilization of AMCs in areas of automotive and aerospace industries includes the parameters like performance, economic and environmental benefits are taken into consideration. A composite material is a material consisting of two or more physically and/or chemically distinct phases of the materials. The composite generally has better characteristics than those of each of the individual component materials. Usually the reinforcing component is distributed in the continuous or matrix component i.e., parent material. When the matrix material is a metal, the composite is known as a metal-matrix composite (MMC). In MMCs, the reinforcement usually takes the form of whiskers, particles, short or continuous fibers.

Objectives for Development are to produce the improved materials with the required characteristics. The reinforcement of metals can have many different objectives. The reinforcement of light metals opens up the possibility of application of these materials in areas where light weight is major priority. The main aim here is the improvement in the component properties.

1.1 OBJECTIVE:

- Improvement in tensile strength and yield strength at room temperature and above while maintaining the minimum ductility or rather toughness,
- Increase in creep resistance at higher temperatures compared to that of conventional alloys.
- Increase in fatigue strength, especially at higher temperatures,
- Improvement of thermal shock resistance,
- Improvement of corrosion resistance,
- Increase in Young's modulus,
- Reduction of thermal elongation.

In conventional casting processes, liquid metal is filled into a mould and solidifies as cooling occurs. The morphology of the improving solid–liquid interface is generally dendritic. The natural progression of poring followed by solidification often leads to internal structural defects, such as entrained oxide or shrinkage porosity, which combine to yield a casting of relatively poor mechanical properties.

Although the major concepts of composite materials go back to antiquing, the technology was essentially build and most of the progress occurred in the last few decades. Composite having unique advantages over monolithic material, such as high strength, high fatigue life, stiffness, low density and adaptability easily. Now day's automobile and marine industries are need of superior class of materials that need all different uses. In this paper different composite of Mg–CNT prepared by stir casting. CNT has perfect physical and chemical properties and also mechanical properties. In this study, recent progress in magnesium matrix composite technology is reviewed. The conventional and new processes for the fabrication of magnesium matrix composites are summarized.

CNT's distribution with composite matrix was traced characterized. The standard specimens fabricated using different process followed by machining. Samples are prepared at different process was then tested their properties like mechanical, physical, chemical. In mechanical tensile, compression test studied. Microstructure was also studied using an optical microscope. And what happen when proper mixing of CNT with Mg their density will increases or not ,the density and hardness measurement show what happen about weight of Nano composite.

II LITERATURE REVIEW

2.1 Research Paper

Weiping Xu,Xi Lihuan,Xing L et. All Studies on "Uniformity of MWCNTs/Al Composites by Friction Stir Processing" developed multiple walls carbon nano-tubes reinforced aluminum matrix (MWCNTs/Al) composite. After his test , he founded that the performance of composite material was influenced by the content of MW-CNTs. When the content of W-CNTs is 0.75%, the performance is perfect, and the relative density is 99.5%, tensile strength increased by 28.3%, Vickers hardness increased by 11.0%, conductivity increased by 93.9%.[1]

L.Girisha and Raji George Studied on "Multi walled Carbon Nanotube (MWCNT)/aluminum composites were fabricated by stir casting process". Commercial purity aluminum is used as matrix and multi walled carbon Nanotubes as reinforcements with 0.5, 1,1.5& 2 weight percentage. Scanning electron microscope (SEM) method is used to analyze the dispersion of reinforcement in the matrix.[2]

Zhang Yinghui, Tian Haixia, Zhu Gensong, et al. "The density and hardness of W-Cu composite materials affected by nanotubes" 20% C/Cu composite materials using CNTs as the strengthening phase. The content of CNT can affect the density and hardness of the composite materials. CNTs can play a role of fine-grain strengthening when it added into 20% W-Cu composite materials. The density and hardness of the material increased with the increase of addition amount of CNTs.[3]

Tang Qihua, Zhou Xiaohua. Study on "Wearable Performance of Carbon Nanotube/Zinc Alloy Marix Composites". Zn-CNT composite has excellent mechanical properties and wear resistance, and can overcome the poor temperature resistant, large thermal expansion coefficient. The research showed that the friction coefficient of composites will decrease when the load content increasing. Under the steady-state friction conditions, friction coefficient matrix alloy is about 0121, the friction coefficient of the composite material is about 0114, and the adding of CNTs reduced the coefficient of friction materials.[4]

J. Jayakumar et.all has "Investigated the mechanical properties of Metal-Matrix Composites (MMCs)" that can be enhanced significantly by the reinforcement of MWCNTs into AZ31 Mg alloy with planetary ball milling. They did the work on how to improve fracture resistance of the materials by understanding the deformation and failure mechanisms. This investigation focused on examination of the effects of weight fraction of MWCNTs on the mechanical properties and fracture mechanism of AZ31- MWCNT Nano composites. They used AZ31 Mg alloy material, which was reinforced with 0.33wt%, 0.66wt% and 1wt% fraction of MWCNTs. The samples were tested at room temperature for uniaxial compression and sample sections were characterized for microstructure properties using optical microscope and SEM (Scanning Electron Microscope).The effect of addition of weight fraction of MWCNTs on mechanical property, microstructure and fracture modes were studied. The result shows that the fracture modes of the composites were increased by the increased weight fraction of MWCNTs because of their agglomeration, clusters and micro voids are susceptible route for crack propagation.[5]

2.2 Research gap

By reviewing all research paper we found that some researchers worked on composite material to improve strength. Composite materials definitely reduce a weight and load carrying capacity is maximum. By overall analysis there is need of finding composite of Mg (400gm) +CNT (0.2,0.5%) material to overcome drawbacks of conventional material

2.3 Objective

i)Study of microstructure of Mg-CNT Composite

ii)Reduce weight of component

iii)To Find Mechanical Properties:

- Tensile Strength
- Compressive Strength
- Hardness test

III. METHODOLOGY

Experimental Method identified for the thesis work: Step 1: Preparation of mould as it is popularly known is used with binding material to form the cope and the drag or the cores of the mould. Material add in crucible at temperature 840^{0}C and 100-200 volt.

Fig. 2.1 Stir Casting Process

Step 2: Preparation of Specimen of various compositions

The alloying element CNT is mixed in proper proportion by weight in the ratio of different percentage. The percentage of alloying element to be used is determined by literature review and history for development of this work. Three specimen of 40mm in diameter and 180 mm in length.

Fig.2.2 formation of Specimen

Step 3: Machining of specimen for test.

The material needs to be sized as a circular section of different dimension for tensile, compression, hardness and microstructure.

i)Tensile-D-13mm,G L-65mm

ii)Compression-D-14,L-70.

Step 4: Checking tensile and compression testing

This test is carried on UTM having 40 tons capacity

Step 5: Checking Hardness over `Hardness testing

This test is carried on Brinell Hardness Tester.

Step 6: Analysis and graphs

Various Experiments are to be conducted on MMC samples by changing weight fraction of CNT (0.2%, 0.5% and one pure Mg) and size of CNT-Mg particles to analyse the casting performance characteristics of CNT/Mg-MMCs.

IV. EXPERIMENTATION

3.1 Tensile and compression

For this test UTM of 40 tons capacity used.one pure and two composite (0.2, 0.5%) specimen used.

Fig.4.1 Tensile and Compression test

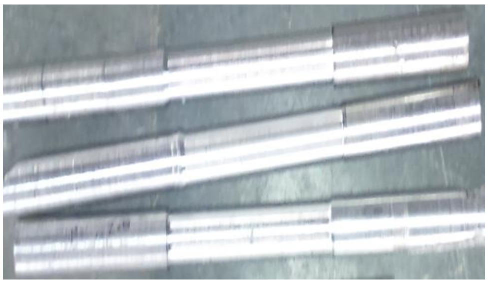
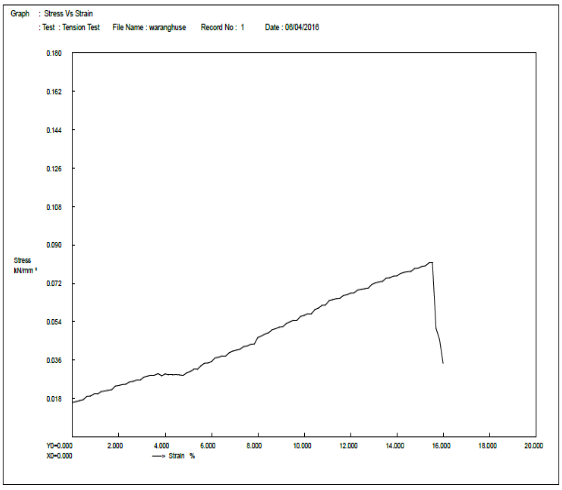
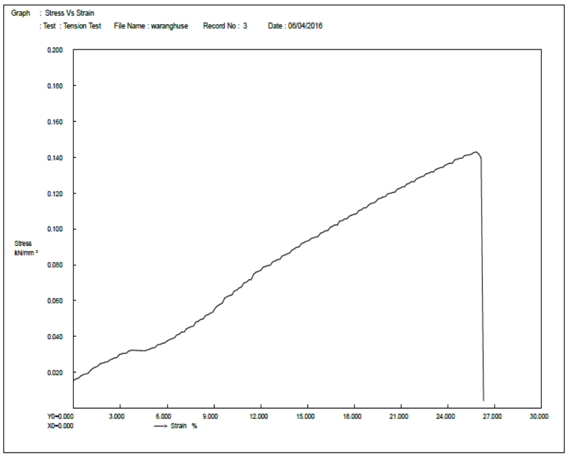


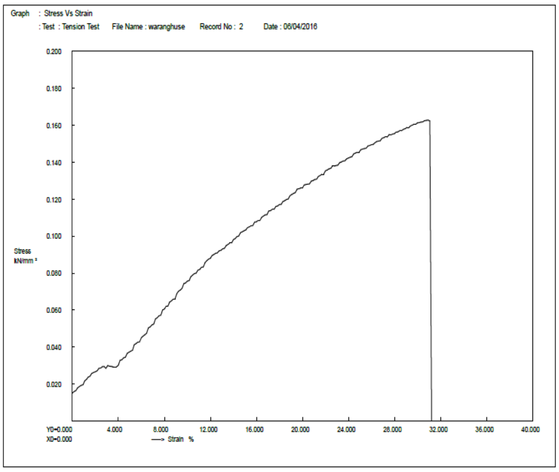
Fig. No.4.2 Tensile specimen



Graph 4.1 Stress Vs Strain(Pure)



Graph 4.2 Stress Vs Strain(0.2%CNT)



Graph 4.3 Stress Vs Strain(0.5%CNT)

Above Graph shows:

i) Graph 4.1 Stress Vs Strain(Pure)

ii)Graph 4.2 Stress Vs Strain(0.2%CNT)

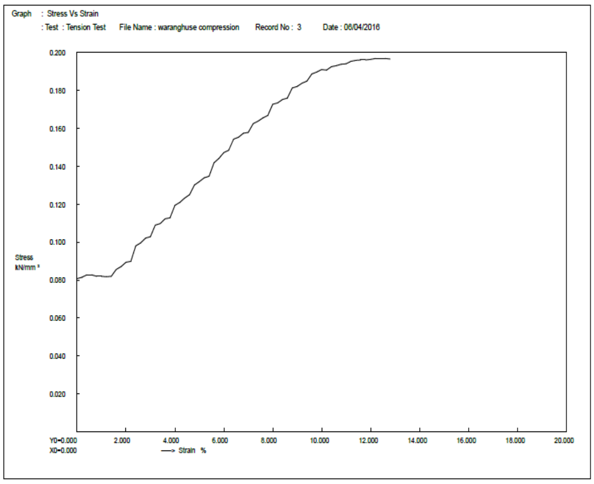
iii)Graph 4.3 Stress Vs Strain(0.5%CNT)

Table No. 1: Tensile Test Results

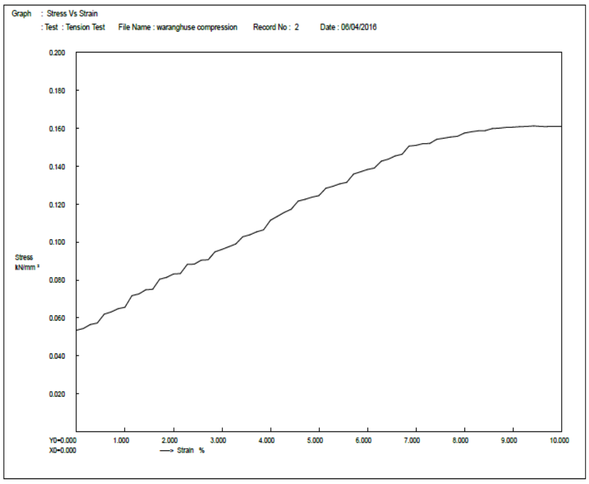
Parameter	Result value for pure	Result value for 0.2%	Result value for 0.5%
Maxi. Force	10.880KN	18.980KN	21.620KN
Disp.	10.100mm	16.000mm	20.100mm
Maxi. Disp	10.400mm	17.100mm	20.300mm
C/S area	132.78mm	132.786mm^2	132.786mm^2
Tensile strength	0.082KN/mm^2	0.143KN/mm^2	0.163KN/mm^2
Elongation	16.00%	26.308%	31.231%

Fig. No.4.3 compression specimen

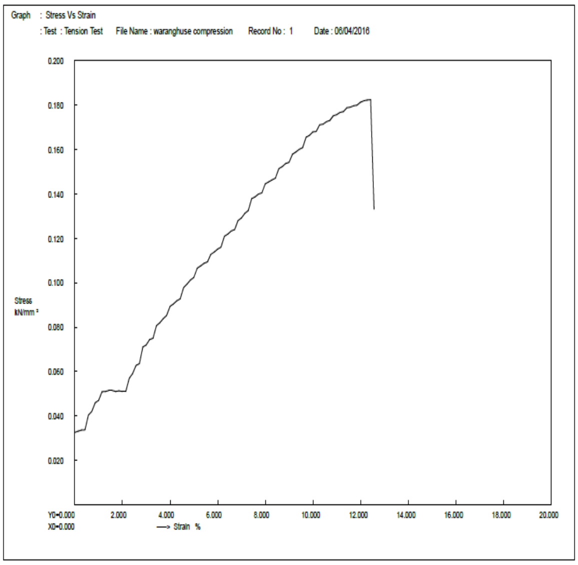
Compression Test Graph:



Graph 4.4 Stress Vs Strain (Pure)



Graph 4.5 Stress Vs Strain(0.2%)



Graph 4.6 Stress Vs Strain (0.5%)

Table No. 2: Compression Test Results

Parameter	Result value for pure	Result value for 0.2%	Result value for 0.5%
Maxi. Force	15.480 KN	24.840 KN	28.220 KN
Disp.	6.200mm	6.600mm	8.800mm
Maxi. Disp	6.400mm	7.000mm	8.800mm
C/S area	154.000mm^2	154.000mm^2	154.000mm^2
Tensile strength	0.100KN/mm^2	0.161KN/mm^2	0.183KN/mm^2
Elongation	9.200%	10.000%	12.571%

4.2 Hardness

The Brinell hardness test is carried out over Brinell hardness tester. two samples of CNT/Mg-MMC's for different sizes and weight fraction of Mg particles are prepared. After test and hardness value on dial, the Brinell hardness values.

What is Hardness?

Hardness is the property of a material that resist plastic deformation, generally by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting.

*Measurement of Hardness***:**

Hardness is not an intrinsic material property dictated by precise definitions in terms of fundamental units of mass, length and time. A hardness property value is the result of a defined measurement procedure. Hardness of materials has probably long been assessed by resistance to scratching or cutting.

Procedure:

i) Place the specimen on anvil with its surface normal to the direction of applied .

ii) Select correct weight

iii) Turn the large side hand wheel in counterclockwise direction until it stop. Hold it in place of right hand.

iv)Using left hand ,raise the anvil with the capstan hand wheel turning in C/W direction until the specimen just makes contact with the ball indenter .see indenter is at least 5mm from edges of specimen.

v) Apply load by slowly by reliesing the lever.

vi)Make sure this is done gently to avoid dynamic load from rapid descend of the weight and holder.

vii) Lower specimen by turning capstan hand wheel counter-clockwise until it clear the indenter.

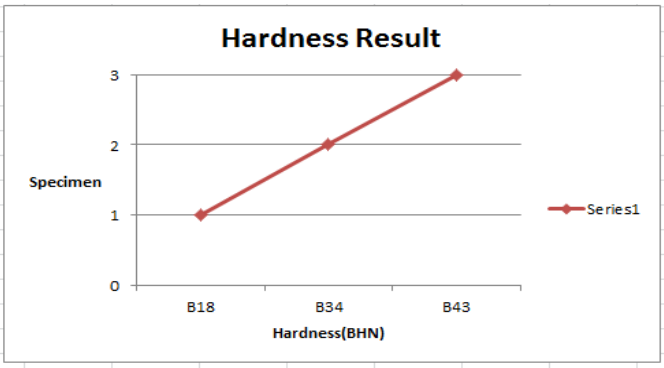
viii)Measure the BHN show in dial when dial shows zero deflection .

Fig.4.4 Brinell and Rockwell hardness Tester

Table No. 3: Hardness test results

Specimen No	Diameter of indenter (mm)	Load applied (kg)	BHN
1)Pure mg	3.2	60	B18
2)0.2% CNT +Mg	3.2	60	B34
3)0.5%CNT +Mg	3.2	60	B43

From above result table we get the following graph of different percentage of CNT (on Y axis) vs Hardness in BHN (on X axis). This graph shows that when we increase the percentage of CNT then hardness also increase .So that 0,5 % CNT specimen are having high hardness .



Graph 4.7 Specimen with different CNT % Vs Hardness

If the file slides without biting or marking the surface, the test material would be considered harder than the file. If the file bites or marks the surface, the test material would be considered softer than the file. The above relative hardness tests are limited in practical use and do not provide accurate numeric data or scales particularly for modern day metals and materials.
The usual method to achieve a hardness value is to measure the depth or area of an indentation left by an indenter of a specific shape, with a specific force applied for a specific time. There are three principal standard test methods for expressing the relationship between hardness and the size of the impression, these being Brinell, Vickers, and Rockwell. For practical and calibration reasons, each of these methods is divided into a range of scales, defined by a combination of applied load and indenter geometry.

4.3 Optical Microstructure

Metallographic samples are normally sectioned from the cylindrical cast bars. A 0.5 % HF solution is used to etch the samples wherever required. To see the difference in distribution of Mg particles in the CNT matrix, microstructure of samples are developed on Inverted type Metallurgical Microscope and weight fraction (0.5%, 0.8%) of CNT-Mg particles. Optical micrographs shows the distribution of CNT particles within the matrix.

Fig. No. 4.5 Microstructures Study by Optical Microscope

Fig. No.4.6. PURE Mg

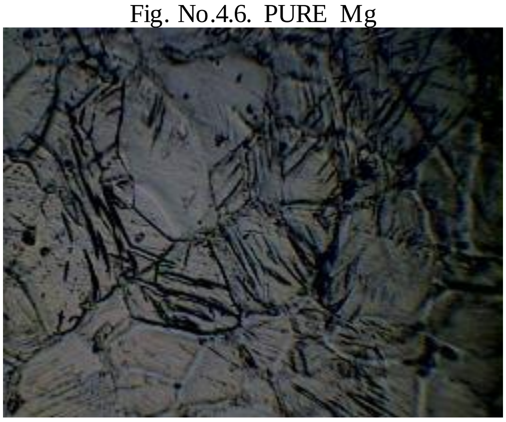


Fig. No. 4.7 Mg + CNT Composite 0.2%

Fig. No.4.8 Mg + CNT Composite 0.5%

Result analysis

Pure Material:

i)AT 100 X MAGNIFICATION :

Longitudinal Section

Hair line micro cracks visible. Little porosity seen.

ii)At 250 X MAGNIFICATION :

As cast coarsed grain structure seen.

Composite Material:

i)AT 100 X MAGNIFICATION

Longitudinal Section-Micro cracks not seen. Little Porosity seen.

ii)AT 250 X MAGNIFICATION :

i)Uniform distribution of lamellar particles of Magnesium alloy with globular particles of Carbon nano tubes seen.

ii) Randomly distributed Carbon Nano partial seen

4.4 SCANNING ELECTRON MICROSCOPY (SEM) TESTING

Scanning electron microscopy (SEM) is one of these characterization techniques, whose data is used to estimate the properties, determine the shortcomings and hence improve the material. The phenomenon of superconductivity initially develops within the grain and eventually crosses over the grain boundaries, leading to the bulk. Hence SEM can be useful tool to probe the microstructure of the superconductors and the properties related to it. Along with this the Energy dispersive Spectroscopy (EDS) can tell about the chemical composition of compounds.

Fig.4.9 Microstructures study by SEM

Results of SEM

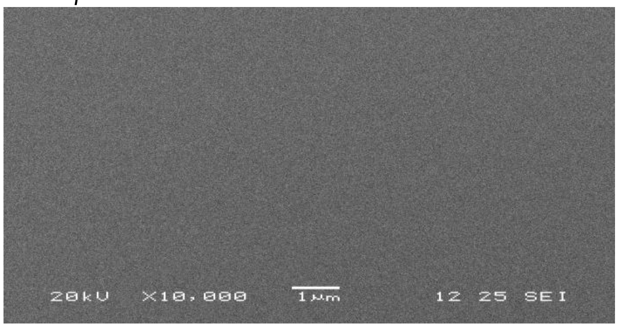


Fig. No.4.10 PURE Mg

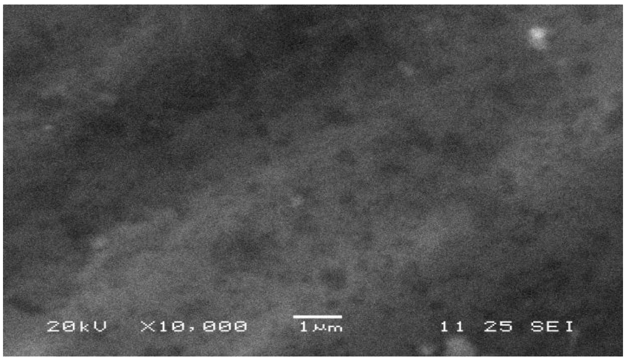
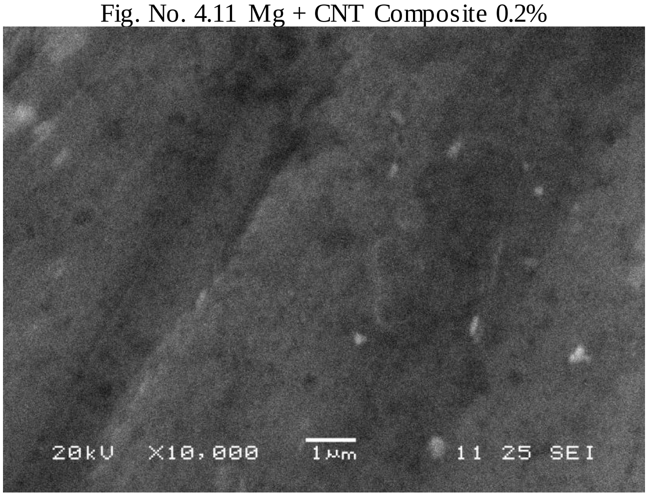


Fig. No. 4.11 Mg + CNT Composite 0.2%



. Fig. No. 4.12 Mg + CNT Composite 0.5%

Results of SEM

i) Types of reinforcement

ii) Matrix

iii) Amorphous matrix

iv) Porosity

V. RESULT & DISCUSSION

Table No. 4: Comparative Result

MATERIAL	TENSILE TEST	COMPRESSIVE TEST	HARDNESS TEST
Pure Mg	0.082 KN/mm^2	0.100 KN/mm^2	B18
0.2% CNT+Mg	0.143KN/ mm^2	0.161KN/mm^2	B34
0.5% CNT+Mg	0.163KN/ mm^2	0.183KN/ mm^2	B43

Following conclusions were deducted from the study:

i)The Mg-CNT Nano composite have been successfully synthesized using the stir casting techniques.

ii)It is observed that the density values of the composite increases with increasing weight % of CNT. This happens because, during & stirring the distribution within the matrix of the composite is uniform.

iii)The hardness and strength increases with the increase in % of CNT content increases. It distributes throughout the matrix in more uniform way & there is transfer of load from matrix to reinforcement. The reason behind the increase in porosity is due to the clustering effect of CNT.

iv)From microstructure study by SEM and optical microscope has study Types of reinforcement,Matrix,Amorphous matrix, Porosity and Randomly distributed Carbon Nano partial seen in composite.

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