THERMAL, MECHANICAL AND STRUCTURAL PROPERTIES EVALUATION OF CARBON NANO TUBE BASED ALUMINIUM MATRIX COMPOSITE

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Abstract

The practical work carried out as a part of research in the field of carbon nano tube (CNT) metal matrix composites (MMCs). Much research has been undertaken in utilising CNTs as reinforcement for composite material. However, CNT-reinforced MMCs have received the least attention. These composites are being projected for use in structural applications for their high specific strength as well as functional materials for their exciting thermal and electrical characteristics. The present work focuses on the critical issues of CNT-reinforced MMCs that include processing techniques, nano tube dispersion, interface, strengthening mechanisms and mechanical properties. Samples are prepared after the fabrication process and the mechanical property improvements achieved by addition of CNTs in various metal matrix systems are summarised. The factors determining strengthening achieved by CNT reinforcement are tested for the structural and chemical stability of CNTs in different metal matrixes. The importance of the CNT/metal interface has been reviewed. The importance of CNT dispersion and its quantification is highlighted. Tensile, hardness, X-ray Radiography, and conductivity tests are processed to find out exact results for further research.

Key words: Carbon nanotubes, Metal matrix composites, Sample preparation, Machinability, Mechanical& Thermal properties ,Conductivity, Radiography tests.

1.0 INTODUCTION

The need for lightweight, high strength materials has been recognised since the invention of the airplane. As the strength and stiffness of a material increases, the dimensions, and consequently, the mass, of the material required for a certain load bearing application is reduced. This leads to several advantages in the case of aircraft and automobiles such as increase in payload and improvement of the fuel efficiency. With global oil resources on a decline, increase in the fuel efficiency of engines has become highly desirable. Research in the field of carbon was revolutionised by the discovery of carbon nanotubes (CNTs) by Iijima in 1991. Although CNTs might have been synthesised in 1960 by Bacon, it took the genius of Iijima to realise that they are tubes made by rolling a graphene sheet onto itself. A multiwalled carbon nanotube (MWCNT) is made up of many single walled carbon nanotubes (SWCNT) arranged in a concentric manner. Unless otherwise specified, CNT in this work refers to MWCNTs. Carbon nanotube reinforced metal matrix (MM-CNT) composites are prepared through a variety of processing techniques.

1.1 OBJECTIVES

1. Preparation of testing samples to check machinabilty of the composites.
2. To evaluate mechanical properties by conducting tensile and hardness tests.
3. To find out thermal and electrical properties of composites by conducting conductivity tests.
4. Process the NDT tests to check out the internal flaws in bonding and structural formations.

1.2 Samples taken for testing of composites

Sample 1: Al SIC +Fly ash + Husk

Sample 2: Al Sic + Fly ash *+ TiB2*

Sample 3: Al 6061 + Fly ash+ Husk

2.0 Literature review

Aluminium-CNT composites Kuzumaki et al.57 were the first researchers to show a 100% increase in the tensile strength with 10 vol.-% CNT addition. Researchers have tried to incorporate 1– 65 vol.-%CNTs into a free standing Al-CNT composite structure by the powder metallurgy route accompanied by SPS60 and/or hot deformation. A maximum of 129% increase in the tensile strength has been reported with the addition of 5 vol.-%CNT addition.60 On the contrary, Salas et al.145 have reported deterioration in hardness in a shock-wave-consolidated Al- 5 vol.-%CNT composite. Agglomeration of CNTs in the matrix and weak interface bonding led to deterioration in the properties. Carbon nanotube reinforcement to composite coatings prepared by Laha et al.86,87,161 using thermal spraying methods, have been shown to improve the hardness by 72%, elastic modulus by 78%, marginal improvement in tensile strength and 46% decrease in ductility with 10 wt-%CNT content. Sintering (673 K, 72 h) of the sprayed coating has been reported to further increase the elastic modulus of the composite coating by 80%, which has been attributed to reduction in porosity and to residual stress.95 Al-12 vol.-%CNT composite produced by plasma spray processing shows 40% increase in elastic modulus and CNT addition has been reported to increase the elastic recovery of the composite.89 Carbon nanotube reinforced Al composite fabricated by cold spraying has been shown to behave heterogeneously with respect to mechanical properties, and no quantification on enhancement of the strength has been provided as a result of CNT addition.90 Noguchi et al.158 have reported a 350% increase in the compressive yield strength with 16 vol.-%CNT addition, which, is due to a very homogeneous distribution of CNTs obtained by the nano-scale dispersion method. He et al.27 have also emphasised homogeneous distribution and good interfacial bonding of CNTs growing them directly on Al powder through the CVD method before compacting and sintering them. They also have achieved 333% increase in hardness and 184% increase in tensile strength with 65 vol.-%CNT addition. Hence, it is clear that homogeneous distribution of CNTs and strong bonding with the matrix are the main means to control the mechanical properties of the MM-CNT composites.

3. METHODOLOGY

Preparation of samples

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Observation of machinability

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Test samples preparation by using CNC machining

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Tensile Test & BHN

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X-ray Radiography& conductivity tests

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Results and Discussions

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Conclusions

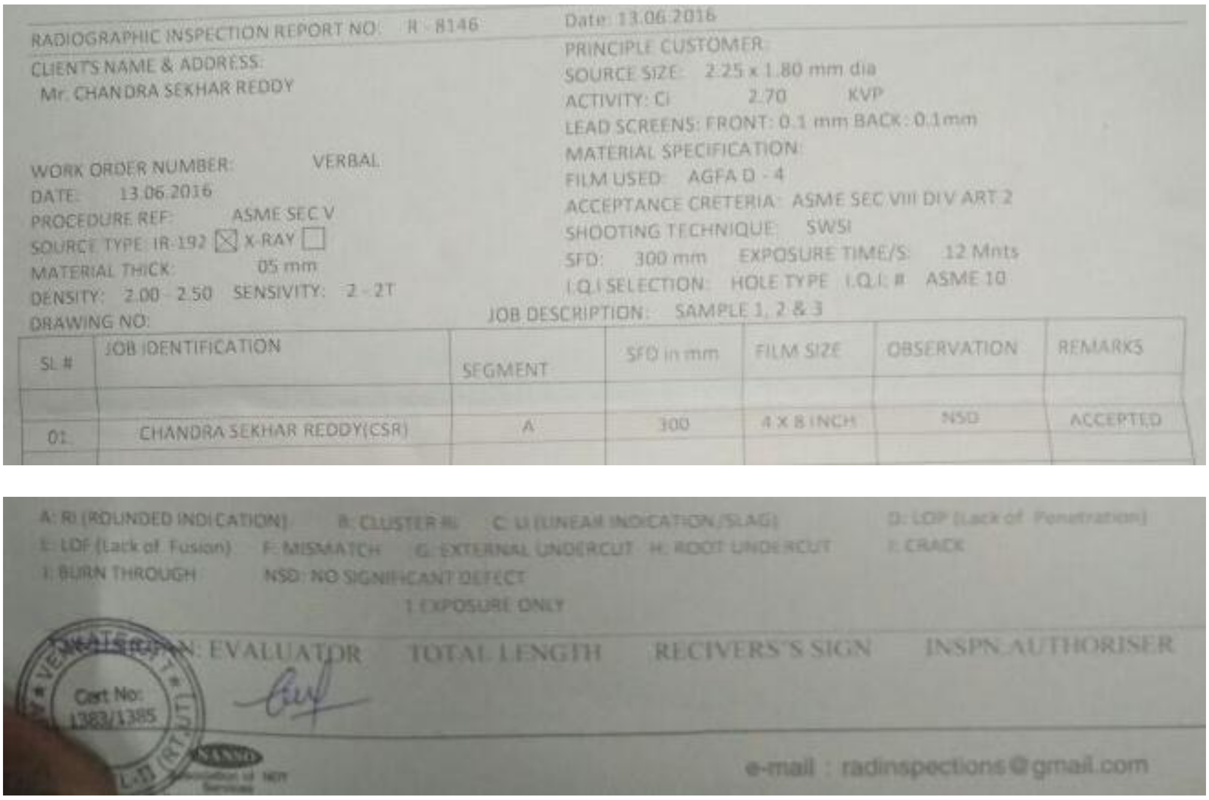
NDT & Tensile samples

Following figures shows testing sample preparation

Machinability Observations

By checking the machining samples it is observed that machining done very smoothly and there is no blow holes find in the casting samples. By checking threaded portion we can find the bonding ability of atoms while casting is done becuse of constant stirrer speed .

5. Results



RADIOGRAPHIC INSPECTION REPORT NO: R - 8146
Date: 13.06.2016
CLIENTS NAME & ADDRESS:
Mr. CHANDRA SEKHAR REDDY
PRINCIPLE CUSTOMER:
SOURCE SIZE: 2.25 x 1.80 mm dia
ACTIVITY: Ci 2.70 KVP
LEAD SCREENS: FRONT: 0.1 mm BACK: 0.1mm
MATERIAL SPECIFICATION:
WORK ORDER NUMBER: VERBAL
FILM USED: AGFA D - 4
DATE: 13.06.2016
ACCEPTANCE CRETERIA: ASME SEC VIII DIV ART 2
PROCEDURE REF: ASME SEC V
SHOOTING TECHNIQUE: SWSI
SOURCE TYPE: IR-192 ☒ X-RAY ☐
SFD: 300 mm EXPOSURE TIME/S: 12 Mnts
MATERIAL THICK: 05 mm
I.Q.I SELECTION: HOLE TYPE I.Q.I. # ASME 10
DENSITY: 2.00 - 2.50 SENSIVITY: 2 - 2T
DRAWING NO:
JOB DESCRIPTION: SAMPLE 1, 2 & 3

SL #	JOB IDENTIFICATION	SEGMENT	SFD in mm	FILM SIZE	OBSERVATION	REMARKS
01	CHANDRA SEKHAR REDDY(CSR)	A	300	4 X 8 INCH	NSD	ACCEPTED

A: RI (ROUNDED INDICATION) B: CLUSTER RI C: LI (LINEAR INDICATION/SLAG) D: LOP (Lack of Penetration)
E: LOF (Lack of Fusion) F: MISMATCH G: EXTERNAL UNDERCUT H: ROOT UNDERCUT I: CRACK
J: BURN THROUGH NSD: NO SIGNIFICANT DEFECT
1 EXPOSURE ONLY

TECHNICIAN: EVALUATOR TOTAL LENGTH RECIVERS'S SIGN INSPN.AUTHORISER

Cert No: 1383/1385

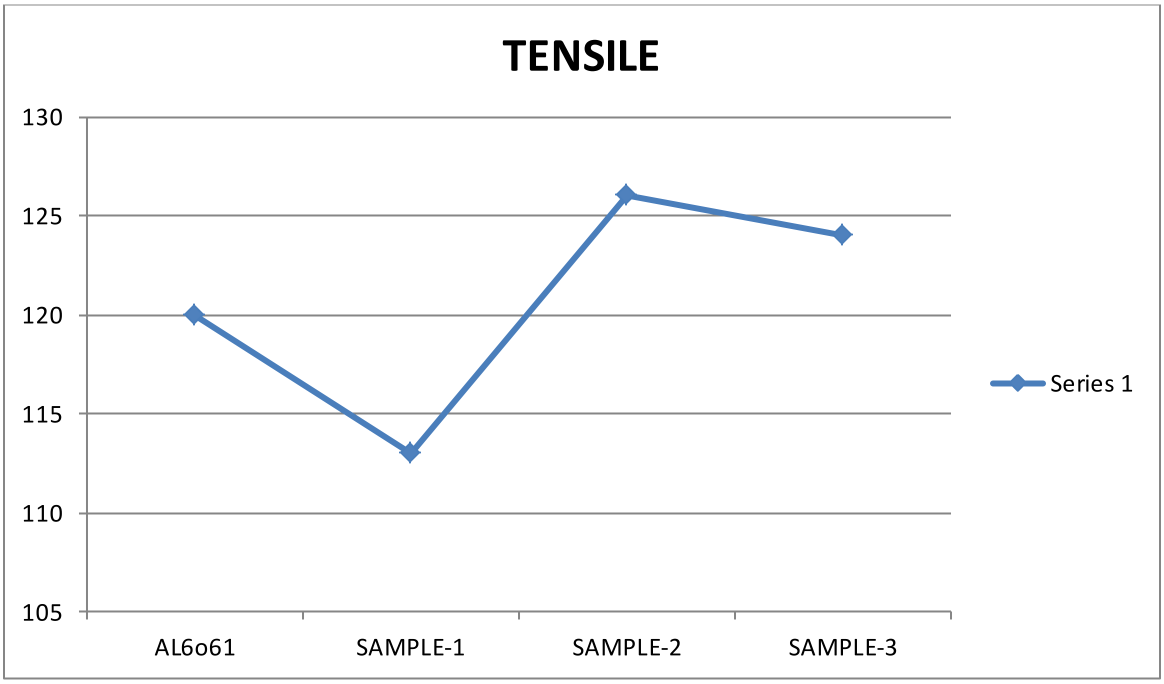
e-mail : radinspections@gmail.com

Fig shows test certificate of NDT

TENSILE TEST:

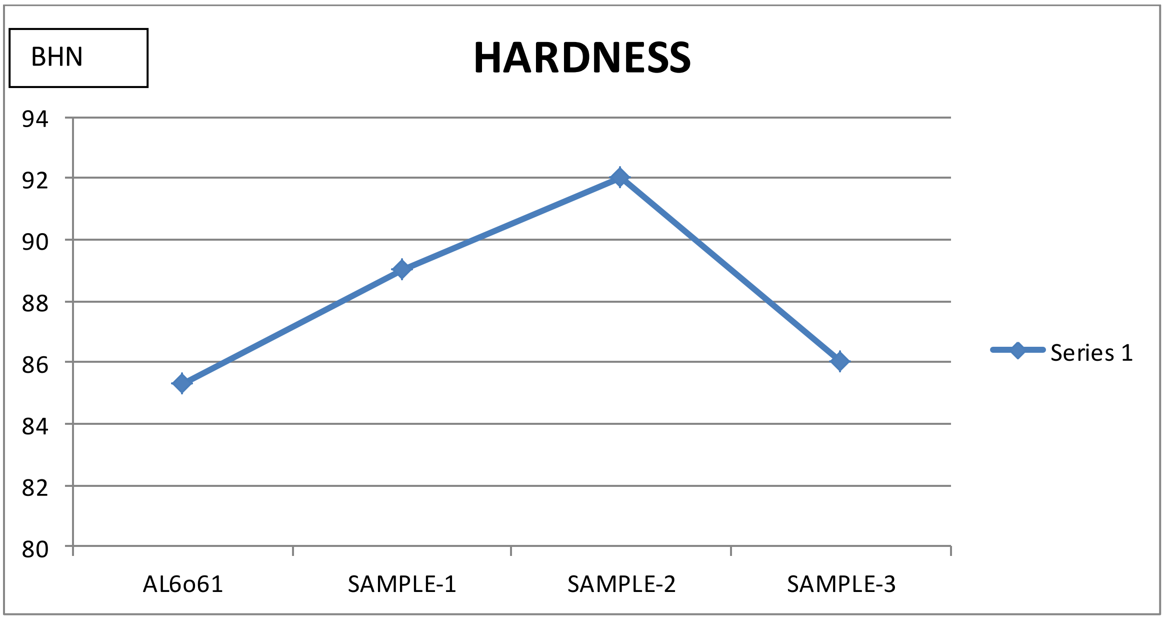
S.No	Sample Designations	U.T.S (Mpa)
1	ALSIC	120
2	Sample 1	113
3	Sample 2	126
4	Sample 3	124

Above is tensile test report be half of our testing specimens.

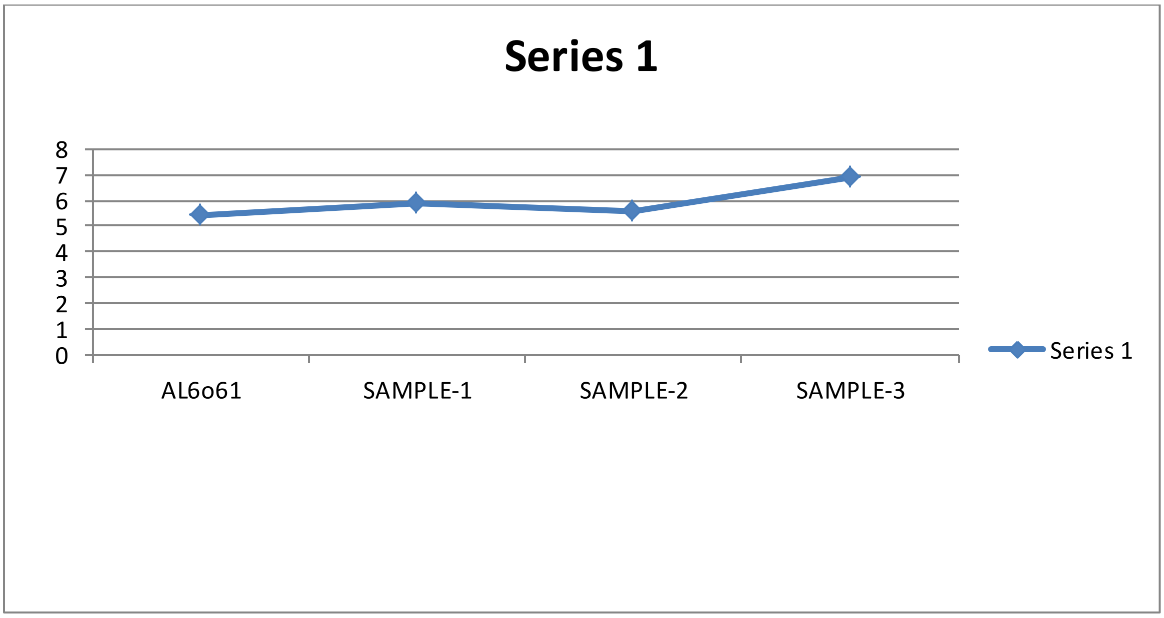


HARDNESS TEST (BHN)

S.No	Sample Designations	HARDNESS BHN	U.T.S (Mpa)	% Elongation
1	ALSIC	85.3	162.2	5.42
2	Sample 1	89.0	170	5.92
3	Sample 2	92.0	164	5.57
4	Sample 3	86.0	158	6.87



% Elongation



THERMAL EXPANSION:

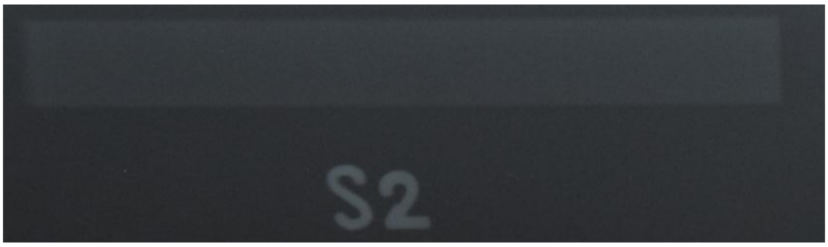
S.No	Sample Designations	Temperatures 30-100 ^0C	30-150 ^0C	30-200 ^0C
1	Sample 1	8.00 σ=0.26/ ^0C	8.37 σ=0.26/ ^0C	8.75 σ=0.27/ ^0C
2	Sample 2	9.77 σ=0.26/ ^0C	10.16 σ=0.26/ ^0C	10.56 σ=0.25/ ^0C
3	Sample 3	10.9 σ=0.25/ ^0C	11.20 σ=0.25/ ^0C	11.7σ=0.25/ ^0C

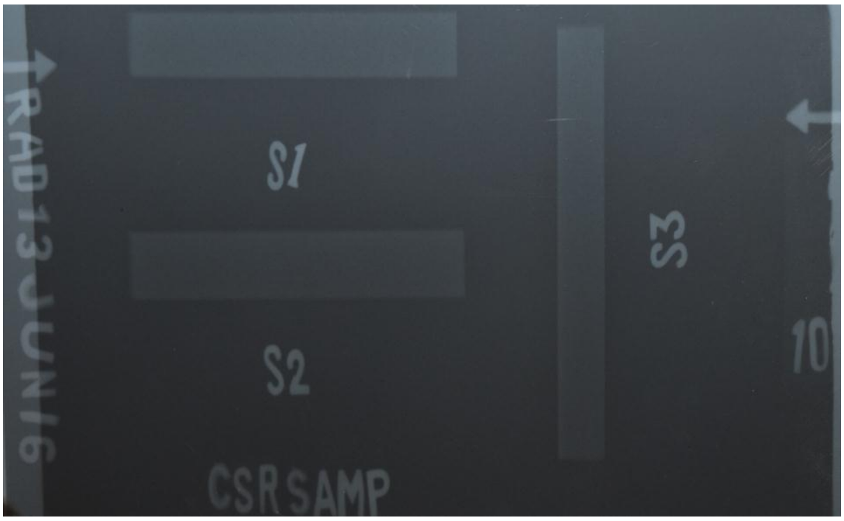
Electrical resistance

S.No	Sample Designations	Electrical resistance(Ω/cm)	
1	ALSIC	3.9e-6	
2	Sample 1	3.94e-6	
3	Sample 2	3.99e-6	
4	Sample 3	3.96e-6	

RADIOGRAPHY TEST RESULTS

X-radiography (sometimes abbreviated XR) is the most commonly used radiographic NDT method. In it, x-rays are used to take a shadowgraph image of the sample, and shades in the shadowgraph show the attenuation to the signal while it has passed through the corresponding spot in the sample. Traditionally films have been used to obtain the shadowgraphs in x-radiography, but use of films wouldn't allow on-line testing. Nowadays x-ray detectors that instantly output the image to computer, making even live viewing possible, are used.





Discussions

The casted samples are analysed to different tests to find out properties of the matrix material,

Sample 1&3 shows almost similar properties while sample 2 which mixed with a less % of TiB2 given better results than any other samples after fabrication. Thermal expansion and electrical resistivity also good for sample 2 when compared to another.

6.0 Conclusions

By observing the above results mechanical properties of the sample materials are quite good enough than other materials available, the distribution of fly ash particles are too good in casting samples obtained and there is no defects found in NDT tests . The entire practical process carried out by visual observation and the work output gives an scope of composites using in NANO tubes.

7.0 REFERENCES

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