International Journal of scientific research and management (IJSRM)
||Volume||3||Issue||11||Pages|| 3769-3774||2015||
Website: www.ijsrm.in ISSN (e): 2321-3418

Influence of Multiwall Carbon Nanotubes on Shearstrength of Single Lap Joint

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Abstract:
This paper presents a comparison between strength of adhesively bonded single lap joint with and without addition of Multiwall Carbon Nanotubes(MWCNT) in adhesive. Shear strength analysis of adhesively bonded single lap joint is done applying pulling load which produces shear stress at overlap between two substrates which joined together by using adhesive. Al-Al substrates were used and as per ASTM standard single lap joints are prepared. Various specimens were prepared by changing overlap and thickness of substrates. Four tests were carried out for each specimen with change in overlap and thickness of Al-Al substrates with and without addition of MWCNT in adhesive. Araldite AW 106, Hardener HV 953 used as adhesive,it has various properties and used as per their data sheet and processing given by respective company.

The result of the comparative strength analysis of adhesively bonded single lap joint is presented and on the basis of experimental observation it is clear that MWCNT filled epoxy resin gives higher bonding strength than unfilled epoxy resin bonded substrates.

Keywords: single lap joint, shear strength, mwcnt

INTRODUCTION

Adhesive lap joints are widely used in aerospace industries due to their improved mechanical properties and better interface strength. Various adhesives can be used such as araldite, locktite, etc to prepare adhesive lap joint as per application and properties of adhesive and working condition.

Adhesive joints can have many types, the most common being the single lap, the double lap, the scarf and the stepped lap joints. Because of its ease of manufacture, the single lap joint (SLJ) has been used in many applications.

Due to exceptional mechanical properties of carbon nanotubes (CNTs) they are used as reinforcing nanofillers in composite materials. The results indicate enhancement of mechanical properties through selective use of CNT and processing conditions. The accuracy of the results of strength tests of adhesive bonds will depend on the conditions underwhich the bonding process is carried out. The bonding conditions shall be prescribed by the manufacturer of the adhesive.

V. K.Shrivastva [1] done the study on the basis of experimental observations, it is clear that MWCNT (Multiwall carbon nanotubes) filled epoxy resin adhesive gives higher bonding strength of substrates of carbon/carbon (C/C) and carbon/carbon–silicon carbide (C/C–SiC) composites substrates than the unfilled epoxy resin bonded substrates. The MWCNT could also resist the crack bridging and barrier of crack propagation path. However, adhesive bonded strength of C/C–SiC composite substrates has a higher value than that of the C/C

DOI: 10.18535/ijsrm/v3i11.19

composite substrates, because of strong interface bond strength in between MWCNT filled epoxy resin and C/C–SiC composites.

S. A. Meguid and Y. Sun [2] focused attention on the determination of the influence of the homogeneous dispersion of nanofillers in a special epoxy adhesive for the purpose of increasing its interfacial strength and properties. Two different types of nanofillers were used; namely, carbon nanotubes and alumina nanopowder. The work concentrated on the experimental determination of the tensile and shears properties of the nano-reinforced interface. The results reveal that at a given weight (volume) percent, the presence of nanoparticles plays a major role in determining the strength of the interface. Experimental results also show that there is a limit to the number of dispersed nanofillers beyond which a drop in the properties is observed.

Florian H. Gojny, Malte H.G. Wichmann, Bodo Fiedler, Karl Schulte [3] conclude that Small amounts of carbon nanotubes in epoxies lead to increased mechanical properties. The most significant improvements of strength (+10%), stiffness (+15%) and especially fracture toughness (+43%) were attained with amino-functionalised DWCNTs at 0.5 wt% filler content under the given processing conditions also carbon nanotubes enable the development of a new generation of materials with multi-functional properties, such as a combination interesting physical properties together with improved mechanical performance. CNTs are a valuable chemical additive for the modification of epoxies and other polymers.

Al-Al substrates with and without addition of MWCNT in adhesive is prepared as per ASTM standard and strength analysis of single lap joint is carried out on universal testing machine.

EXPERIMENTS

2.1 Substrate material

Aluminum copper alloy substrate is selected to prepare substrate used for lap joint. Araldite AW 106, Hardener HV 953 is used as epoxy resin. Aluminum alloy 5251 is a medium strength alloy possessing good ductility and therefore good formability. Aluminum alloy 5251 is known for work hardening rapidly and is readily weldable

Table1: Typical mechanical properties for aluminum alloy 5251

Temper	*H22*	*H24*	*H26*	*0*
Proof Stress 0.2% (MPa)	165	190	215	80
Tensile Strength (MPa)	210	230	255	180
Shear Strength (MPa)	125	135	145	115
Elongation A5 (%)	14	13	9	26

Table 2: Typical physical properties for aluminum alloy 5251

Property	**Value**
Density	2.69 g/cm3
Melting Point	625°C
Modulus of Elasticity	70 GA
Electrical Resistivity	0.044x10-6 Ω.m
Thermal Conductivity	134 W/m.K
Thermal Expansion	25x10-6 /K

2.2 Adhesive material

Araldite AW 106, Hardener HV 953 is used as epoxy resin. Araldite AW 106 resin/Hardener HV 953U epoxy adhesive is a multi-purpose viscous material that is suitable for bonding a variety of materials like metal, ceramic, and wood etc.

Araldite AW 106 resin/Hardener HV 953U epoxy adhesive cures at temperatures from 68ºF (20ºC) to 356ºF (180ºC) with no release of volatile constituents.

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Table 2: Typical physical properties of Araldite AW 106

Property	Araldite AW 106
Density	0.95 g/cm3 at 25 °C
Viscosity	77°F (25°C) is 35000 (centiPoise)
PH value	12 at (20 °C)1:1 in water
Curing Temperature	From 20^0C to 180^0C

Multi-walled nanotubes (MWCNTs) consist of multiple rolled layers (concentric tubes) of graphene. The interlayer distance in multi-walled nanotubes is close to the distance between graphene layers in graphite, approximately 3.4 Å.For this testing MWCNT used with specifications:

Carbon purity: min.95%.

Number of walls: 3-15

Outer diameter: 5-20 nm;

Inner diameter: 2-6 nm;

Length: 1-10 um;

Apparent density: 0.15-0.35 g/cm3

Loose agglomerate size: 0.1-3mm

Single lap joint is prepared as per ASTM standard in which first substrates of aluminum were cut into size 101.6 X 25.4 X 3,Before bonding process Al substrate were properly cleaned with acetone and then dried for some time, Araldite AW 106 (50%) and Hardener HV 953 (50%) by weight were used as epoxy resin, Now this mixture is used as adhesive glue to join two Al substrate together with 10 mm overlap area. Overlap area is common area between two substrate where adhesive is applied. MWCNTs 3% by weight were added in araldite by sonication process. To prepare nanocomoposite with epoxy resin,CNTs were ultrasonicated for 1 hour in ethanol (0.1mg/ml) and then for another hour after the addition of epoxy. The ethanol was then removed by heating the mixture to 70 ^{0}C while stirring followed by evaporation under high vaccum at 50 ^{0}C for 24 hour. The above epoxy resin is applied on the surface of Al substrate with uniform layer of 1 mm. After the joining the substrate constant load of 5 kg is applied with the use of C clamp then curing is done in oven for 24 hours at 210°c. After 24 hour the oven shutoff and substrate removed after 2 hours from oven .We have done same process for 4 specimens with and without adding MWCNTs in epoxy resin with 10 mm overlap.

2.3 Lap joint testing without reinforcement of MWCNTs in epoxy resin

For this project work, the computer interfaced universal testing machine of 1000 KN capacity is used for shear testing. For shear testing single lap joint samples prepared without reinforcing multiwall carbon nanotubes in epoxy resin. In this testing Universal Testing machine shows results load Vs displacement, load Vs time, displacement Vs time etc

Shear strength testing results are as follows

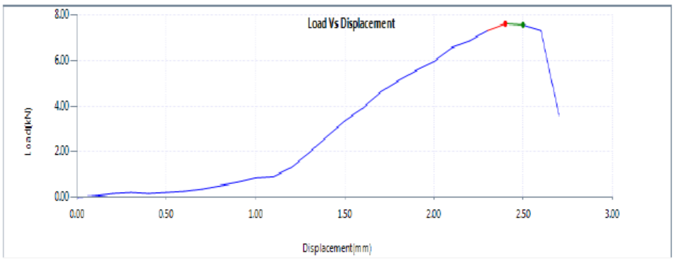

Fig-1: Load Vs Displacement for Single lap joint Specimen-1 with 10 mm overlap at joint.

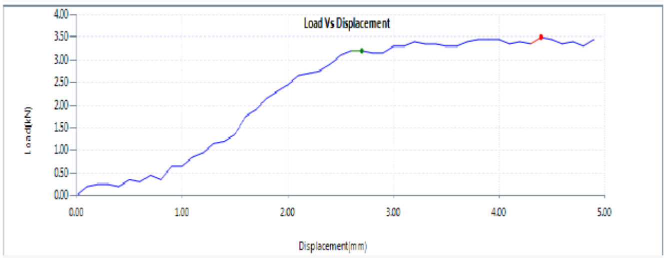

Fig-2: Load Vs Displacement for Single lap joint Specimen-2 with 10 mm overlap at joint.

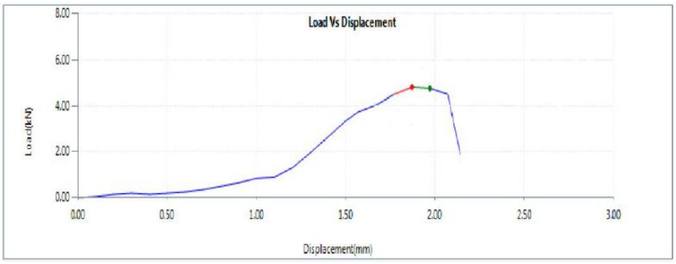

Fig-3: Load Vs Displacement for Single lap joint Specimen-3 with 10 mm overlap at joint.

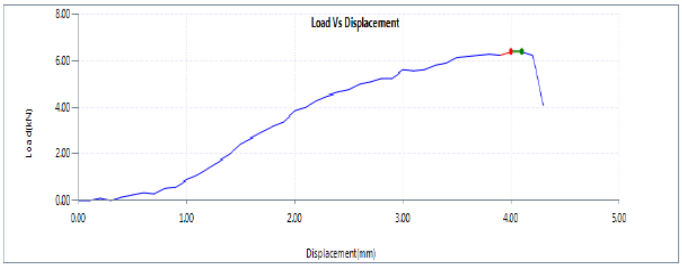

Fig-4: Load Vs Displacement for Single lap joint Specimen-4 with 10 mm overlap at joint.

Shear strength (Ʈ) is calculated by formula,

Ʈ = P/ (w X l)

Where:

Ʈ-Shearstrength (N/mm2)
P -Force applied (N)
w- Width of strap (mm)
l-Overlap length (mm)

Table 1: Shear strength of single lap joint with 10 mm overlap

Overlap (l) (mm)	Thickness (mm)	Width (w) (mm)	Max. Force (P) in (N)	Shear strength (Ʈ) N/mm 2	Average value of shear strength of 4 specimens (N/mm 2)
10	5	25.4	7600	29.92	22.14
10	5	25.4	3600	14.17	
10	3	25.4	4900	19.29	
10	3	25.4	6400	25.19	

With 10 mm overlap average value of shear strength obtained is 22.14 N/mm2.

2.4 Lap joint testing with reinforcement of MWCNTs in epoxy resin.

Single lap joint samples prepared with adding 3% MWCNTs in epoxy resin and shear testing is carried out, results are as follows.

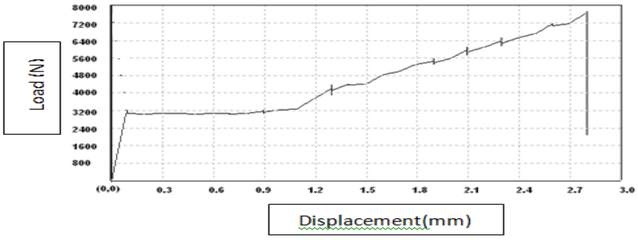

Fig-5: Load Vs Displacement for Single lap joint Specimen-1 with 10 mm overlap and MWCNTs in epoxy resin 7.6

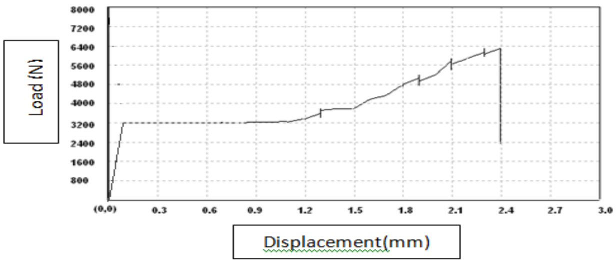

Fig-6: Load Vs Displacement for Single lap joint Specimen-2 with 10 mm overlap and MWCNTs in epoxy resin.6.3

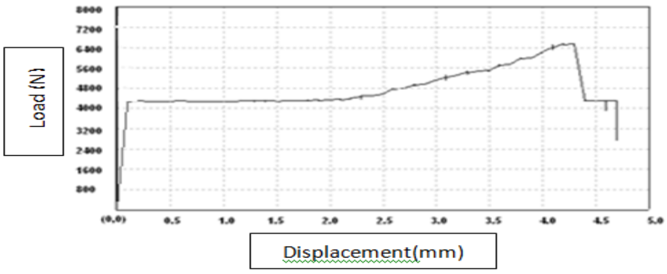

Fig-7: Load Vs Displacement for Single lap joint Specimen-3 with 10 mm overlap and MWCNTs in epoxy resin.6.6

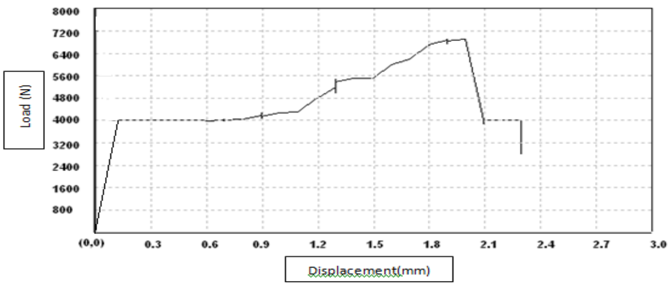

Fig-8: Load Vs Displacement for Single lap joint Specimen-4 with 10 mm overlap and MWCNTs in epoxy resin.

Table 2: Shear strength of single lap joint with 10 mm overlap and MWCNTs in epoxy resin

Overlap (l) (mm)	**Thickness (mm)**	**Width(w) (mm)**	**Max. Force (P) in (N)**	**Shear strength (Ƭ) N/mm2**	**Average value shear strength of 4 specimens (N/mm2)**
10	5	25.4	7600	29.92	26.86
10	5	25.4	6300	24.80	
10	3	25.4	6600	25.98	
10	3	25.4	6800	26.77	

Average value of shear strength obtained is 26.86 N/mm2

RESULT AND DISCUSSION

From table no 1and 2 it can be seen that average value of shear strength is obtained by taking average of four samples of lap joints. MWCNTs filled epoxy resin has 17.57% more strength as compared to MWCNTs unfilled epoxy resin.

It is clear that MWCNT filler particles improve bonding strength of araldite but the accuracy of the results of strength tests of adhesive bonds will depend on the conditions underwhich the bonding process is carried out. The lap shear strength is practically independent of the substrate thickness as strength obtained for 3 mm thickness is almost same for shear strength obtained for 5 mm.

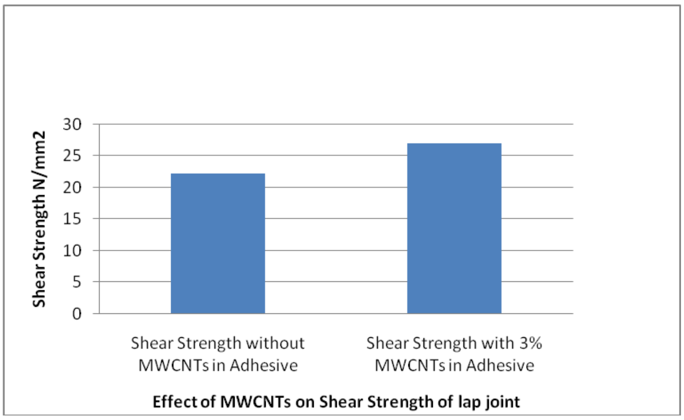

Chart-1: Graph of shear strength Vs %MWCNTs in adhesive

CONCLUSION

The results indicate that the adhesive joint strength increased with the use of MWCNT filler. MWCNTs filled epoxy resin has 17.57% more strength as compared to MWCNTs unfilled epoxy resin. It is clearly indicated that the MWCNT filled epoxy resin adhesive bonded substrates give higher bonding strength than the epoxy resin without MWCNT. Bonding strength can be varying from 9 to 18% depends upon conditions underwhich the bonding process is carried out. The lap shear strength is practically independent of the strap thickness

References

1. V.K. Srivastava, "Effect of carbon nanotubes on the strength of adhesive lap joints of C/C and C/C–SiC ceramic fiber composites" ,Department of Mechanical Engineering, Indian Institute of Technology, BHU, Varanasi 221005,India,2011,pp 486-489.
2. S.A. Meguid,Y.Sun "On the tensile and shear strength of nano-reinforced Composite interfaces" Engineering Mechanics and Design Laboratory, Department of Mechanical and Industrial Engineering,University of Toronto,5 Kings College Road, Toronto, Ont., Canada M5S 3 G8,Received 9 June 2003; accepted 29 October 2003,pp 289-286
3. Florian H. Gojny 1, Malte H.G. Wichmann, Bodo Fiedler, Karl Schulte "Influence of different carbon nanotubes on the mechanical properties of epoxy matrix composites – A comparative study" ,Technical University Hamburg-Harburg, Polymer Composites Section, Denickestrasse 15, 21073 Hamburg, Germany Received 14 February 2005; received in revised form 14 April 2005; accepted 20 April 2005 Available online 16 June 2005,pp 2300-2313.

DOI: 10.18535/ijsrm/v3i11.19

4. Ashcroft, D.J. Hughes, S.J. Shaw, (2000) "Adhesive bonding of fibre reinforced polymer composite materials", Assembly Automation, Vol. 20 Iss: 2, pp.150 – 161
5. L. F. M. da Silva and R. D. Adams, J."Adhesion Sci.Technology", 29, 109 (2005).
6. K. L. DeVries and P. R. Borgmeier "Testing of adhesive", 5, 40 (2003)

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