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MECHANICAL PROPERTIES OF CFRP COMPOSITE WITH CARBON NANO FIBER INCLUSION

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Abstract

Conventional carbon fiber reinforced epoxy resins are widely used to prepare carbon/carbon composites due to their high strength. Property enhancement of carbon fabric/epoxy composites is possible through carbon nano fiber dispersion in the matrix. The effect of carbon nanofiber dispersion in epoxy resins/carbon fabri composites was investigated. The dispersion efficiency in different systems and conditions was studied and the effect of carbon nanofiber concentration on the properties determined. Carbon nano material incorporation influences the mechanical properties of the composites.

Keywords: carbon nanofiber, flexural testing

, glass fiber, Polymer composite

1. Introduction

Epoxy resin is extensively used for fabric reinforced carbon-carbon composite due to its highest yield of carbon after carbonizing. Carbon fiber finds use in both filament and fabric form as reinforcement in polymeric matrices for high performance structural applications [1]. Textile structured composites plays an important role in preparation of carbon-carbon composites [2] and exhibit in plane balanced properties. Consequently they find uses in many high-end applications where their special properties can be taken advantage of e.g. spacecraft re–entry frames. Carbon nano tubes have been successfully used to improve the wear resistance properties of carbon-carbon composites [3]. The use of carbon nano tubes in epoxy matrix also results in significant rise in dynamic mechanical properties [4]. In this work, efforts have been made to fabricate carbon fiber reinforced composites with carbon nanofiber inclusion with carbon fiber reinforced composite in epoxy combinations to identify flexural strength of the composite.

2. Experimental work

2.1.1 Raw material used

- Carbon nanofiber – Pyrograf II (PR-25 -XT) (DIA. 125 – 150nm).
- Carbon fabric 195 gm/m2
- Araldite standard epoxy resin CY 230-1 (HUNTSMAN).
- Aradur HY 951(Hardner)

Dispersion of carbon nanofiber

0.1% carbon nanofiber (on weight of resin) was dispersed into the resin through two different processes,

- Magnetic stirring for 2 hrs.
- Ultra-sonication of 20 KHz for 1 hr.

2.1.2 Fabrication of carbon fabric/carbon nano fiber Coupons:

The CNF inclusion with carbon fabric four layer laminate coupons and another set was carbon fabric four layer laminate was fabricated by using a hand-lay-up method. The thickness of the plate is 2 mm with each layer of a thickness of 0.55 mm. The laminate was fabricated using CY 230-1 epoxy with hardener HY951. Coupon with the dimension 80, 25, and 2 mm, length, width and thickness respectively were fabricated without any edge damage. The ASTM D790 coupons are shown in figures 1 (a) & (b).

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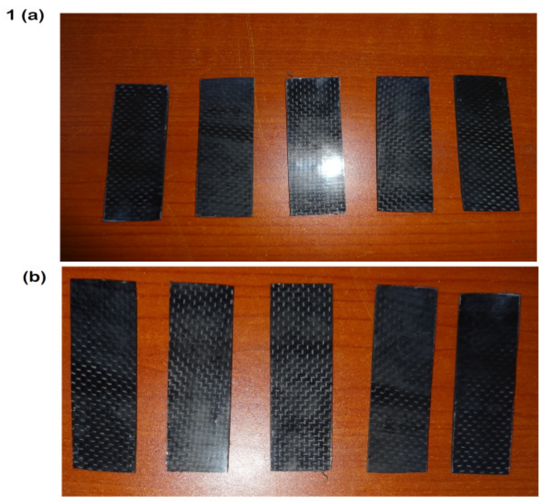


Figure 1(a) CNF inclusion with carbon fabric reinforced coupons (b) carbon fabric reinforced coupons.

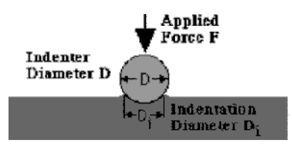
2.1.4. Flexural Testing

The flexural coupons obtained from the CNF inclusion carbon fabric reinforced coupons and another set carbon fabric reinforced coupons are subjected to the Point load was applied using a DAK 10-ton universal testing machine (UTM). Ten coupons were tested. The spans were 60 mm and the support length is 10 mm each side. The feed rate was 5 mm/min maintained throughout the testing. The test coupons were loaded with a three point bending test as per ASTM D790. The load was gradually applied in the middle of the coupon. The load was applied until the coupon failure and was repeated for all coupons as shown in figure 2.

Figure 2. Flexural Test Setup

2.1.5. The brinell hardness test

The Brinell hardness test method consists of indenting the test material with a tungsten carbide ball of either 1, 2.5, 5 or 10 mm diameter by applying a test force of between 1 and 3000 kgf. The full load is normally applied for 10 to 15 seconds in the case of iron and steel and for at least 30 seconds in the case of other metals. The diameter of the indentation left in the test material is measured. The Brinell harness number is calculated by dividing the load applied by the surface area of the indentation as shown in figure 3.



$$BHN = \frac{F}{\frac{\pi}{2} D \cdot \left(D - \sqrt{D^2 - D_i^2}\right)}$$

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Figure 3. Shows the Brinell Harness setup

3 . RESULT AND DISCUSSION

3.1 Analysis of data in brinell hardness test:

3.1.1 Observation:

Load applied (p) = 500 kg

Diameter of indenter (D) = 10mm

$$BHN = \frac{F}{\frac{\pi}{2} D \cdot (D - \sqrt{D^2 - D_i^2})}$$

Where

P=applied force (kgf)

D=diameter of indenter (mm)

d=diameter of indention (mm)

3.1.2 Hardness for CFRP

Hardness value for carbon fiber reinforced and CFRP/CNF reinforced composite as shown in table 1&2.

Table 1. Hardness for CFRP

SI. NO	Material used	Diameter of indention (d)(mm)	Brinell Hardness Number (BHN)
1	CFRP	6	15.92
2	CFRP	6	15.92
3	CFRP	5.9	16.52

Table 2. Hardness for CFRP WITH CNF inclusion

SI. NO	Material used	Diameter of indention (d)(mm)	Brinell Hardness Number (BHN)
1	CFRP /CNF	5	23.77
2	CFRP /CNF	4.8	25.94
3	CFRP / CNF	5	23.77

3.2 Comparison of hardness test

Average hardness value for carbon fiber reinforced polymer using brinell hardness test is 16.12 BHN. Average hardness test for carbon fiber reinforced polymer with carbon nano fiber inclusion using brinell hardness test is 24.49 BHN. So it is clearly identified that the hardness value of CFRP with CNF inclusion has increased 8% as shown in figure 4.

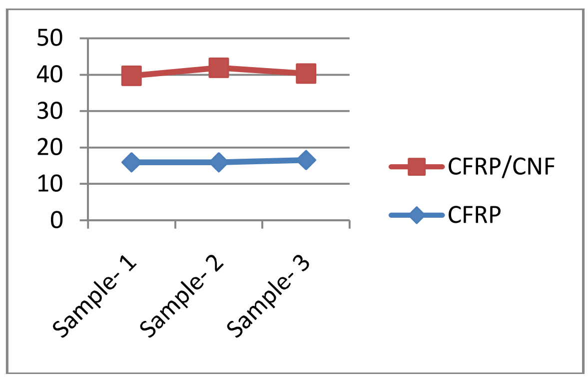

Figure 4. Brinell hardness value of CFRP and CFRP/CNF specimens

3.3 Flexural test:

Flexural value for carbon fiber reinforced and CFRP/CNF reinforced composite as shown in table 3&4.

Table 3. Load test for CFRP

Sl.No	CFRP	LOAD (kg)
1	Specimen 1	43.5
2	Specimen 2	44.9
3	Specimen 3	47.3
4	Specimen 4	44.8

5	Specimen 5	43.6

Table 4. Load test for CFRP with CNF inclusion

Sl.No	CFRP /CNF	LOAD (kg)
1	Specimen 1	56.6
2	Specimen 2	56.4
3	Specimen 3	53.5
4	Specimen 4	52.6
5	Specimen 5	54.2

3.4 Comparison flexural test

Average load bearing capacity for carbon fiber reinforced polymer using three point bending test is 44.82 kg. Average load bearing capacity for carbon fiber reinforced polymer with carbon nano fiber inclusion using three point bending test is 54.66 kg. So it is clearly identified that the load bearing capacity of CFRP with CNF inclusion has increased 10% as shown in figure 5.

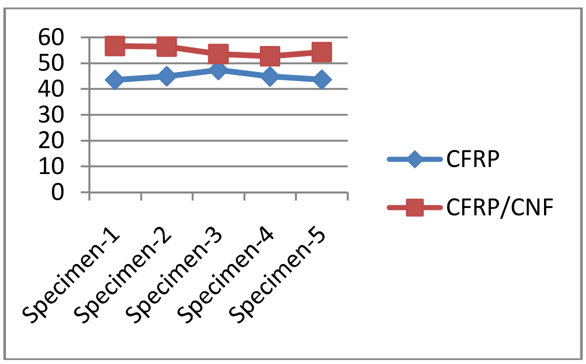

Figure 5. Flexural test value of CFRP and CFRP/CNF specimens

6. CONCLUSION:

The brinell hardness test and compression test proved that the inclusion of carbon fiber with carbon nanofiber has more strength than carbon fiber reinforced polymer in a composite materials. This project clearly shows the mechanical properties of the CFRP in composite materials due to the dispersion of nanofibers. The hardness value of CFRP with CNF inclusion has increased 8% when compared to the CFRP. The load bearing capacity value of CFRP with CNF inclusion has increased 10% when compared to the CFRP.

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