Evaluation of flexural properties of Carbon Nano Tubes (CNT) modified Carbon Fibre Reinforced Composite using Electrophoretic Deposition as the modification technique

Soubhik De*, Pavan Kumar Gangineni, Rajesh Kumar Prusty, Bankim Chandra Ray
FRP Composite Laboratory, Department of Metallurgical and Material Engineering,
National Institute of Technology, Rourkela-769008
*soubhikde2013@gmail.com

Abstract

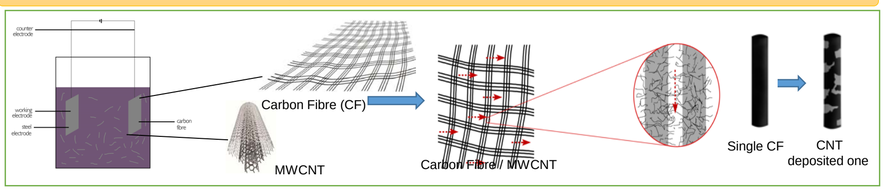
This work proposes to develop nanophased fibre reinforced polymer (FRP) composite using epoxy as matrix and modified carbon fibres as reinforcement. Carbon fibre modification has been achieved by Electrophoretic Deposition (EPD) of nanofillers on the surface of carbon fibre. This also involves stabilization of the EPD process by optimizing the sonication time (for making a suspension of nanofillers) and deposition current and deposition time. After EPD, the deposition of nano filler on the fibre is confirmed by a Scanning Electron Microscopy (SEM). The modified fibres thus obtained are used in laminate making with epoxy resin as matrix by using hand lay-up technique. Selection of the best nano filler-multiwalled carbon nanotube (MWCNT) is done with respect to the exhibited flexural strength of the composite. Laminates that were fabricated using MWCNT modified carbon fibres have shown an improvement of Flexural properties when compared to that of neat Carbon fibre reinforced polymer (CFRP) composites, Fragtography study was also done.

Introduction

- Carbon fibre reinforced polymer (CFRP) composites has been widely due to excellent stiffness, high strength to weight ratios, high impact strength, corrosion resistance, low maintenance, weather resistance, long-term durability, dimensional stability and low coefficient of thermal expansion
- Mechanical properties of CFRP composite is closely related to its interfacial bond strength of carbon fibre(CF) and matrix
- However, the interface performance related to the carbon fibre surface properties, the interface bonding of untreated carbon fibre has large specific surface inertia and resin is weak which affects the carbon fibre composite material's performance .
- Among various available routes surface modification with Carbon Nano Tubes has been proved to be one of the most promising route. Electrophoretic Deposition (EPD) is known to be one of the most promising manipulation techniques to produce large-scale reinforcement of nano-particles in composite applications, which have several advantages over other surface coating process, such as simple process, homogeneity of the deposited films and easy control of the deposited thickness

Key Words : Multiwalled Carbon nano tubes, Carbon Fibre Reinforced Composite, Electrophoretic Deposition, Mechanical properties.

Electrophoretic Deposition of MW-CNT on Carbon fibre



Applications

Results and Discussion

(A) Flexural behavior

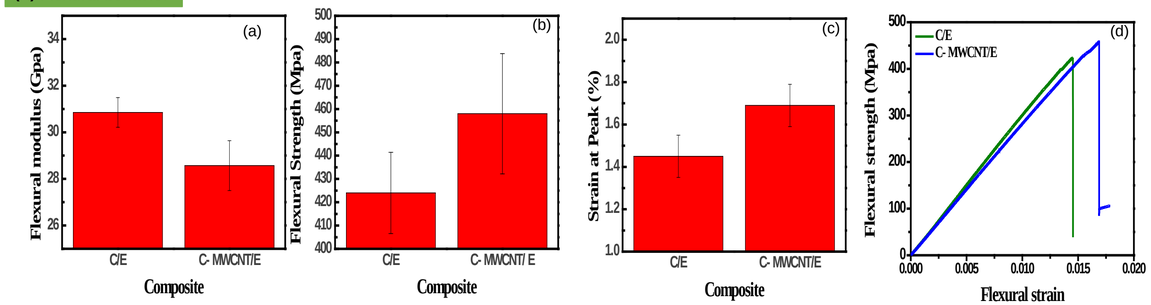


Fig.1. Flexural properties of CFRP composites modified with MWCNT(a) Flexural modulus (b) Flexural Strength (c) Strain at peak (d) Stress-Strain Curve

- Surface treatment of carbon fibre by EPD process enhance bonding between fibre and matrix by lowering contact angle.
- MWCNT nanofillers act as bridge material between fibre and matrix as result enhance interfacial properties.
- Incorporation of the nanofillers lowers the fracture strain as compare to carbon fibre epoxy composite.
- Flexural strength of the MWCNT modified carbon fibre reinforced polymer composite was observed 458 Mpa and for neat CFRP composite was found 424 Mpa

(B) Fractographic study:

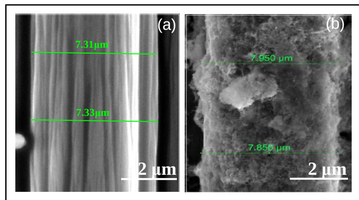


Figure. 2. SEM images showing diameter of (a) neat carbon fibre (b) MWCNT modified carbon fibre

- From the figure 2. (b) shows the uniform deposition of the nanofillers and can be confirmed by increase in diameter which in turn resulted good flexural strength.
- Diameter of modified CFRP composite was observed 7.9 µm and for neat CFRP was 7.32 µm

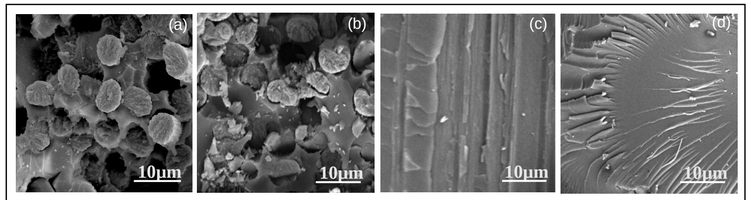


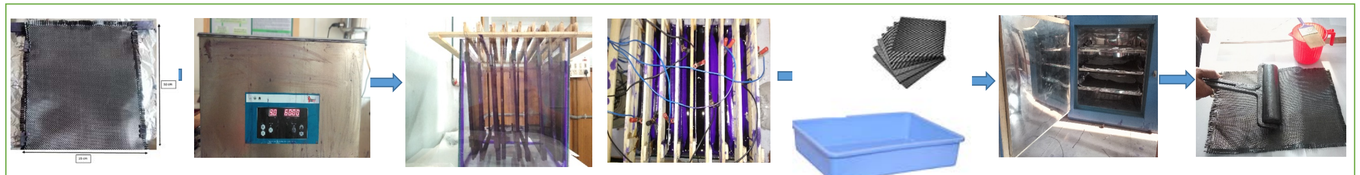
Figure.3. Modes of failure (a) fibre pull-out in neat CFRP (b) fibre pull-out in MWCNT- CFRP (c) matrix imprint in MWCNT- CFRP(d) deformed matrix in MWCNT- CFRP

- In case of MWCNT modified CFRP composite minimal fibre pull out observed (Figure. 3.b) due to good interfacial adhesion, thus provided good mechanical properties. But in case of neat CFRP composite poor adhesion at the fibre-matrix interface was observed reveals poor stress transfer across the interface.
- Figure.3. c and d shows matrix imprint and deformed matrix in MWCNT-CFRP composite as during fracture stress transfer from matrix to fibre.

Experimental procedure

Bidirectional Carbon fibres were desized at 120°C for 2 hours to remove the epoxy coating → Multiwalled carbon nano tube(MWCNT-Source- company) (1g/Litre) added in Distilled water) Sonication for 1 hour → Methyl Violet-2B (source-Sigma Aldrich company) (0.5g/Litre) is added in the suspension, again Sonication for 1 hour → EPD Process had been carried out for 40 minutes at a current of 5.7 Amperes on desized carbon fibre (CF) → Thermal annealing at 140°C for 2 hours of the CNT-deposited CFs for making the covalent bonding between the CNT and CFs. → Than CF was dipped in acetone to remove extra additive and weak physical adhesion bond, for 1 hour → The laminate obtained is cut to dimensions according to ASTM D7264 → The samples are tested in UTM Instron5967

Pictorial representation of the experimental procedure



Desized carbon fibre + MWCNT with methyl violet dispersed in distilled water in the ultrsonicator

Electrodeposition Set up

Cleaning with aceton for 2 hours

Thermal annealing of deposited fibres at 140 ^{0} C for 2 hours

Laminate fabrication by hand lay-up technique

Conclusion

1. Present investigation demonstrates EPD as a promising and successful processing technique for MW CNT based nanofillers modified carbon fibre /epoxy composites, for uniform deposition of the nanofillers a constant amount of current 5.7 ampere was determined , applied for 30 minutes.
2. SEM analysis confirmed uniform deposition of MWCNT on the carbon fibre with a sonication time for 60 minutes.
3. Deposition of the nano fillers on the carbon fibre resulted 8% increase in flexural strength.

Acknowledgement

The authors convey their sincere thanks to Indian Institute of metals and for providing an opportunity to present the aforementioned poster at the NMD ATM-2018, Kolkata and also NIT Rourkela for providing necessary financial and instrumental support to carry out this project work successfully.

References

1. R. K. Prusty, D. K. Rathore, and B. C. Ray, "CNT/polymer interface in polymeric composites and its sensitivity study at different environments", *Advances in Colloid and Interface Science,* vol. 240, pp. 77-106, 2017.
2. Caifeng Wang, Jun Li , Shaofan Sun , Xiaoyu Li , Feng Zhao a, Bo Jiang and Yudong Huang , "Electrophoretic deposition of graphene oxide on continuous carbon fibers for reinforcement of both tensile and interfacial strength", *Composites Science and Technology,* vol. 135, pp. 46-53, 2016
3. Sheng-Yun Huang, Gang-Ping Wu, Cheng-Meng Chen, Yu Yang, Shou-Chun Zhang and Chun-Xiang Lu, "Electrophoretic deposition and thermal annealing of a graphene oxide thin film on carbon fiber surfaces", *Carbon,* vol. 52, pp. 605-620, 2013.
4. B. J. C. Thomas, A. R. Boccaccini and M. S. P. Shaffer, "Multi-Walled Carbon Nanotube Coatings Using Electrophoretic Deposition (EPD)", *J. Am. Ceram. Soc.,* vol. 88, pp. 980-982, 2005 .

Theme Name : Advances in Material Science & Registration No. NMD-ATM-2018R-00653