Investigations of Compression and Impact Behaviour of Hemp - Graphene Composites

B Vijaya Ramnath, A Manivasagam, R Rohit, V Sudharsan and S Sheshathri

July 6, 2020

INVESTIGATIONS OF COMPRESSION AND IMPACT BEHAVIOUR OF HEMP - GRAPHENE COMPOSITES

B.Vijaya Ramnath[1],A.Manivasagam[2], R.Rohit[1],V.Sudharsan[1],S.Sheshathri[1]

[1]Department of Mechanical Engineering,

Sri Sairam Engineering College, West tambaram, Chennai-44.

[2] System engineer, Tata consultancy services, Chennai.

***Corresponding author mail ID: vijayaramnathb@gmail.com**

Abstract

In recent years, both academic and industrial world are focusing their attention toward the development of sustainable composites, reinforced with natural fibers. In this present work, the compression and impact behaviour of graphene reinforced with hemp fiber composites were investigated. Two different laminates of hemp fiber with graphene is prepared. The fiber is blended with epoxy resin of grade LY556 along with hardener HY 951 made through hand layup method for laminate formation with 2% graphene nano platelets. Results indicate that mechanical properties were enhanced due to the addition of graphene in natural composites. This environmentally friendly nano composite can be used for various commercial applications with partial load acting conditions.

Keywords: hemp fiber graphene handlay up process, compression test, impact test.

1.0 Introduction

Various researchers fabricated hybrid natural fiber composites and performed mechanical testing. They are summarised in ths section. Bastiurea et al (2015) studied behavior of polyester composite with graphene oxide/graphite in which they concluded that graphene oxide and graphite pickup a different effect on polyester composites.It can be noticed that both graphene and graphite have increased in glass transition temperature.Graphene oxide at small content does not have a significant influence on thermal degradation of polyester composites. SEM microscopy revealed the presence of graphene flakes, graphite particles and dispersion degree.

Vijaya Ramnath et al (2014) studied mechanical behaviour of hybrid composite (banana jute glass fiber) and compares it with single fiber composites .They fabricated composites using hand layup method. The tensile, flexural, impact, double shear and delamination tests were performed. They concluded that hybrid composite has better overall mechanical properties when compared to mono composites. Ilaria Cacciotti et al(2015) Investigated mechanical properties and equal sustainable improvement in production of composites usage in automobile and civil engineering. They have adopted the electrospinning technique to produce neat and graphne nanoplatelets loaded with natural fiber. Uniform and defect free structure is observed while distributing it randomly and aligned fibers mat were maintained. They concluded that by using techniques namely field emission-scanning electron microscopy (FEG-SEM), X-Ray diffraction(XRD) and infrared spectroscopy (FTIR-ATR) there was a strong orientation of polymer chains in case of aligned fibers when compared to randomly distributed fibers. Pathak et al (2016) investigated that, improvement in the mechanical properties of polymer composites with Graphene Oxide was observed in fiber/graphene oxide-epoxy hybrid composites. At first the modification of epoxy resin was carried out by changing the weight percentage of the Graphene Oxide .Then by compression moulding technique, modified epoxy and carbon fiber was linked to make a hybrid composites. The graphene oxide synthesized was characterized by various techniques such as FTIR, XPS, NMR, XRD and Raman Spectroscopy. They observed that, there was an better interaction of functional groups present in hybrid composites. Also, they concluded that increase in mechanical properties such as flexural strength, flexural modulus and interlaminar shear strength in hybrid composites. The enhancement in the properties of composites at the percolation threshold of graphene oxide is due to hydrogen type bonding and mechanical interlocking of graphene oxide with carbon fibers and epoxy resin.

Vijaya Ramnath et al (2015), investigated the effect of fiber twisting and the fiber orientation on the mechanical properties of fiber composites. Vacuum assisted compression moulding is used to fabricate the composite namely twisted neem and twisted kenaf. The result shows that there is a significant improvement in mechanical properties of composites due to the presence of twisted fibers.

Mechanical behaviour of Kevlar based hybrid composites was performed and concluded that hybrid composites shows better mechanical behaviour. [11,15]. Mechanical behaviour sisal, kenaf- flax, pine apple, jute- flax were studied and concluded that always hybrid composites shows better bahaviour since its has effect of two more reinforcement . [12,13,14,16]. Abaca based hybrid composite re fabricated and their mechanical behaviour are studied. It wa concluded that hybrid comsites shows better strength and also ave goothemal characteristics. [17-20]

2.0 Materials and methods

2.1 Hemp fiber

Hemp or industrial hemp typically found in the northern hemisphere, which is species that is grown specifically for the industrial uses of its derived products. Hemp fiber is extensively used in textile industry to manufacture dresses, fabrics, bags, and many more. Construction arena uses hemp to produce boards, thermal insulating materials, acoustic ceiling and concrete blocks. Automobile industry uses hemp as plastic interior in their car doors and in columns and also in glove box. Figure 1 shows hemp fiber.

Figure 1: Hemp fiber

2.2 Graphene

Graphene can be considered as an indefinitely large aromatic molecule of the family of flat polycyclic aromatic hydrocarbons. It is about 200 times stronger than the commercial steel. It efficiently conducts heat and electricity and is nearly transparent. Graphene shows a large and nonlinear diamagnetism, greater than graphite and can be levitated by neodymium magnets. Table 1 shows properties of Graphene.

Table 1 Graphene properties

Colour	Black Powder
Purity	>99%
Average Thickness(z)	2-4 nm
Average Lateral Dimension(X&Y):	5-10 μm
Number of Layers	2-3 layers
Surface Area	~ 350 m2/g

2.3 Epoxy and hardner

The raw materials for epoxy resin production are largely petroleum derived. Epoxy resins are polymeric materials that rarely exist as pure substances, since chain length results from the polymerization reaction that can be produced for certain applications, e.g. using a purification process. Also sodium hydroxide (NaOH) also known as lye and caustic soda is an inorganic compound used in this work to treat the hemp fibers. Epoxy resin is used to give great binding properties between the fiber layers to form the matrix. The Epoxy resin used at room temperature is LY 556. Hardener (HY 951) is employed to improve the interfacial adhesion and impart strength to the composite. A resin and hardener mixture of 10:1 is used to obtain optimum matrix composition

2.4 Retting and treating

Retting and water retting is a process which is generally applied to all natural fibers which is a process of removing and cleaning the fibers from its stem. Water retting is followed by Retting process in which retted fibers are allowed for curing after final cleaning. In this work, the fibers are treated with NaOH to improve its mechanical behaviours and also make fibers workable.The concentration of alkali solution that was used to treat the fibers in the range of 0.5% up to 28%, but most of the researchers used below 10% alkali solution. The temperature and soaking time to treat the natural fiber in the solution are in the range of 20-180°C and 15 minutes to 48 h period of time. Hemp fiber is treated with 5% NaOH solution (50 grams in 1 kg of water) and it is left to react with chemical to acquire more strength. The treated fiber which is left untouched for 24 hours are washed under tap water to remove the surfactants and taken to the process of drying. After treating the fibers they are allowed to dry under sunlight. Combing is a process which follows drying to separate fibers followed by sponning. So, in order to prepare quality fiber composite laminate all the above procedures must be carried out.

2.5 Handlayup Method

Handlayup is the most common and least expensive method in which reinforcements are placed by hand in a mould and resin is applied with a brush or roller. It offers low cost tooling, simple processing steps and a wide range of part sizes. It needs minimum investment in this equipment with skilled operators, good production and consistent quantity are available. In this process, initially releasing agent is applied to the mould using a spray gun to get good surface finish and also easy removal of the composite laminate from the die cavity. Later laminating resin is applied. The resin is mined with graphene of 3% and 5% along with hardener. Rollers and squeegees are used to consolidate the fibers, thoroughly wetting the reinforcement and removing entrapped air in the mold. Subsequent layers of hemp fiber and glass reinforcements are added to build laminate thickness in mould. Finally, the specimens are kept under load of 200 KN for proper binding and increasing bonding for 15 hours. Thus, the fiber gets into proper shape. Two different specimen plates are prepared namely.

2.6 Testing of composites

2.6.1 Compression Test

A compression test is a test in which a material experiences opposing forces that push inward upon the specimen from opposite sides. In this test, the test sample is generally placed in between two plates that distribute the applied load across the entire surface area of two opposite faces of the test sample and then the plates are pushed together by a universal test machine causing the sample to flatten. A compressed sample is usually shortened in the direction of the applied forces and expands in the later direction. The sample is prepared as per ASTM D-695.

2.6.2 Impact Test

.Impact test is used to find the strain energy that a material will and it is performed while the sample is placed in a holding fixture with the geometry and orientation as per ASTM:D5379 Standard as shown in figure 2.. The main purpose of this test is to find the ability of the material to absorb energy during a collision. This energy may be used to determine the toughness, impact strength, fracture resistance and impact resistance.

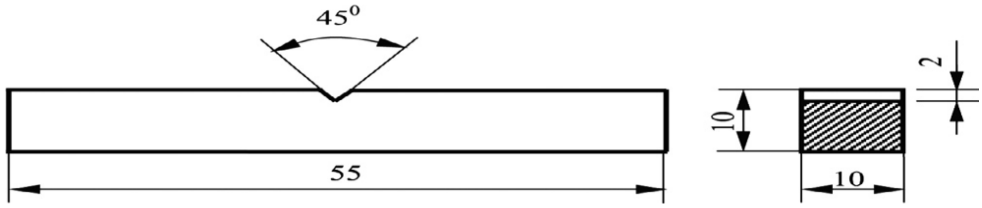

FIGURE 2 : IMPACT TEST SEPCIMEN (ASTM:D5379)

3.0 Results and Discussion

The result of compression and impact test is discussed in this section.

3.1 Compression Test

The results of compression test for various specimens are furnished in table 2.

Table 2: Result of compression test of various specimens

SPECIMEN	COMPRESSION LOAD
HEMP FIBER(Untreated) + GRAPHENE (3%)	13.30 KN
HEMP FIBER(Treated) + GRAPHENE (5%)	11.01 KN

It is found that adding graphene and treating with NaOH, reduces the effect of compression when compared with non NaOH treated fiber. It also suggested that absence of NaOH produces comparatively good compressive strength. The graph representing results of specimens at various compressive strength are indicated in figure 3. Also result for Compressive Test of treated composite is shown in figure 4. Compression specimen after test is shown figure 5.

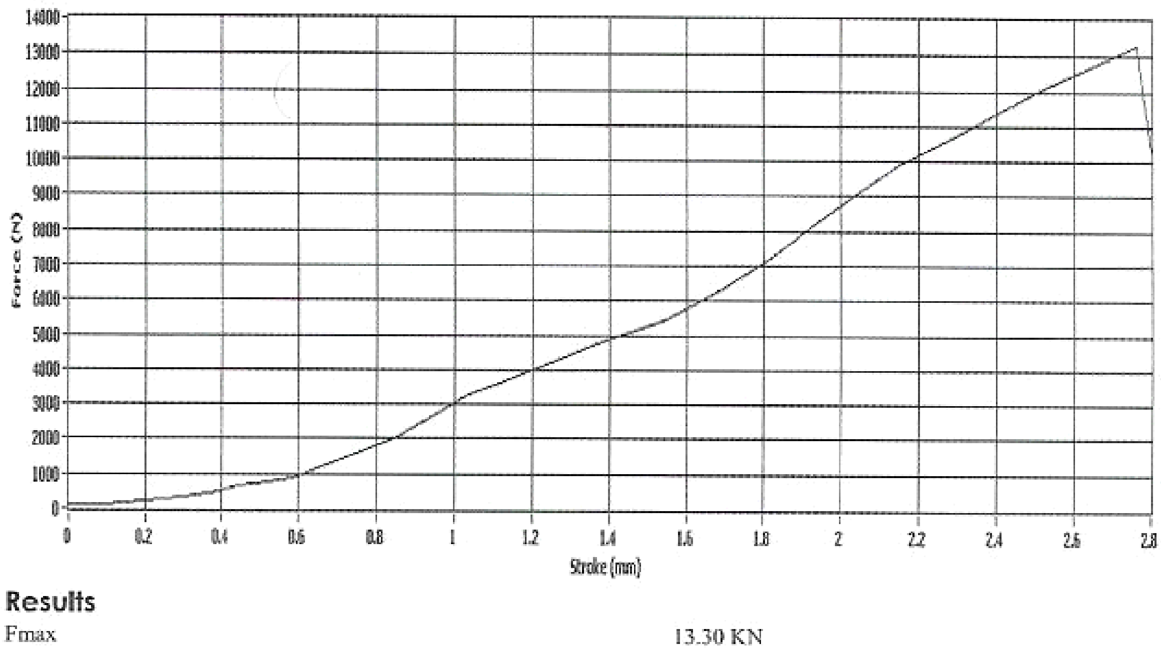

Fig 3: Result for Compressive Test of untreated composites

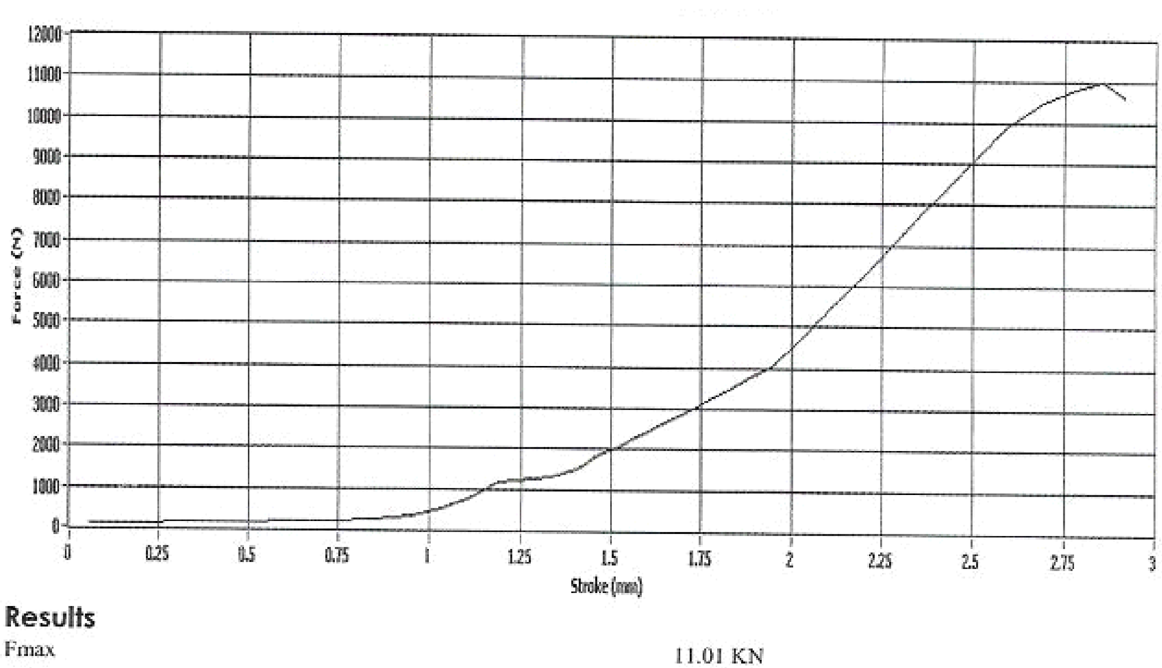

Fig4 : Result for Compressive Test of treated composites

Fig 5 : Compression specimen after test

Morphological analysis is performed on the tested specimen to know the internal structure of the fabricated composite. SEM image of compression tested specimen is shown in figure 6.

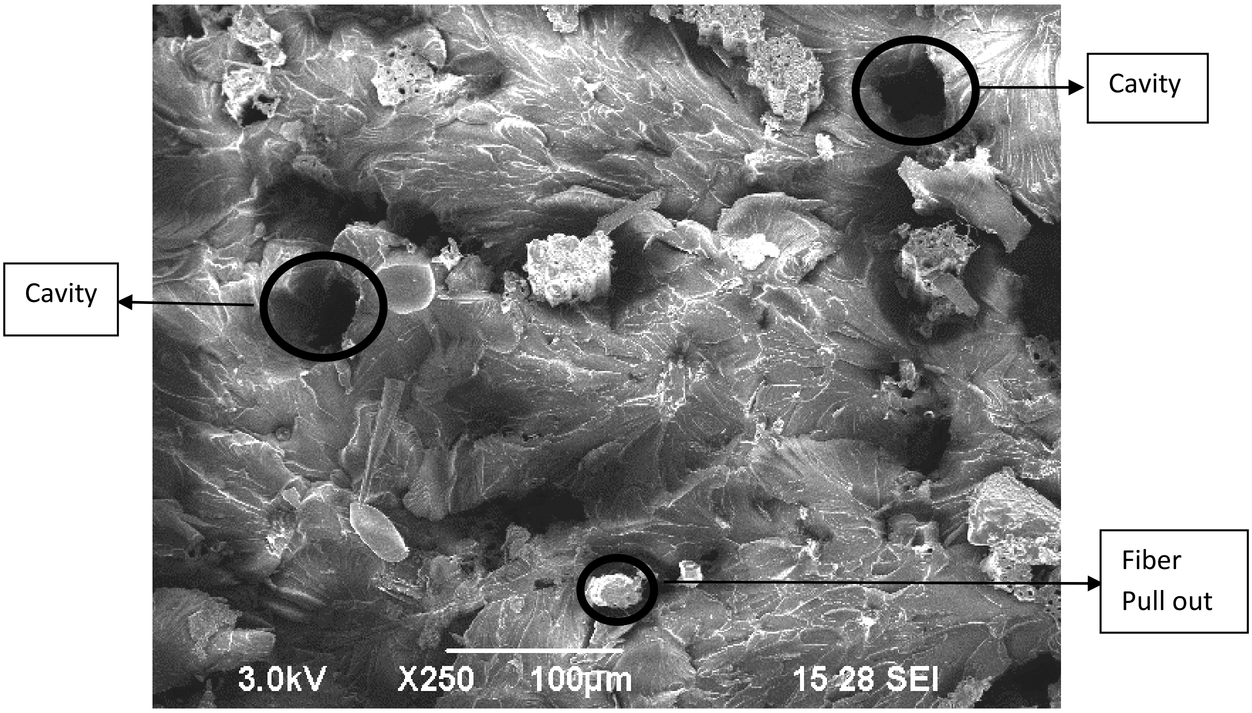

Fig 6:SEM image of compression tested specimen

In figure 6 fiber pull out and some cavities are observed which may lea to reduction in strength of composites. It may be reduced by properly mixing the resin and hardener and apply them within stipulated time for complete curing.

3.2 Impact Test

The Result of impact test of various specimens is furnished in table 3.

Table 3: Result of impact test of various specimens

SPECIMEN	IMPACT
HEMP FIBER(Untreated) + GRAPHENE (3%)	2 J
HEMP FIBER(Treated) + GRAPHENE (5%)	2.5 J

It is evident from the table 2 that though graphene has been added to the specimen it does not improve the impact strength. Also the fiber improves little strength of the composite samples. The tested specimen is shown in figure 7.

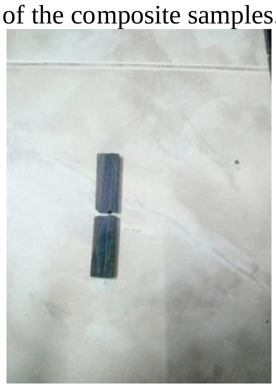

Figure 7. Impact specimen after test

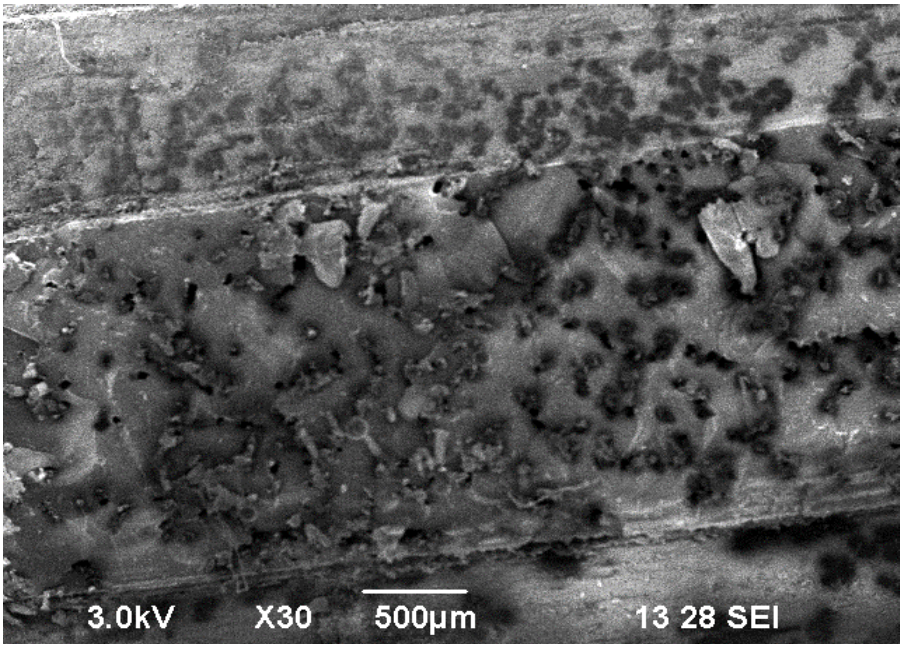

Figure 8: SEM image of impact fractured surface – 1

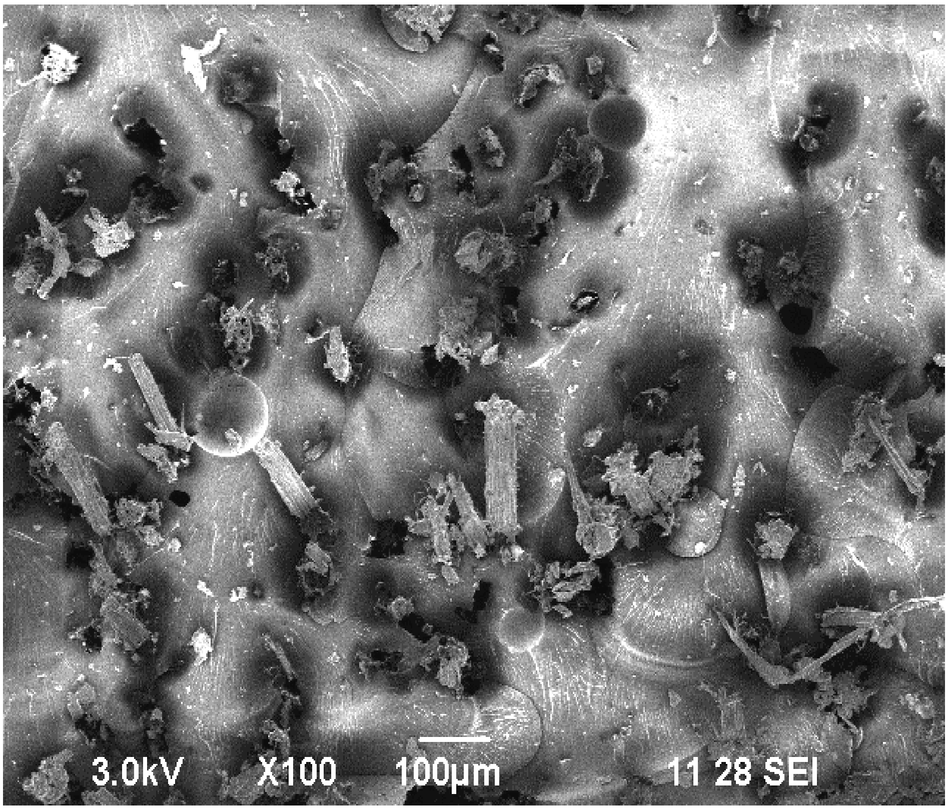

Figure 9 :SEM image of impact fractured surface – 2

Morphological analysis of impact tested specimen is shown in figure 8 and 9 from which it is clear that the fibers are distributed evenly and very less defect observed.

4.0 Conclusion:

In this work grephane based composite is fabricated using hemp fiber as reinforcement. Both treated and untreated hemp fibers were used to study and analysis the effect of fiber treatment on the mechanical behaviours namely compression and impact. From the result, it is evident that fiber treatment has no effect on compression strength of composites while little effect on impact properties. Addition of grephane also having impact on strength of composites. Moreover, addition of graphene improves mechanical strength of composites and also make the material suitable for engineering applications.

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