

STUDY ON MECHANICAL PROPERTIES OF HEMP/CARBON FIBER REINFORCED EPOXY BASED HYBRID COMPOSITES

Satish¹, Baljeet Singh²

¹Mechanical Engineering, Ganpati Institute of Technology and management,

²Mechanical Engineering, Ganpati Institute of Technology and management,

Abstract— Now-a-days, the natural fibers from renewable natural resources offer the potential to act as a reinforcing material for polymer composites alternative to the use of glass, carbon and other man-made fibers. Among various fibers, hemp is most widely used natural fiber due to its advantages like easy availability, low density, low production cost and satisfactory mechanical properties. For a composite material, its mechanical behavior depends on many factors such as fiber content, orientation, types, length etc. The present experimental study aims at learning the mechanical behavior of hybrid natural fiber composites. Samples of Hemp-Carbon-Epoxy hybrids, Carbon-Epoxy and Hemp-Epoxy were manufactured using hand layup method. Specimens were cut from the fabricated laminate according to the ASTM standards for different experiments. For Tensile test & flexural test samples were cut in Dog-bone shape and flat bar shape respectively. After that experiment is performed under Universal testing machine (UTM). ILSS (flexural strength), Izod Impact Test & Tensile strength were observed. Hemp fiber gives the properties when carbon is reinforced as the tensile strength is increased from 10.65MPa to 42.37 MPa. Displacement at peak load were decreased from 5.78 mm to 3.92 mm. Strain at peak load also decreased. Modulus of rupture increased from 1.06 N/mm² to 2.69 N/mm². The Flexural load carrying capacity is increased from 10.037 N/mm² to 28.837 N/mm². The capability of taking the flexural load increased from 0.01kN to 0.077 kN.

I. INTRODUCTION

When more than one different materials are combined in a way that the resultant material have the properties different from the parental one. These reinforced Fiber composites, with different properties, are used in different fields due to the reinforced properties such as engineering applications, aerospace, defense, sports goods, etc. Due to their eco-friendly properties natural fiber composites have gained increasing interest in now a day. Based on these natural fibers, researchers have been done a lot of work. Natural fibers like jute, sisal, silk, hemp and coir are renewable, inexpensive, lightweight, abundant, with low density, biodegradable, and high toughness. Natural fibers such as Hemp have the potential to be used as a replacement for traditional reinforcement materials in composites for applications which requires high strength to weight ratio and further weight reduction. Hemp is a fiber plant. Hemp is one of the most natural environment friendly fibers. Hemp grows with a height of 6 feet to 12 feet and 6mm diameter without balancing. Hemp plant grows in very dense such as 300 plants per square yard. Hemp is also used in medicines. Hemp fibers have some qualities such as strength, durability, absorbency. Hemp is produces over 30 countries such as India, China, Nepal, South Korea, Thailand, Australia, Russia Canada, France etc. France is the world leading producer about more than 70% of world. China is in second number. The production rate of hemp in India is very less than as compare to other countries such as France and china. Due the demand of environment friendly fiber and scientist interest attraction toward natural plant, the scope of hemp production can be increased. India has an association known as India Industrial Hemp Association also known as IIHA. Navjot et al. [1] worked on Tensile strength of Sisal-Hemp reinforced composite and they observed the effect on tensile strength is increases with increasing sisal content from 5% to 20% but decrease with increasing of hemp fiber content 5% to 20%. Bhoopathi et al. [2] worked on Banana-Glass-Hemp Fiber Reinforced Composites and they observed that the banana-hemp-glass fibers reinforced hybrid epoxy composites contains superior properties and used as an alternate material for synthetic fiber reinforced composite materials. Asim [3] worked on mechanical and physical properties of Hemp fiber and find the hemp fiber wears the properties that it can be used as a reinforced material in composite. But it has a problem that it wears moisture. Subhash [4] worked on bamboo fiber and its mechanical behavior and concludes that the various mechanical properties are highly dependent on the fiber size used. Fiber access reduces the properties. Avtar & Vishvendra [5] worked on hybrid of Jute-Bagasse-Epoxy & Jute-Lantana camara-Epoxy and comparison between the results of tensile and flexural test. DeeDee [6] worked on hemp fiber and find that the difference between the hemp fiber and cotton. And conclude that the maximum physical and mechanical properties are same. Supriya et al. [7] worked on Mechanical Characterization of Graphene based Hybrid Polymer and observed that the Carbon fiber hybrid with graphene sheet polymer composite exhibits special properties on the mechanical section. It is authorize that both graphene and carbon fiber show assure as reinforcements in superior Nano composites. They have prodigality of stiffness, strength, versatile and firm. This means that the Nano composites had prominent mechanical properties compared to the neat polymer or traditional composites. Carbon fibers were treated with a simple yet efficient method that resulted in the deposition on their surface of a high density of uniform and well dispersed graphene particles as well as sheet. Gangadhar et al. [8] worked on ‘Testing of Polymer matrix Hybrid Composites’ and observed that the Polyester performed better with respect to mechanical properties compared to epoxy in tensile &

flexural behavior. Kevlar is best suited for impact load applications and gives a better performance, whereas glass and carbon have shown improvement in compression and flexural behavior compared to other hybrids. Varying the fiber stacking sequence w.r.t angle ply at $\pm 45^\circ$ better properties can be achieved. Variation in forming pressure and coupler concentration has effect on the improvement of properties. Natural fibers such as jute, kenaf, banana and pineapple have shown improvement in the properties compared to a monolithic natural fiber composite. Hybridization of glass and carbon doesn't improve the hardness properties of composite. Gupta and Srivastava [9] worked on Hybrid Fibres Reinforced and conclude that the hybrid fibers have the many advantages and can be used in many fields. Manikandan et al. [10] worked on 'Banana/Hemp Fiber and Its Hybrid Composites' studied that the centuries ago usage of composites materials plays important role in industrial revolution. In ancient days Egyptians used straw as reinforcement in clay bricks to build house. With the invented of glass fiber and resins, glass fiber reinforced composites found its application in many areas. Abundance nature and moderate specific strength than most of the organic fibers, low density and biodegradable nature make the natural fiber as attractive reinforcement in polymer matrix in recent few decades. [Sanjay and Arpitha](#) [11] worked on Hemp and E-Glass reinforced fibers and find that the hemp fiber is a good alternative reinforced material. Yerramsetti et al. [12] 'Worked on Jute/Hemp reinforced fiber and find that hemp fiber and jute fiber have properties are very closer of each. Suresha et al [13] worked on Tensile, Compression and Flexural Behavior of Hybrid Fiber (Hemp, Glass, and Carbon) Reinforced Composites observed that Specimens with varying thickness of laminates are fabricated by simple hand layup technique and they are: Hemp/Glass/Epoxy laminate composite (3mm thickness) Hemp/Carbon/Epoxy laminate composite (3mm thickness) From the composite s the test specimens have been prepared in accordance with the ASTM standards for tensile, compression and flexural strength determination. In the overall study, they found the strength of Hemp/Carbon/Epoxy laminates has higher value than that of Hemp/Glass/Epoxy laminates

II. MATERIALS AND METHODS

MATERIAL

Material used are Hemp Fiber and carbon fiber as a Reinforced material and epoxy is used as a matrix material. Silicon Spray is used as a releasing agent and roller (to remove air) and mold is used as a tool.

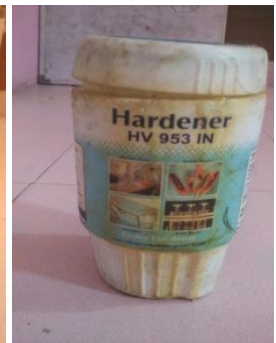
Hemp Fiber is a natural fiber obtained by the plant named as hemp. Hemp fibers were supplied by Uttarakhand Bamboo and Fiber Development Board (UBFDB), Uttarakhand. Natural white color soft hemp fibers were obtained with subtle sheen woven mat. The size of woven mat is approximate $01 \times 01 \text{ m}^2$. As received Hemp fires are in natural white color and shown in Figure 1(A)



(A) Hemp Fiber



(B) Carbon Fiber



(C) Araldite AW 106 IN Hardener HV 953 IN

Figure1



(A) Silicone spray



(B) Roller



(C) Mould

Figure 2

Carbon Fiber was supplied by CFW Enterprises, Delhi. Black color Soft carbon fibers were obtained with subtle sheen woven mat. The size of woven mat is approximate $01 \times 01 \text{ m}^2$. As received carbon fires are shown in Figure.1(B).

Epoxy: was bought from industrial area from hardware shop and shown in Figure 1(C).

Epoxy resin Name - Araldite LY 556. (Araldite LY 556 = AW 106 IN + Hardener HV 953 IN)

Properties of Epoxy: - Great adhesive, Formed Great strength and high toughness resistance, Moisture Free, Odorless, Nontoxic, Minimum (Neglected) shrinkage Etc.

Preparation of Mould: The mould is prepared of the material of the stainless steel. The material is cut by the CNC plasma cutting m/c. The cavity in the mould is created 3.17mm. The dimension of the mould is 220mm * 160mm. Prepared mould is shown in shown in Figure 2(C).

FABRICATION OF HYBRID COMPOSITE

Hemp fiber and Carbon Fiber are the Reinforcing material and Epoxy is the matrix used to prepare the specimen for this investigation and the method used to perform is hand Lay-up method. Heavy duty silicon spray is used as releasing agent. Stainless steel mould is used with dimensions 220mm * 160mm. Before starting to prepare the specimen, it is necessary to remove the moisture from the both material (carbon and hemp fiber). And to remove the impurities and enhance interfacial bonding, so to remove the impurities. So dry the fibers in sun light. After drying the material, washes with distilled water. And allow to dry. After that both of the fibers are cut according to the size of mould. The silicon spray is sprayed inside the mould. The hemp fiber is laid inside the mould and then epoxy resin is spread on the hemp fiber inside the mould and let's dry it fir 15-20 min. Before drying completely, the carbon fiber is laid on the hemp fiber. After this uniformly distribution of resin is necessary. So with the help of roller resin distributed uniformly. Now the air bubbles are formed inside the sample, so it necessary to remove them from the sample, so by pressing hard the samples with mould air bubbles are removed. And the access resin is pushed out. And allow the sample to dry for long hours. After drying completely, the sample is taken out from the mould, and the same process is repeated to obtain the samples of Hemp-Epoxy Resin and Carbon-Epoxy Resin. Samples of (Hemp + Carbon) Epoxy Fibers, (Carbon) Epoxy Fiber, (Hemp) Epoxy fiber are shown in figure 3 (A), (B), (C) .After prepared the sample, the specimens are formed by cutting with the help of dies according to the ASTM standard.

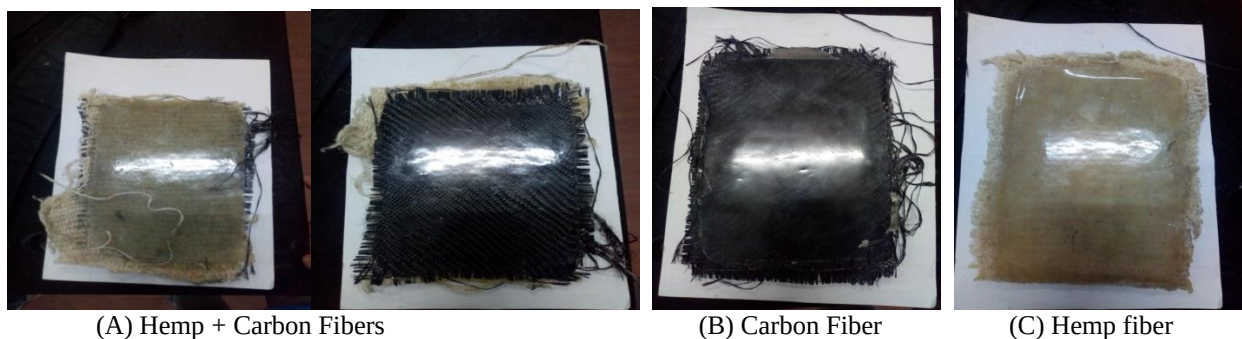


Figure: 3

MECHANICAL TESTING OF COMPOSITES

Tensile Test: To perform the tensile test ASTM: D 638 standard is used. According to this standard the size required of the specimen is 165mm X 19.05mm X 3.17 mm. The test is performed on the Universal Testing Machine (UTM). Plastics can be changing rapidly their property with a small change in temperature. So to neglect the error the test is performed at the standard Lab. Temp. 21-25°C and 45-55 % relative humidity. So to perform the test the specimen is clamped in the jaws of fix and moveable member.

Flexural Testing: Flexural strength of the composite specimens is found by using 3 point bending test. The composite specimen size is 100X 19.05 X 3.17 mm. Flexural test is use determine the flexibility (bending). Flexural test can be performed by two methods. The main difference between both methods is either single load point or double point. In first method, (known as three point bending test system or center loading) have the two supporting point and one load point at center (mid-point) of both support and opposite direction. The test specimen is placed on the support and the single center load is applied on the specimen In the second method (known as four point loading test system) have the two supports like method one, but there are two load points which are opposite direction of support and are at a distance of 1/3rd of the total distance between supports and equally space from their adjacent side. The load point is connected to a moveable member of the machine. The Mechanism use to measure the deflection in member is known as strain gauge (compressometer or deflectometer). Load is applying on the specimen and deflection is measured in the specimen by the gauge.

Izod Impact Test: Impact test can be performed by two methods. One method is izod impact test and another method is charpy impact test. The difference between the methods is about the position of the specimen. In izod impact test, the specimen is placed vertical and notch is the side of pendulum where the pendulum strikes. Whereas in the charpy test, the specimen is placed horizontal and notch is the opposite side of pendulum where the pendulum strikes. In these experiments the Izod Impact Tests is done. The specimen is placed vertically and the notch is in the side of pendulum strike. The experiment is done on the composite specimen with size is 63.5X 12.7 X 3.17 mm. after clamping the specimen hammer is released and hammer strikes on the specimen and swing. If the specimen did not break by strike the pendulum, then the loads increased until the specimen did not break. After break the specimen by striking with pendulum, the scale shows the reading in in-lbf or ft-lbf. Dividing the impact value by thickness of specimen, the strength (impact Strength) can be calculated. If scale shows the reading 2.5 ft-lbf is obtained using a 1/8 in. thick specimen. Then the value of impact is 20 ft-lbf/in. of notch. The impact value is measures always in inch; either the thickness of the specimen is thick or thin.

III. RESULT AND DISCUSSION

The need of the composite material in different areas is increasing day by day due to its properties. Composite material possesses improved properties as compared to conventional material. Due to the importance of composite material, the scientists and engineers are attracted towards the composite materials. In this experimental study, the natural fiber reinforced with the carbon fiber with the help of epoxy resin, and the properties of the composite are evaluated and compared with individual reinforcement. The tensile strength, flexural strength, and impact strength results for three specimens as Hemp-Carbon-Epoxy, Hemp-Epoxy, and Carbon-Epoxy are shown below in table 1.

Table 1 Mechanical properties of different composite samples

Tensile Test: The different specimens of composite as Hemp-Carbon-Epoxy, Hemp-Epoxy, and Carbon-Epoxy are

Composite	Tensile strength (MPa)	Flexural strength (MPa)	Izod Impact strength (J/m)
Hemp composite	10.65	10.04	80.59
Carbon composite	222.10	49.68	424.26
Hemp + carbon composite	42.39	28.84	127.65

tested in Universal Testing machine (UTM). The specimen strength is measured up to the Ultimate Tensile Stress and until break the specimen. The results indicated that carbon specimen gives better tensile strength other than the hemp, and hemp-carbon composites. Displacement at peak load of hemp fibers were decreased from 5.78 mm to 3.92 mm when embedded with carbon fibers. Strain at peak stress also decreased when carbon fibers added in hemp fiber. Modulus of rupture of hemp fiber composite increased from 1.06 N/mm² to 2.69 N/mm². The tensile strength of hemp fiber based composite is less but by adding of carbon fibers, the tensile strength is increased as compared to hemp composite only. The ultimate tensile strength (UTS) of the hemp composite is 10.65 MPa, carbon composite is 222.10 MPa and hemp-carbon composite is 42.39 MPa.

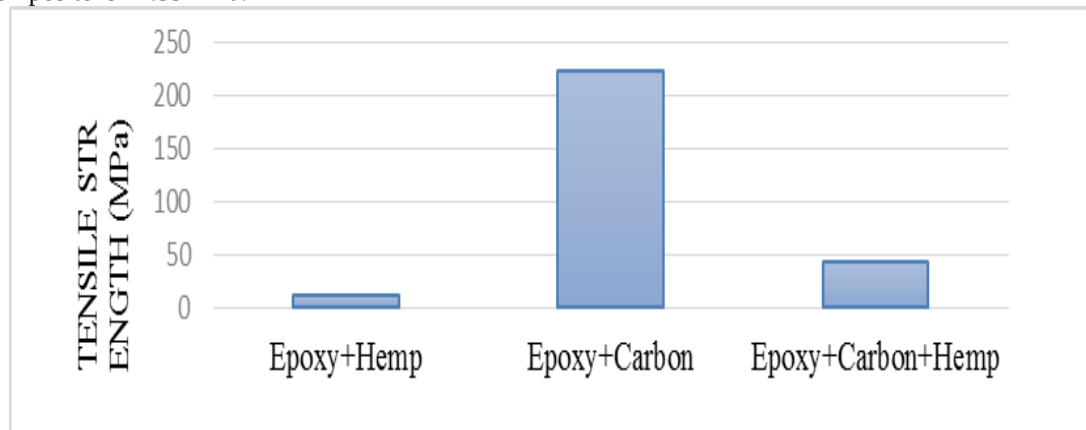


Figure 4 Tensile strength comparisons of different composite materials

Flexural Test: The flexural test results of different composite are shown in the fig.5. As Hemp-Epoxy, Carbon-Epoxy and Hemp-Carbon-Epoxy are 10.04 MPa, 49.68 MPa and 28.84 MPa respectively. As applied forces increased up to 87 N the elongation increases, after 87N, elongation decreases and breaking takes place. Maximum elongation at peak load observed is 8.81 mm. This result shows that, this composite shows better result as compared with other composite results. Up to 29 N/mm² strain increases proportionally, after this, it reduces. The results show that flexural capacity of hemp fiber is increased from 10.037 N/mm² to 28.837 N/mm² with reinforcing carbon fiber. Flexural load capacity of the hemp fiber is up to 0.02kN; whereas the capacity of carbon is 0.116kN and by reinforcing the carbon fiber in hemp fiber the flexural load capacity increases 0.02kN to 0.077kN.

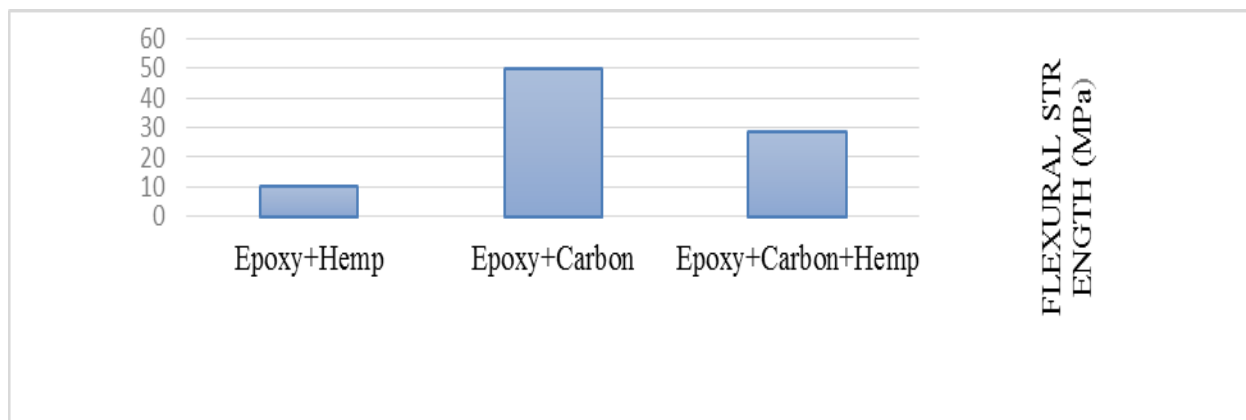


Figure: 5 Flexural strength comparisons of Different composite materials

Izod Impact Test: In the present experiments the impact test is done by the Izod Impact Test. While obtained the readings energy loss is found out. The impact response in prepared composites reflects a failure process involving crack initiation and growth in the resin matrix, fiber breakage and pullout, delaminating and disbanding. In the fig.6 Impact test result for different specimen of composites (Hemp-Carbon-Epoxy, Hemp-Epoxy, and Carbon-Epoxy) are presented. The impact strength of Hemp-Epoxy is 80.59 J/m, and Carbon-Epoxy is 424.26, Hemp-Carbon-Epoxy is 127.65. From the results, find that the strength of hemp fiber is very less as shown in fig. but by reinforcing the carbon fiber the Impact strength of composite is increased as compared to single hemp fiber.

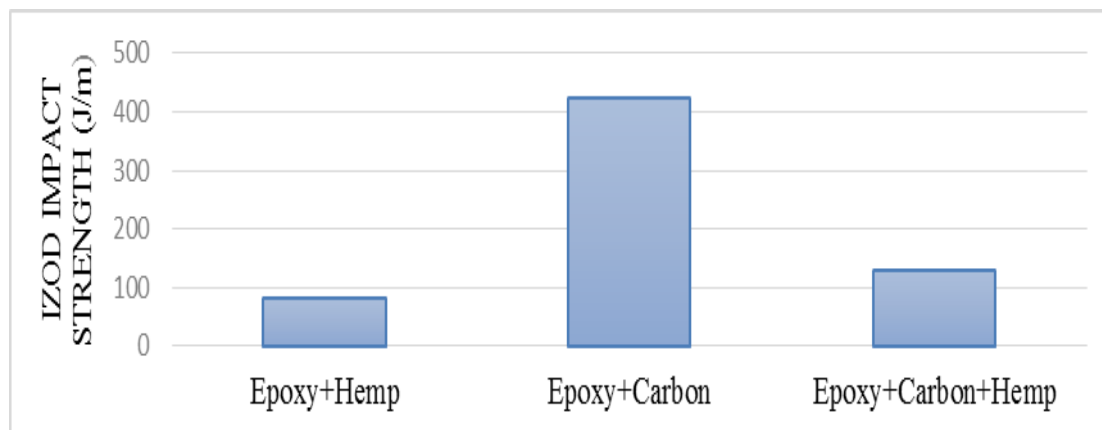


Figure: 6 Izod impact test comparison of different composite materials

IV. CONCLUSIONS

The experimental study on the tensile test, flexural test and izod impact test results, obtained from experiments, Carbon + Epoxy, Hemp+ Epoxy and Carbon Hemp Epoxy results are compared. Carbon specimen gives better strength than the other two. We observed that the strength of hemp fiber is less as compare to carbon fiber composite but with the mixing of carbon fiber in hemp fiber, the strength is increased and it leads to the conclusions are:

- The tensile strength is increased when the hemp is mixing with carbon from 10.65MPa to 42.37 MPa.
- Displacement at peak load of hemp fibers were decreased from 5.78 mm to 3.92 mm when embedded with carbon fibers.
- Strain at peak stress also decreased when carbon fibers added in hemp fiber.
- Modulus of rupture of hemp fiber composite increased from 1.06 N/mm² to 2.69 N/mm².
- The Flexural load carrying capacity is increased when the hemp is mixing with carbon from 10.037 N/mm² to 28.837 N/mm².
- The capability of taking the flexural loan increased when the hemp is mixing with carbon from to 0.01kN to 0.077 kN.

REFERENCES

- [1] Navjot Pal Singh, Lakshay Aggarwal, V.K.Gupta (2015) study on 'Tensile Behaviour of Sisal/Hemp Reinforced High Density Polyethylene Hybrid Composite' Materials Today: Proceedings 2 (2015) 3140 – 3148
- [2] R. Bhoopathi, M. Ramesh,*, C. Deepa (2014) study on 'Fabrication and Property Evaluation of Banana-Hemp-Glass Fiber Reinforced Composites' Procedia Engineering 9(2014)2032–2041
- [3] Asim Shahzad Hindawi Publishing Corporation Advances in Materials Science and Engineering Volume 2013, Article ID 325085, 9 pages
- [4] Subhash Kumar Gupta (2014) study on mechanical behavior of bamboo fiber based polymer composites Thesis, NIT Rourkela.
- [5] Avtar Singh Saroya and Vishvendra Meena (2011) Study on 'study of mechanical properties of hybrid natural fiber composite' thesis, National Institute of Technology Rourkela.
- [6] DeeDee De Miranda (2011) study on 'An Evaluation of Hemp Fiber for Furnishing Applications' thesis, Colorado State University Fort Collins, Colorado.
- [7] Supriya Kunwar, Dr. K. K. S. Mer, Amit Joshi (2015) study on 'Mechanical Characterization of Graphene based Hybrid Polymer' international Journal of Scientific & Engineering Research, Volume 6.
- [8] Gangadhar M Kanaginahal, Anjan Kumar Muniraju, Mr. Madhav Murthy (2014) study on 'Testing of Polymer matrix Hybrid Composites' Materials Today: Proceedings 00 (2014) 000–000
- [9] M. K. Gupta and R. K. Srivastava (2016) study on 'Mechanical Properties of Hybrid Fibres Reinforced Polymer Composite' Polymer-Plastics Technology and Engineering Vol. 55, No. 6, 626–642
- [10] V. Manikandan, P. Amuthakkannan, V. Arumuga Prabu (2015) study on 'Banana/Hemp Fiber and Its Hybrid Composites' Report number: Vol. 1: Issue 2, Affiliation: International Journal of Composite Material and Matrices.

- [11] [Sanjay M R](#), [G.R. Arpitha](#) (2016) study on 'Experimental Investigation on Mechanical Properties of Hemp/E-Glass Fabric Reinforced Polyester Hybrid Composites.
- [12] Yerramsetti Gopi Sai Prasanna Kumar (2017) study on 'Fabrication and analysis of Jute/Hemp reinforced fiber' ISSN: 2454-132X Impact factor: 4.295 (Volume 3, Issue 6).
- [13] Suresha K V, Dr. Sumana B G, Dr H K Shivanand, Mahesha (2017) worked on Tensile, Compression and Flexural Behaviour of Hybrid Fiber (Hemp, Glass, Carbon) Reinforced Composites Volume 5, Issue 4 ISSN: 2321 – 9939.