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Experimental Investigation of Mechanical Properties of Hybrid Laminated Composites Reinforced with Kevlar, Hemp Fibers & Crab Powder

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Abstract - *The synthetic polymer composite filled with natural fillers became an important area of research and development in recent years due to their applications in various fields. The aim of present work is to fabricate and evaluate the mechanical properties of hybrid laminated reinforced with Kevlar, hemp fibers & crab powder. Composites by varying the orientations of hemp fiber 0°,30°, 45°, 60° and maintaining the constant orientation of Kevlar fiber with 0° were prepared using hand layup method because this method was easy to fabricate, with low tooling cost and resulting in good surface finish. The tensile, flexural and impact strength of the samples are evaluated. The variations in properties with respect to change in the orientations of hemp fiber were obtained and represented by graphs. The composite with 60° orientations of hemp fiber have shown better results in tensile (281.194 N/mm^2), flexural (1632.1N/mm^2) and Impact tests (8.66 J).*

Key Words: **- Kevlar fiber, hemp fiber, crab powder, epoxy, orientation, hand layup method, tensile strength, flexural strength, impact strength.**

1. INTRODUCTION

Composite material is material made from two or more materials with similar or different, physical or chemical properties with a great improvement in performance. EG: - steel bar reinforced concrete. Modern composite materials are typically optimized to accomplish a proper balance of properties for a given range of applications.

The properties like high strength, high modulus, good fatigue resistance, High damage tolerance, and good damping characteristics, polymer matrix composites are occupying major applications in areas like air craft, aerospace, construction industry, anti-corrosion equipment, electrical and electronic industry, agriculture and fisheries and mechanical manufacturing.

AsimShahzad [1] determined that properties of hemp fibers are good and can replace the glass fibers. Various surface treatments have been shown to improve the mechanical properties of hemp fiber by his work.

The properties of Kevlar laminated aluminum composite will be suitable to replace the conventionally used aluminum was investigated by B. Senthil Kumar, D. Muraganandam, and J. jayapriya [2].

In the work by Mohammed Hisham, Mohammed Fahaduddin, Mohammed Azhar khan Ashok B C, Prashant Kumar Shrivastava [3] anisotropic nature of Kevlar fiber provides very ratio of tensile to compression strength. The hybrid and treated Kevlar offer improved mechanical properties are determined

In the article by Gayatri U, malkapuram R, vasu AT, chavali m [4] determines the use of bio-degradable waste as a composite material. The discarded waste of the prawn shell wastes is used for making a composite material. Particulate reinforcement used in prawn shell powder and the matrix used is LAPATOXY-SP 100 resin along with hardener (MYK altercate). The prawn shells have a much higher mechanical strength than the convectional plastics.

In the paper by MS VanasarlaHema, Mr. K. srinivasa Rao [5] the different compositions of matrix and epoxy is fabricated and compared among composites prepared and result is shown. Composite materials are substitute for the conventional plastics and possess higher mechanical properties than those materials.

In the article by KishorkumarGadgey and Dr. AmitBahekar [6] reviewed completely and explained the progress of study of crab shell conducted by various scientists. The properties of which are closely analogous to those of pre-stressed concrete. The crab shell material posse's good mechanical properties.

In the present work thermo set polymer i.e., epoxy resin [LY556 & HY951] was taken as matrix material and one of the reinforcements was Kevlar fiber it provides high specific strength and specific modulus and other was hemp fiber which provides high toughness, and stiffness to the composite. The tensile strength, tensile modulus, bending strength, bending modulus, and impact strength of composites were determined experimentally by fixing the orientation of Kevlar fiber and varying orientations of hemp fiber.

2. Experimentation

2.1. Materials

Kevlar: -

Kevlar is the one of the most favorable composite material. Properties of Kevlar include high rigidity, toughness, thermal stability and most importantly strength. Kevlar is the wide range of application race cars to bullet proof armors etc. Racing cars is prone to accidents. Kevlar is used to reinforce its fuel tanks due to its tensile strength. This makes the fuel tank difficult to be puncturing in case of any impact or accidents resulting in a low risk of fire during a crash. And since the property of Kevlar is being so light, it is an ideal material. Traditionally steel was the material of choice for body armors. But it was bulky and heavy. Kevlar on the other hand is light weight and 18 times stronger than steel. Due to Kevlar's high tensile strength it is the best suited material for protection against knife hits and bullets.

Hemp: -

Hemp is naturally one of the most ecologically friendly fibers and also the oldest. The Colombia history of the world states that the oldest relics of human industry are bits of hemp fabric discovered in tombs dating back to approximately 8,000 BC. In hemp plant, fibers are contained with the tissues of the stems which help to hold the plant erect. This high strength and stiffness of hemp fibers makes them a useful material to be used as reinforcement in composite materials.

Epoxy: -

Epoxy is a most common type of thermo set resin used to make the composites. It has good electrical and resistance to corrosion properties. It has the good properties at elevated temperatures.

Mixing Ratios of Epoxy and Hardener:

The mixing ratio of epoxy and hardener is 1:10, i.e., the weight of epoxy must be ten times more than the weight of hardener. The total epoxy and hardener weight ratios for natural fiber is 1:2 and for artificial fiber is 1:1. The ratio is between the weight of fiber and the weight of epoxy.

Properties of epoxy resin LY-556

The composition of this resin is based on bisphenol-A which makes it suitable for high performance FRP composite applications. It has good fiber impregnation, thermal and dynamic properties. It is preferred for aircraft and aerospace adhesives.

Form: liquid

Visual appearance: clear, pale yellow liquid.

Density at room temperature: 1.25gm/cm^3.

Viscosity at room temperature: 10,000 – 12,000 MPA.

Properties of hardener HY-951

It's a multipurpose two component, room temperature curing, transparent liquid adhesive of high strength. It is suitable for bonding wide variety of metals, ceramics, glass, rubbers, rigid plastics, and most other materials in common use.

Density: 0.95gm/cm^3.

Drying temperature: normal room temperature (25° -30°c).

Water solubility: soluble.

Crab Powder:

It is the powder made from the ex. skeleton of the crab. The shell or ex. skeleton of the crab is dipped in sulphuricacid for 3 to 5 days. Then the shell is dried and breaks down in to small pieces. The small pieces are grind to powder.

2.2 Fabrication Process

There are different methods used to manufacture the composite material. They are hand layup method, spray-up, vacuum bagging and automated tape process.

Hand Layup Method

The present work was done by using the hand layup method to fabricate the composite materials. This method is very easy to fabricate and having low tooling cost and results in good surface finish.

In the hand layup method, the clear film is placed first and epoxy is applied on the film with the help of brush. Then the Kevlar fiber of (200mm*200mm) is placed on it as a first layer, then again, the epoxy is applied on Kevlar, and now the hemp fiber is placed as second layer. Like this the plate with 6 layers is made. The final dimensions of the plate are 200*200*6mm.

Specimen Preparation:

After the completion of fabrication, the plates are dried. The plates are prepared with the Kevlar and hemp fibers. The dimensions of each plate are 200*200*6 mm. Total four plates are fabricated by varying the orientations of hemp fiber. The specimens are cut by the use of hand cutter, from each plate according to the dimensional standards.

For Tensile Test : 200*15*6mm

For Flexural Test: 100*15*6mm

For Impact Test: 55*10*3mm

Orientations

SNO	KEVLR	HEMP	HEMP	HEMP	HEMP	KEVLAR
Plate 1	0	0	0	0	0	0
Plate 2	0	30	30	30	30	0
Plate 3	0	45	45	45	45	0
Plate 4	0	60	60	60	60	0

2.3 Testing

Tensile Test

Tensile test specimen is prepared according to the standard ASTM 3039 standard. According to the standard the dimensions of the specimen used are 200*15*6mm. The specimen was fixed in between rigid fixture and movable fixture of universal testing machine. Three samples are tested for each orientation of the composite to find the average tensile strength and modulus.

Flexural Test

Flexural test is also known as bending test. Flexural test specimen is prepared according to ASTMD790 standard. According to the ASTMD790 standard the dimensions of the specimen used are 100*15*6mm. The specimen was fixed in the grip of universal testing machine. Three and average flexural modulus samples are tested for each orientation of the composite to find the average flexural strength.

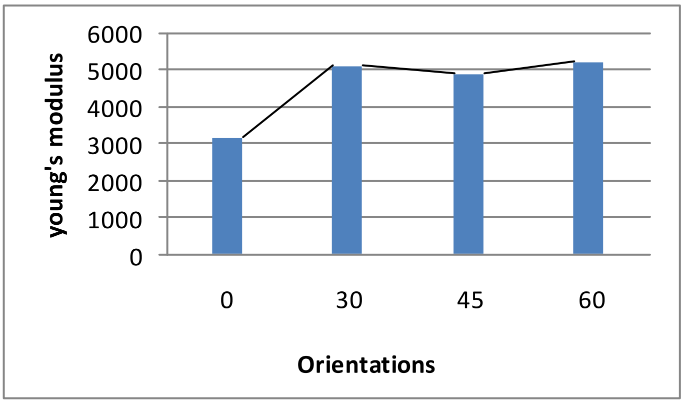
Impact Strength

Impact test specimen is prepared according to the standard ASTM A370 standard. According to the standard the dimensions of the specimen used are mm.55*10*3mm. The specimen was fixed in fixture of Charpy impact testing machine. Three samples are tested for each orientation of the composite to find the average impact strength.

3. Results

3.1 Tensile test

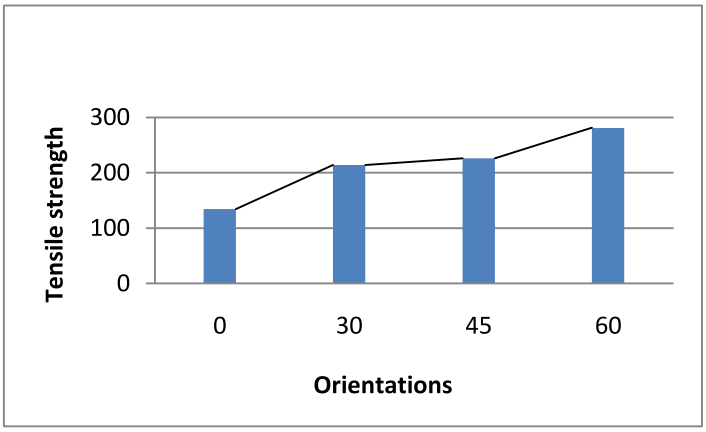
S. No	Type Of Orientation	Average Load (Kn)	Tensile Strength (N/Mm^2)	Young's Modulus (N/Mm^2)
1	(0 /0 /0 /0 /0 /0)	7.65	134.497	3183.36
2	(0 /30 /30 /30 /30 /0)	12.35	214.161	5145.00
3	(0 /45 /45 /45 /45 /0)	13.43	225.885	4884.00
4	(0 /60 /60 /60 /60 /0)	18.816	281.194	5232.55



Graph: 1

The above graph shows the relation between tensile modulus and orientations.

In this figure the young's modulus of 0° value is (3183.36), 30° value is (5145.00), 45° value is (4884.00), and 60° price is (5232.55). it is determined that in this figure the highest value of young's modulus is at 60°, and the lowest value of the young's modulus is at 0°.



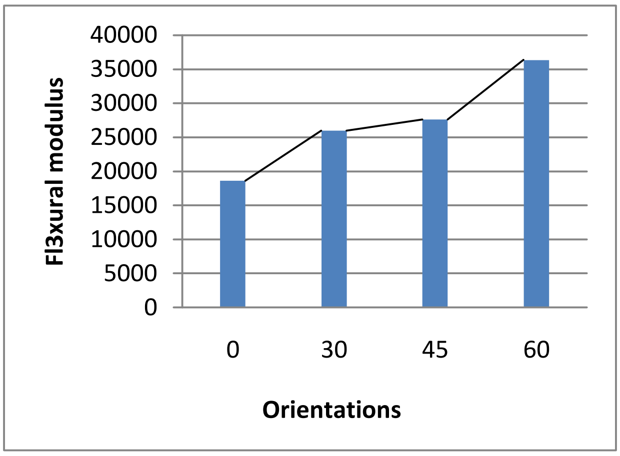
Graph: 2

The above graph shows the relation between tensile strength and orientations.

In this figure the Tensile strength of 0° value is (134.497), 30° value is (214.161), 45° value is (225.885) and 60° value is (281.194). It is located that in this figure the highest value of Tensile strength is at 60°, and the lowest value of the Tensile strength is at 0°.

3.2 Flexural test

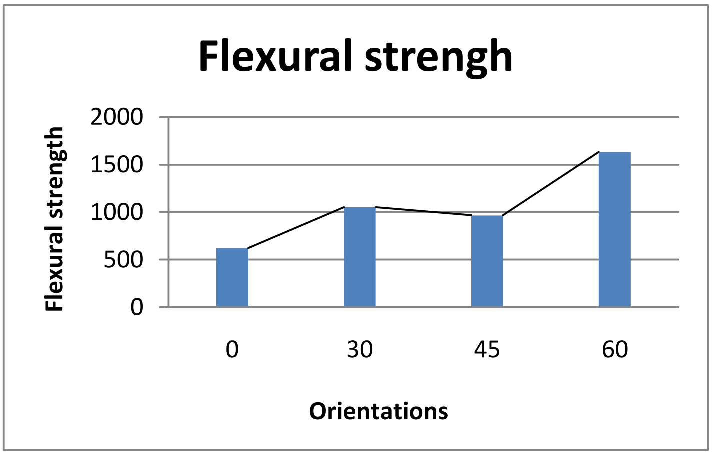
S. No	Type Of Orientation	Flexural Strength (N/Mm^2)	Flexural Modulus (N/Mm^2)
1	(0 /0 /0 /0 /0 /0)	621.8	18616.76
2	(0 /30 /30 /30 /30 /0)	1051.9	25972.83
3	(0 /45 /45 /45 /45 /0)	966.1	27602.85
4	(0 /60 /60 /60 /60 /0)	1632.1	36349.66



Graph: 3

The above graph shows the relation between flexural modulus and orientations

In this graph the flexural modulus of 0° value is (18616.76), 30° value is (25972.83), 45° value is (27602.85), and 60° value is (36349.66). It is found that during this figure the highest value of flexural modulus is at 60°. And the lowest value of the flexural modulus is at 0°.



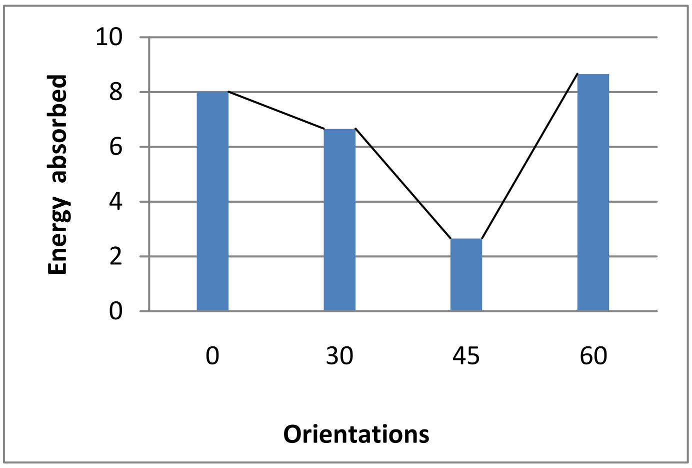
Graph: 4

The above graph shows the relation between flexural strength and orientations

In this graph the flexural strength of 0° value is (621.8), 30° value is (1051.9), 45° value is (966.1), and 60° value is (1632.1). It is determined that during this figure the highest value of flexural strength is at 60°, and the lowest value of the flexural strength is at 0°.

3.3 Impact Strength

S. No	Type Of Orientation	Energy Observed (J)
1	(0 /0 /0 /0 /0 /0)	8.00
2	(0 /30 /30 /30 /30 /0)	6.66
3	(0 /45 /45 /45 /45 /0)	2.66
4	(0 /60 /60 /60 /60 /0)	8.66



Graph: 5

The above graph shows the relation between energy absorbed and orientations

In this graph the impact strength of 0° value is (8), 30° value is (6.66), 45° value is (2.66), and 60° value is (8.66). It is determined that during this figure the highest value of impact strength is at 60°, and the lowest value of the flexural strength is at 45°.

3. CONCLUSION

Work In this the mechanical behavior of Kevlar and hemp fiber composite have been determined and orientation of(0,60,60,60,60,0) showed the better result of tensile strength(281.194 N/mm^2), flexural strength(1632.1 N/mm^2)and impact strength(8.66 J).These composites have applications in the areas of air craft, aerospace, construction industry, anti-corrosion equipment, electrical and electronic industry, agriculture, bulletproof vests, fireproof clothing and mechanical manufacturing.

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