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Effect of Filler Material on the Natural fiber reinforced polymer matrix Hybrid composites for the Automobile Applications

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Abstract: The development of manmade resins during and just after Second World War led to the mass production of synthetic fiber reinforced polymer composites, and decrease in the use of natural fibers. But ecological concerns of society made the Researchers to gain interest again in natural fiber composites. Germany is in forefront in using natural fibers in automobiles applications.The main objective of this experimental work is to fabricate the Natural fiber reinforced polymer composites. Analyze the effect of filler material and identify it for suitable to use in the applications of Automobiles.In this experimental work many journals, conference papers and text books are referred and Natural fiber reinforced Hybrid polymer composite composing Hemp as natural fiber along with synthetic Glass fiber are laid one over the other with Cenosphere and Epoxy resin mix as matrix in between the layers. The specimen composites properties are investigated through conventional testing methods with ASTM standards for Tensile strength, Compression strength, and Flexural strength. And test results were analyzed to identify the specimen composite suitable for automobile application.

Key Words: Composites, Natural fiber reinforced composites, Hybrid Composites, Automobile applications , Mechanical testings

1.INTRODUCTION

Although the synthetic composites posses extensive properties, but also have drawbacks, like High cost of manufacture, high dense, non recycling and non biodegradable property, because of these reasons the natural fiber reinforced polymer composites(NFRPC) getting more attention since from last ten years.

The change over from synthetic to natural fibers reinforced polymer composites is mainly due to the natural fibers abundant availability, comparable specific tensile properties, renewability, less health risk, less abrasive, acoustic and thermal insulation, low price, light weight, biodegradability, the biodegradability develops healthy ecosystem, the low cost and abundant availability attracts the industries and fulfills the economic related interests of company [2, 29, 38].

The hybrid composite exhibits superior in all-round properties over polymer matrix composites with one fiber. Commonly both carbon and glass fibers are reinforced in resin [21]. The hybrid fiber reinforced polymer matrix composites are prepared by using rule of mixture using different volume fraction formulae [36]. Increase in environmental awareness and potential to replace the synthetic fibers made the researchers to think of towards the encashment of disadvantages of synthetic fibers, Environment hazards due to non biodegradability, high cost of manufacture and complicated method of manufacturing of synthetic hybrid composites which made the researchers to choice of natural fibers along with synthetic fiber like glass (natural and synthetic) as reinforcement have better properties and reduced impact on environment, and are partially biodegradable, following other two important facts makes researchers to turn towards Hybridization, first at the end of life cycle of natural fibers reinforced plastics, the release of amount of CO_2 due to combustion or landfill is neutral with respect to intake of CO_2 during their growth, and second the low abrasive nature of natural fibers compared to synthetic fibers [31].

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2 EXPERIMENTAL WORK

2.1 Materials Used

In this experimental work following different materials are used in the fabrication of Hemp-Glass fiber reinforced epoxy polymer matrix hybrid composites.

1. Hemp fabric
2. Glass fiber mat
3. Epoxy thermoset resin & Hardener
4. Cenosphere
5. Fabrication and cutting tools

This experimental work uses the Hemp fiber fabric, procured from Sri Laxmi group, Guntur, Andhra Pradesh, who is supplier of various natural fibers.

This experimental work uses the Glass fiber fabric, procured from SunTek Fibers Bangalore, who is supplier of various natural fibers.

This work uses the Epoxy resin Lapox L-12 supplied by YUGE Marketing Bangalore.

The hardener helps in curing of composites. This experiment work uses the hardener Lapox K-6, supplied by YUGE Marketing Bangalore.

This work uses the VA-LD-300 Cenosphere, procured from KULIN Corporation Wadoda Nagpur.

International Journal of Scientific & Engineering Research, Volume 10, Issue 7, July-2019

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Fabrication and cutting tools: the fabrication and cutting tools used are

- Flat base plate or plane granite surface.
- Different thickness card board sheets for mould preparation.
- Brushes, squeezing roller or plate
- Weighing machine, Electric cutting machine, Safety gloves, glasses and mask

2.2 Composites Preparation

Table 2.1: Volume fraction of different Types of Hybrid laminates

Type	Epoxy(%)	Hemp	Glass	Cenosphere
Type-1	70	30	0	0
Type-2	70	0	30	0
Type-3	60	30	0	10
Type-4	60	0	30	10
Type-5	60	20	10	10
Type-6	60	15	15	10

In this experiment uses Six Types of Natural fiber reinforced polymer Hybrid composites(NFRPHC's) of Three Samples each is prepared by Hand layup method.
Table 3.7 shows different Six Types of NFRPHC's with different volume fractions of constituents.
Composites laminates are prepared by Hand layup method and following figures shows different steps in the preparation.

Fig 2.1:Mould Preparation **Fig2.2**: Pouring Resin

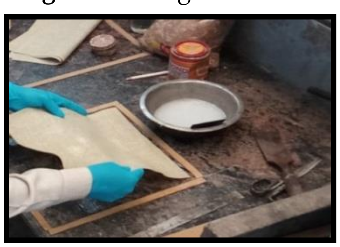

Fig 2.3: Hand layup process **Fig2.4**:Laying of Hemp

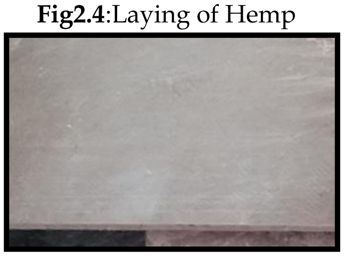

Fig2.5:Resin pouring **Fig:2.6** NFRPHC's composite

Above figures from 2.1 to 2.6 shows the different steps in the preparation of NFRPHC's
Specimens are cut to the sizes as per the ASTM standards for Tensile, Compression and flexural test. Standards followed, dimension details for different hybrid composite are as shown

Table 2.2: Specimens sizes as per ASTM Standards

Sl.No	Test method	ASTM Standard	Specimen Size
1	Tensile test	ASTM D 3039	250mmX25mmX3 mm(L x W x T)
2	Compression test	ASTM D 3410	150mmX25mmX3mm (L x W x T)
3	Flexural test	ASTM D 790	120mmX13mmX3mm (L x W x T)

Specimens shown in **Table 2.2** are cut to sizes by water jet cutting machine

Fig 2.7:Water jet cutting **Fig2.8**: Specimen samples- 3sets

3. MECHANICAL TESTING

Following mechanical testing were carried out on 1- 6 Types of NFRPHC's samples,

1) Tensile test
2) Compression test
3) Flexural test

Tensile Test: Tensile test is carried out on 2 Ton Tensometer set up, where pulling loads are applied till the failure of sample, to determine how the material behaves in tensile load and maximum tensile strength, young's modulus are calculated.
Compression test: Compression test is carried out on 2 Ton Tensometer set up, where pushing loads are applied till the failure of sample, to evaluate how the material behaves in compressive load.
Flexural test: Flexural test is carried out on 2 Ton Tensometer set up, where three point loads are applied till the bending failure of sample, and is conducted to determine how the material behaves in bending load.

International Journal of Scientific & Engineering Research, Volume 10, Issue 7, July-2019

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4. RESULTS AND DISCUSSION

In this experimental work Tensile, Compression, and Flexural strength of all Type 1 to Type 6 samples are carried out for each of three samples and results are discussed as below.

4.1 Tensile Strength analysis.

Tensile test is conducted on 18 samples of 6–Types of different ratio of the fiber and matrix volume fraction. The samples according to ASTM standard-D3039 are tested on 2 Ton Tensometer Machine.

Table.4.1 Tensile Test results of samples of NFRHPC

Type	Composition	Tensile strength Mpa
Type-1	E70, H30, G0 C0	31.174
Type-2	E70, H0, G30 C0	98.527
Type-3	E60, H30, G0 C10	31.396
Type-4	E60, H0, G30 C10	82.976
Type-5	E60, H20, G10 C10	58.193
Type-6	E60, H15, G15 C10	49.917

Above **table 4.1** shows the Tensile test results for six Types of NFRPHC's samples.

Fig.4.1: Tensile test specimen before and after test.

Above **fig 4.1** shows Tensile test specimens before and after test.

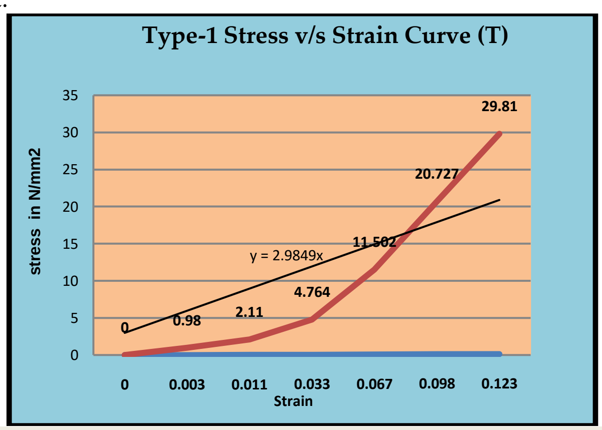

Fig.4.2: Stress Strain Curve (Tensile) for Type-1 NFRPHC's.

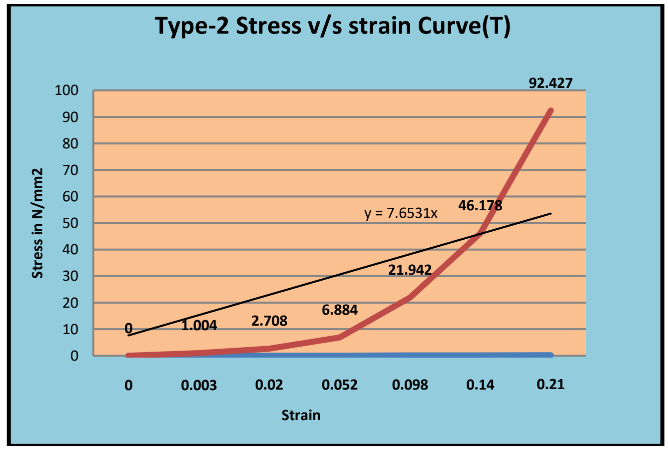

Fig.4.3: Stress Strain Curve (Tensile) for Type-2 NFRPHC's.

Above **Fig 4.2 and 4.3** shows the Stress v/s Strain curves which are obtained directly from the machine for Tensile test. The relationship between the curves is unique for every material.

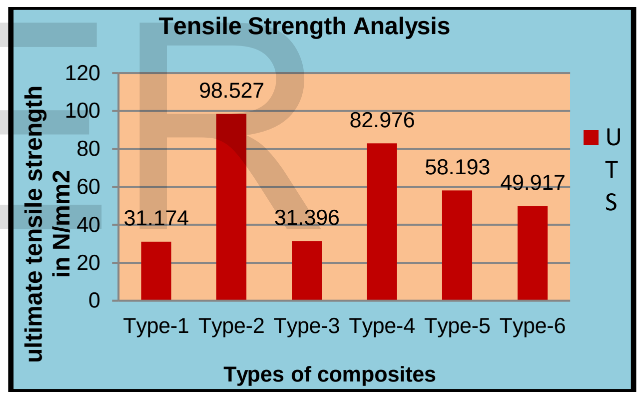

Fig.4.4: Tensile strength of 6-Types of NFRPHC's

Above **Fig 4.4** shows the average tensile strengths of Type-1 to Type-6 NFRPHC's, it is observed that Type-1 is Natural fiber(Hemp) reinforced polymer matrix (Epoxy) composite having tensile strength of 31.174 MPa, Type-2 is Synthetic fiber (Glass mat) reinforced composite shows 98.527 Mpa.

Type 3 to Type-6 are prepared with adding filler material called Cenosphere , for Type-3 and Type-4 addition of filler material decreases the strength of hybrid composite to some extent, compared to corresponding single hemp and glass fiber composites.

In Type-5 and Type-6, it reveals that 2:1 ratio of Natural to Synthetic fibers (Type-5) with filler material yields good tensile strength of 58.193 MPa compared to 1:1 ratio of fibers (Type-6) of 49.917 MPa tensile strength.

International Journal of Scientific & Engineering Research, Volume 10, Issue 7, July-2019

ISSN 2229-5518

4.2 Compression strength analysis.

Compression test is conducted on 18 samples of 6–Types of different ratio of the fiber and matrix volume fraction. The samples according to ASTM standard-D3410 are tested on 2 Ton Tensometer Machine.

Table.4.2 Compression Test results of samples of NFRHPC

Type	Composition	Compression strength Mpa
Type-1	E70, H30, G0 C0	2.518
Type-2	E70, H0, G30 C0	5.297
Type-3	E60, H30, G0 C10	3.629
Type-4	E60, H0, G30 C10	5.467
Type-5	E60, H20, G10 C10	4.618
Type-6	E60, H15, G15 C10	9.834

Table 4.2 shows the Compression test results for six Types of NFRPHC's samples.

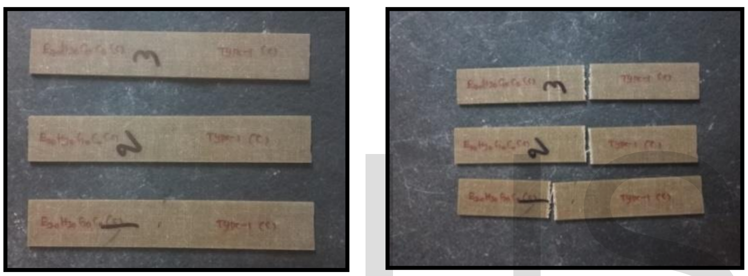

Fig.4.5: Compression test specimen before and after test.

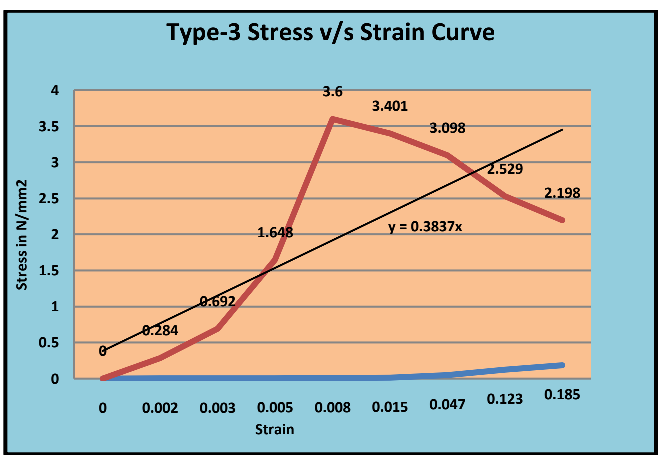

Fig.4.6 Stress Strain Curve (Compression) for Type-3 NFRPHC's.

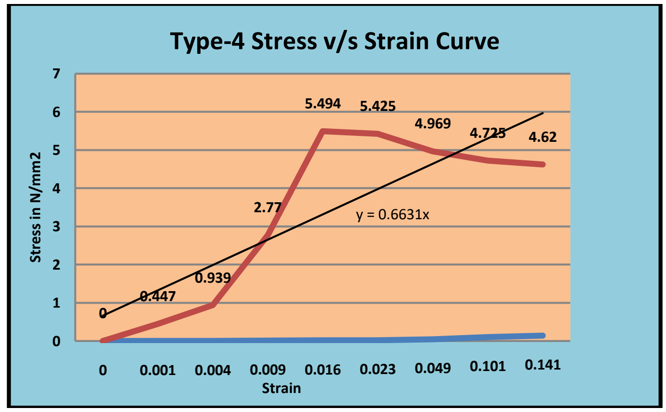

Fig.4.7 Stress Strain Curve (Compression) for Type-4 NFRPHC's.

Above **Figures 4.6 and 4.7** shows the Stress v/s Strain curves which are obtained directly from the machine for Compression test. The relationship between the curves is unique for every material.

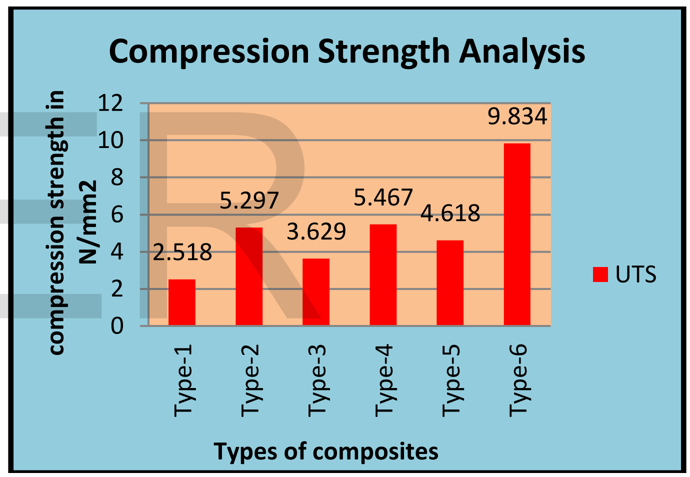

Fig.4.8: Compressive strength of 6-Types of NFRPHC's

Fig 4.8 shows the average Compression strengths of Type-1 to Type-6 NFRPHC's, it is observed that Type-1 is Natural fiber(Hemp) reinforced polymer (Epoxy) composite having Compression strength of 2.518 MPa, and Type-2 is Synthetic fiber (Glass mat) reinforced composite shows 5.297Mpa.

Type 3 to Type-6 are prepared with adding filler material called Cenosphere , for Type-3 and Type-4 addition of filler material decreases the strength of hybrid composite, compared to corresponding single fiber composites.

In Type-5 and Type-6, it reveals that 2:1 ratio of Natural to Synthetic fibers (Type-5) with filler material Hybrid composites yields less compression strength of 4.618 MPa compared to 1:1 ratio of fibers (Type-6) of 9.834 MPa compression strength.

International Journal of Scientific & Engineering Research, Volume 10, Issue 7, July-2019

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4.3 Flexural strength analysis.

Flexural test measures the load required for the composite material for bending under three point loading conditions. This data is helpful in the selection of materials for the parts which are used to support the loads without bending [7].

Table.4.3 Flexural Test results of samples of NFRHPC

Type	Composition	Flexural strength Mpa
Type-1	E70, H30, G0 C0	55.93
Type-2	E70, H0, G30 C0	195.27
Type-3	E60, H30, G0 C10	48.05
Type-4	E60, H0, G30 C10	152.70
Type-5	E60, H20, G10 C10	90.38
Type-6	E60, H15, G15 C10	107.59

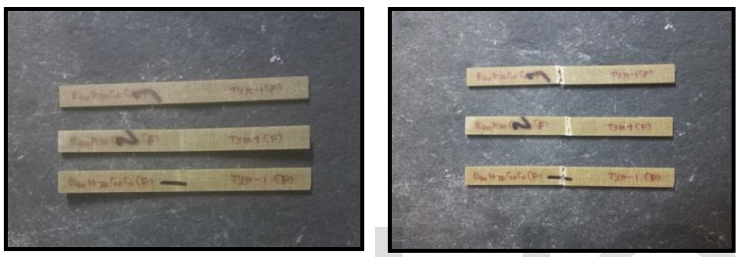

Fig 4.9 Flexural test specimen before and after test.

Above **fig 4.9** shows Flexural test specimens before and after test.

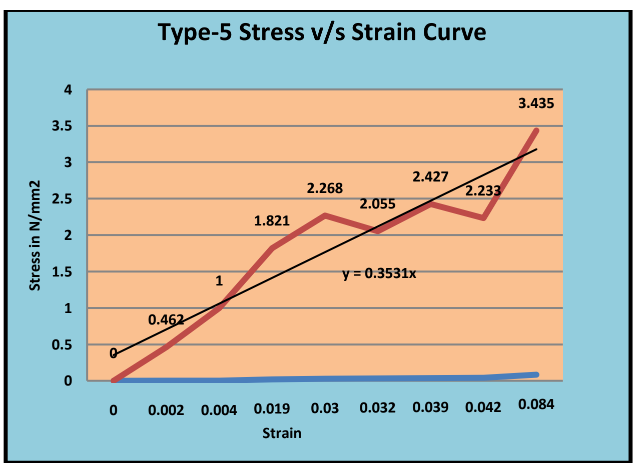

Fig.4.10 Stress Strain Curve (flexural) for Type-5 NFRPHC's.

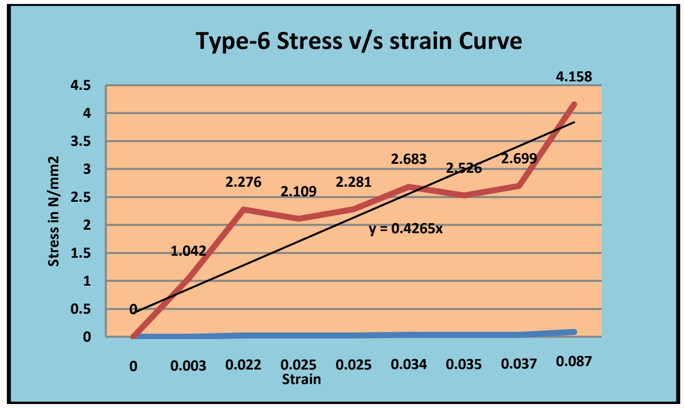

Fig.4.11 Stress Strain Curve (Flexural) for Type-6 NFRPHC's.

Above **Fig 4.10** and **4.11** shows the Stress v/s Strain curves which are obtained directly from the machine for Flexural test. The relationship between the curves is unique for every material.

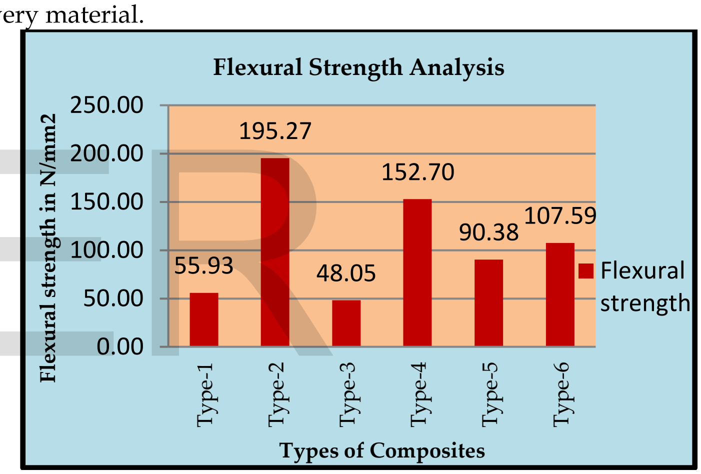

Fig.4.12: Flexural strength of 6-Types of NFRPHC's

Above Fig 412. shows the average Flexural strengths of Type-1 to Type-6 NFRPHC's, it is observed that Type-1 is Natural fiber(Hemp) reinforced polymer (Epoxy) composite having flexural strength of 55.93 MPa, and Type-2 is Synthetic fiber (Glass mat) reinforced composite shows 195.27Mpa.

Type 3 to Type-6 are prepared by adding filler material called Cenosphere , for Type-3 and Type-4 addition of filler material decreases the strength of hybrid composite to some extent, compared to corresponding single fiber composites.

In Type-5 and Type-6, it reveals that 2:1 ratio of Natural to Synthetic fibers (Type-5) with filler material Hybrid composites yields less flexural strength of 90.38 MPa compared to 1:1 ratio of fibers (Type-6) of 107.59 MPa flexural strength.

International Journal of Scientific & Engineering Research, Volume 10, Issue 7, July-2019
ISSN 2229-5518

5. USE OF NFRPHC's FOR AUTOMOBILE APPLICATION

Presently the Bike mud guards in automobiles are manufactured by plastic materials, which is necessary part for guarding the Engine casing against splashing of mud or sand over it. The properties of plastic material used in mudguard and the properties of NFRPHC's samples with variety of combinations of varying volume fractions of our experimental work are compared and discussed.

Table 5.1: comparison of plastic and NFRPHC's [5]

Test parameter	Plastic material Mud Guard	Experimental NFRPHC's	
		Type-1	Type-5
Tensile strength in MPa	18.99	31.174	58.193
Compression strength in MPa	-	2.518	4.618
Flexural strength in MPa	29.68	55.93	90.38

Table 5.1 shows the comparison of plastic material which is used in currently in bikes is compared with the experimental hybrid composites NFRPHC's of Type-1 and Type-5.

Result had shown that in first comparison, Type-1 composite material with only, Hemp natural fiber reinforced epoxy matrix composite with volume compositions of 30% Hemp fabric and 70% Epoxy matrix has greater Tensile, Compression, Flexural and Impact strengths, and is potential to replace the present plastic mud guard.

In second comparison Type-5 a NFRPHC's containing different volume compositions with 60% Epoxy, 20% Hemp fabric, 10%Glass mat, and 10% Cenosphere had shown a remarkable Tensile, Compression, Flexural, and Impact strengths and is potential to replace many steel parts of the bike.

With this results experimental NFRPHC's can be used in automobile sectors and these composites uses less volume of synthetic fiber and are less pollution and partially biodegradable.

6. CONCLUSION AND SCOPE FOR FUTURE WORK

6.1 Conclusion

In this experimental work different tests conducted and analyzed and following conclusions are drawn.

1. Use of fibers ratios in present work NFRPHC's Natural fiber to Synthetic fiber in the ratio 2:1 gives high tensile strength of 58.193 MPa compared to 1:1 fiber ratio which is 49.917 MPa.
2. Type-5 having composition of 60% Epoxy, 20% Hemp(E60, H20, G10 C10) yields high tensile strength 58.193 MPa which is having high potential to replace carbon fiber and even steel material in automobile applications.
3. Present plastic mud guards used in Bikes having lower tensile strength which can be easily replaced by only Hemp fiber epoxy matrix composite Type-1 or Type-5 composite material.
4. Type-5 NFRPHC's found remarkable Tensile, Compression, Flexural and Impact strengths which is high potential to replace many steel parts in automobile sector.
5. In present experimental work the filler material cenosphere kept 10% constant and varied with natural and synthetic fibers volume composition and is observed that ratio of natural to synthetic fibers i.e 2:1 ratio shows high tensile, compression and impact strengths, and less flexural strengths compared to 1:1 corresponding fiber ratios.
6. Cost of manufacture of NFRPHC's may be more compared to plastic mud guards but use of NFRPHC's is more environmental friendly with partial biodegradabile and recyclable.

6.2 Scope for Future work

1. Different types of natural fibers can be used for fabrication of Hybrid composites instead of Glass fiber by mixing with volume fractions.
2. Instead of Epoxy different polymers can be used for fabrication process.
3. Increase the Samples by varying the different volume fractions.
4. Identify the applications by adding different types of natural fibers by replacing Glass fibers.
5. Filler material cenosphere can be added in different ratios to study the physical properties of composites
6. More number of physical properties can be determined to identify the composite material for different applications.

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