Integration and Characterization of Honeycombed Sandwich Composite Material for Automobile Applications.

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Abstract - With the world experiencing rapid global warming, we began to be concerned about the environment and how we could care for it only a few decades ago. The strategy has now shifted to reducing consumption and pollution. In the automotive sector, the need to reduce weight and fuel consumption without sacrificing mechanical strength has become a must-study. This is accomplished by improving existing technologies and developing new ones. Materials engineering is one of these emerging new technologies. Composite materials, which originated in the aerospace and aeronautics industries, are now being brought to the car industry. One such endeavour is to design a material that will allow the vehicle to be lighter. This material can be used to make a variety of automotive parts. This study is unusual in that it incorporates epoxy-based composite materials as well as a honeycomb material filled with liquid foam sandwiched between the fibres that can be used as an alternate material for vehicle applications. Mechanical properties of foam filled honeycomb sandwich composites and without foam honeycomb sandwich composites are compared.

Key Words: Composite materials, Honeycomb material, Foam, Automotive parts

1. INTRODUCTION

Harmful vehicular emissions have had a negative impact on the environment and human health for decades. The rising level of air pollution caused by the transportation sector has prompted many government agencies to impose stringent regulations on automobile manufacturers in order to keep harmful emissions within permissible limits. It is discovered that every 15% reduction in vehicle weight results in a 7% reduction in fuel consumption. All of these factors have contributed to the development of a material that can be used as a substitute in automobiles. This paper focuses on the fabrication and testing of various mechanical properties of foam-filled honeycomb sandwiched epoxy-based composite material. Honeycomb material is utilised to extend the life of the composite material while also increasing its ductility. In this work Kraft paper honeycomb material is used. To enhance strength and improve the stiffness of the honeycomb material, polyurethane foam of different densities are utilised to fill the honeycomb core. Thus prepared composite materials are tested for various properties and compared with that of the sandwich composites in which the paper honeycomb material is not filled with foam.

2. Materials and fabrication

This section goes over the raw materials that are used and the fabrication process that is carried out. The following materials were used:

1) Natural fiber(Jute, Banana)
2) Honeycomb material(Paper)
3) Polyurethane foam(50Kg/m^3 and 60 Kg/m^3)
4) Epoxy and hardener

2.1. Materials

Composites are still commonly employed in various engineering fields of application. Because of its challenges with longevity and the difficulties in assessing its accomplishment over its period of aid, it is still employed in a limited fashion. To counter this disadvantage, honeycomb material is sandwiched between natural fibre in order to extend the life of the composite material while also increasing its ductility. The core of the honeycomb material has been filled with polyurethane foam to give it more stiffness. The polyurethane foam is obtained by mixing polyol and icocyanate in predetermined ratio Epoxy resin was employed in this project, and it has poor thermal as well as mechanical qualities. This resin is treated to a restorative reaction in order to enhance its characteristics. When this happens, the linear chain of the resin is converted to 3D cross linked chain, which is accomplished by adding the hardener, which is also the curing agent, in a 1:10 ratio. The Fig 1,2,3 shows the paper honeycomb spreaded in mould, natural fibers used and polyurethane foam constituent.

Fig-1: Paper honeycomb

Fig-2: Natural fibers

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Fig-3: Polyurethane foam

2.2. Fabrication Process

The hand layup method was employed in this project. Hand layup is the proper approach that is integrated in this operation since the component produced does not need to be linked to any other components. The binding agent and hardener are properly combined at a 10:1 ratio. The honeycomb core is filled with foam and allowed to cure for about an hour. The next step is to stabilise it before moving on to the next step. A layer of fibre is laid down, then a known-weight epoxy is carefully put over the fibre mat. The fibre mat is then covered with foam-filled honeycomb material. A second layer of fibre is applied over the honeycomb material after flawless adherence, with the aid of binder. The sandwich composite material is next subjected to a predefined continuous load for about 16 hours to eliminate air gaps and ensure appropriate binding. Thus prepared sandwich composites mechanical properties are compared with that of the mechanical properties of sandwich composites in which the honeycomb material is not filled with polyurethane foam. The honeycomb sandwich composite material elements are shown in Fig-4

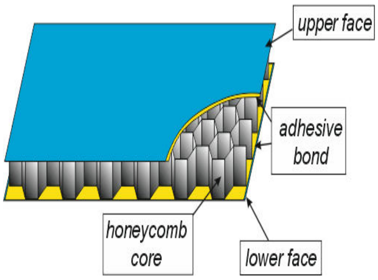

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Fig-4:Honeycomb sandwich composite

Fig-5: Mixing of polyol and isocyanate

Fig-6: Pouring of PU foam

Fig-7: Paper Core material

Fig-8: Sandwich composite

Fig 5, 6 shows some stages of fabrication process. Fig 7, 8 shows the core material and the natural fiber embedded sandwich composite material. Hence prepared specimens are named based on the materials used in it. J and B indicates the name of the fibre used that is Jute and Banana fibre. 1 and 2 represents the density of the foam used that is 50 and 60 Kg/m3.Table 1 shows the detailed description of the specimens. Specimen name JP and BP represents the sandwich composites without foam filled in honeycomb material.

Table-1: Specifications of the specimens

Sl. No	Specimen name	Fiber used	Honeycomb material	Density of the foam(Kg/m^3)
1	JP1	Jute	Paper	50
2	JP2	Jute	Paper	60
3	BP1	Banana	Paper	50
4	BP2	Banana	Paper	60
5	JP	Jute	Paper	Nil
6	BP	Banana	Paper	Nil

3. Experimental procedure

3.1 Tensile strength

The specimens for the tensile test are manufactured in accordance with ASTM D3039. Tensile, compression, and bending tests are carried out in accordance with industry standards. The TUE-C-400 UTM machine was used to perform the tensile test. The specimen was machined to conventional dimensions of 150mm in length, 20mm in thickness, and 30mm in breadth.

Fig-9: UTM Test arrangement for tensile test

3.2. Compressive strength

The compression test was conducted according to the ASTM C365 standard, with specifications of 150mm length, 20mm thickness, and 30mm breadth. The TUE-C-400 UTM machine was used to perform the compression test.

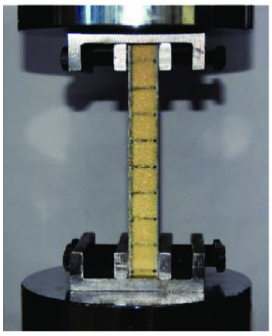

Fig-10: UTM Test arrangement for compressive test

3.3. Impact strength

Ability of the material to withstand the predetermined load which is applied suddenly on it is termed as impact strength of that material. Specimen was made as per the ASTM D7766 standard and impact strength was tabulated by carrying out Charpy test with 5Joule of impact energy. Specimen size is as same as that of the tensile strength specimen dimensions.

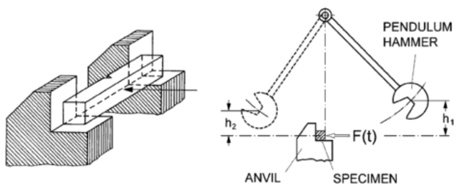

Fig-11: Schematic of the Impact test arrangement

4. Results and discussions

4.1 Tensile strength

Table 2 shows the tensile strength of the different specimens. It is been observed that specimen JP2 i.e. the specimen with foam density of 60Kg/m^3 embedded with jute fiber exhibited better tensile strength when compared to that of other specimens. Minimal tensile strength was observed in specimen BP which is not filled with foam material and it is embedded using banana fiber.

Table-2: Average tensile strength

Specimen name	Average tensile strength(MPa)
JP1	5.35
JP2	6.02
BP1	3.92
BP2	4.58
JP	3.81
BP	3.33

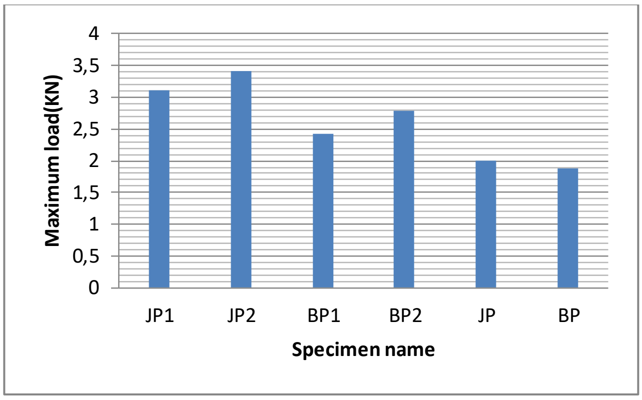

Fig-12: Maximum Tensile Load Comparison

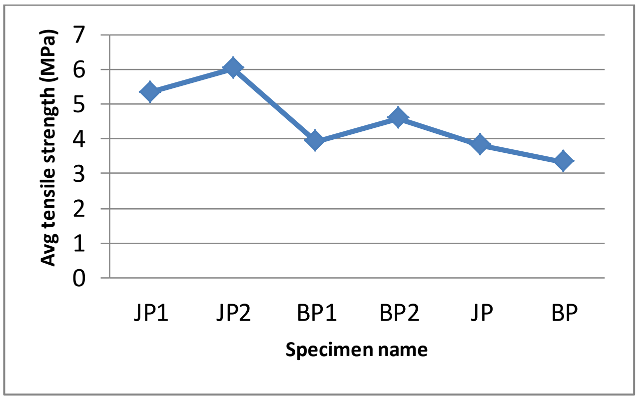

Fig-13: Comparison of Average tensile strength

From Fig-13 it is clear that foam filled honeycomb with jute fiber exhibits more enhanced tensile property than the material without foam. Also the maximum load bearing capacity was also found to be greater for specimen JP2.Fig-12 shows the comparison of maximum tensile load.

4.2. Compression strength

The average compressive strength of the sandwich composite materials is shown in Table 3.

Table-3: Average compression strength

Specimen name	Average compressive strength(MPa)
JP1	17.54
JP2	18.03
BP1	14.36
BP2	15.12
JP	11.22
BP	10.73

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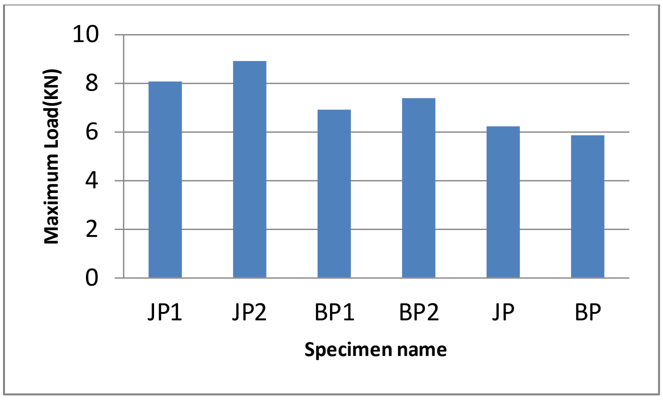

Fig-14: Comparison of Maximum compressive load

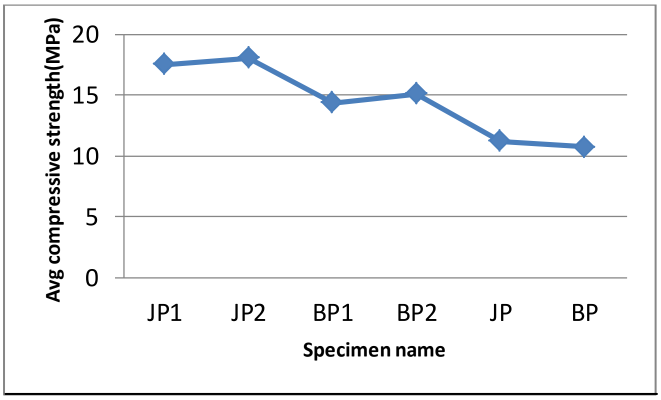

Fig-15: Comparison of average compressive strength

Fig-14 represents the comparison of maximum compressive load that a material can bear. From this graph it is been observed that specimen with jute fiber which is filled with 60Kg/m^3 of foam had better load bearing capacity which is 8.68KN.Fig-15 indicates the average compressive strength of various specimens. It is clear that the addition of foam to the honeycomb cores enhances its properties. The composite which is not filled with foam into their cores had a compressive strength of 6.24 and 5.86MPa respectively for specimens JP and BP.

4.3. Impact strength

The impact energy is dispersed over the specimen's breadth. In comparison to previous specimens, a paper core filled with 60 kg/m3 density foam and sandwiched between jute fibers could absorb more impact energy. The average impact strength of the various sandwich specimens is compared in Fig-16. When compared to other sandwich specimens, the JP2 specimen, i.e. the specimen with an paper honeycomb core filled with higher density foam sandwiched between the jute fibers, has good impact strength. Moreover, it is noticed that banana reinforced sandwich composites is having less impact strength as of compared with the jute reinforced sandwich composites. The maximum impact strength observed was 83J in the specimen JP2 and the minimum impact strength observed was 34J in the specimen BP.

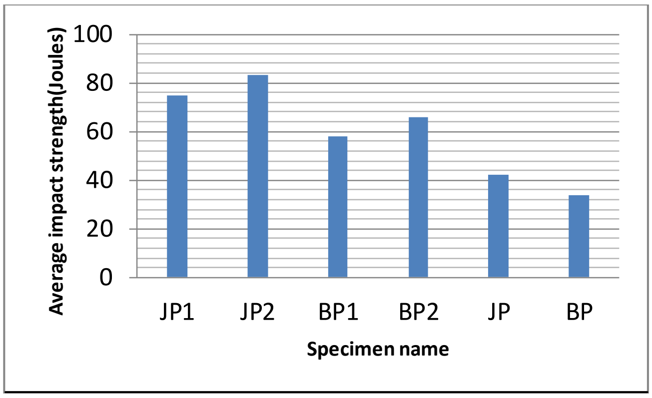

Fig-16: Comparison of average impact strength

5. CONCLUSIONS

The mechanical characteristics of sandwich composites implanted with paper honeycomb material and various foam densities were compared to those of a paper honeycomb sandwich composite that was not filled with foam material. The study employed two types of fibers, namely jute and banana fibers, and the following conclusions were drawn based on the findings.

1. The specimen implanted with jute fiber had a higher tensile strength than the banana fiber embedded composites, according to the tensile test results. The maximum force for breaking was required for a paper honeycomb material with a foam density of 60 kg/ m^3 (JP2).
2. Jute-embedded sandwich composites demonstrated higher compressive strength than banana-embedded sandwich composites, according to compression tests. It was also observed that when the foam density increased, the material's compressive strength increased somewhat.
3. The impact test confirms that the specimen JP2 has a higher impact energy absorption capability and is less likely to shatter. When compared to banana embedded sandwich composites with paper honeycomb material filled with different foam densities, it was discovered that jute embedded paper honeycomb filled with 50 and 60Kg/m^3 of foam had extremely strong impact strength.
4. With all tests it was also concluded that the addition of foam to the core material will always enhance the properties of the sandwich composites.

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