# EXPERIMENTAL INVESTIGATION OF SUITABLE CAR BUMPER MATERIAL USING GFRP, KENAF, SISAL AND KAPOK FIBER

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**ABSTRACT**

*Bumper is one of the main parts which are used as protection for passengers from front and rear collision. The aim of this project is choose the new composite material to absorb the strain energy under impact loading. In this study, the most important variables like composite materials replace the ABS plastic to natural composites like kenaf,sisal and kapok fiber, hybrid composite materials includes the combination of synthetic fiber such as GFRP and the natural fiber compositions, then the tensile and bending test is used to find the material tensile and compressive strength and IZOD impact testing is used to find the strain energy of the natural and hybrid composite materials are tested and the suitable composite material is suggested according to its impact test values.*

***KEYWORDS***: *Kenaf fiber,kapok fiber,sisal fiber,GFRP*

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## 1.INTRODUCTION

Nowadays, in development of technology especially in engineering field make among the engineers more creative and competitive in designing or creating new product. They must be precise and showing careful attentions on what they produce. Here, we concentrate on automotive industry. The greatest demand facing the automotive industry has been to provide safer vehicles with high fuel efficiency at minimum cost. Current automotive vehicle structures have one fundamental handicap, a short crumple zone for crash energy absorption.One of the options to reduce energy consumption is weight reduction. However, the designer should be aware that in order to reduce the weight, the safety of the car passenger must not be sacrificed. A new invention in technology material was introduced with polymeric based composite materials, which offer high specific stiffness, low weight, corrosion free, and ability to produce complex shapes, high specific strength, and high impact energy absorption.

Substitution of polymeric based composite material in car components was successfully implemented in the quest for fuel and weight reduction. Among the components in the automotive industry substituted by polymeric based composite materials are the bumper beam, bumper fascia, spoiler, connecting rod, pedal box system, and door inner panel. The bumper system consists of three main components, namely bumper beam, fascia and energy absorber.The automotive body is one of the critical subsystems of an automobile, and it carries out multiple functions. It should hold the parts of the vehicle together and serve to filter noise and vibration. Additionally, it should be able to protect its occupants when accidents happen. To do this, the automotive body designer should create a structure with significant levels of strength, stiffness, and energy absorption.

## 2.MATERIALS AND METHODS

### 2.1 Raw materials:

The major raw materials used are Hardener,Resin,Kenaf fiber,Sisal fiber,Kapok fiber and GFRP

## 2.1.1Hardener (HY-951):

Hardener is a curing agent for epoxy or fiberglass. Epoxy resin requires a hardener to initiate curing; it is also called as catalyst, the substance that hardens the adhesive when mixed with resin. It is the specific selection and combination of the epoxy and hardener components that determines the final characteristics and suitability of the epoxy coating for given environment. Chemical reaction initiated by mixing resin and hardener results in the generation of exothermic heat. Unfilled resin systems are suitable only for manufacturing castings weighing up to about 500 grams. To determine whether cross-linking has been carried to completion and the final properties are optimal, it is necessary to carry out relevant measurements on the actual object or to measure the glass transition temperature. Different gel and cure cycles in the customer's manufacturing process could lead to a different degree of crosslinking and thus a different glass transition temperature. Storage Conditions Store the components in a dry place at room temperature.

## 2.2.2 Epoxy resin(LY556):

Epoxy resins, also known as polyepoxides, are a class of reactive prepolymers and polymers which contain epoxide groups. Epoxy resins may be reacted (cross-linked) either with themselves through catalytic homopolymerisation, or with a wide range of co-reactants including polyfunctional amines, acids (and acid anhydrides), phenols, alcohols and mercaptans.. Reaction of polyepoxides with themselves or with polyfunctional hardeners forms a thermosetting polymer, often with favorable mechanical properties and high thermal and chemical resistance. Epoxy has a wide range of applications, including metal coatings, use in electronics/electrical components LEDs, high tension electrical insulators, paint brush manufacturing, fiber-reinforced plastic materials and structural adhesives. Epoxy is sometimes used as a glue**.**

**Table 2.1** Properties of Epoxy LY 556

| | |
|---|---|
| Aspect (visual) | clear, pale yellow liquid |
| Epoxy content | 5.30 - 5.45 Eq/kg |
| Viscosity | 10000 - 12000 mPa s |
| Density | 1.3 g/cm3 |
| Flash point | > 200 °C |
| Storage temperature | 2 - 40 °C |

## 2.2.3 Kenaf fiber:

Kenaf is a traditional, third world crop after wood and bamboo that is poised to be introduced as a new annually renewable source of industrial purpose in the so-called developed economies. Kenaf is a warm-season annual fiber crop growing in temperate and tropical areas. It is related to cotton, okra, and hibiscus due to systematic. It is a fibrous plant, consisting of an inner core fiber (75–60%), which produces low quality pulp, and an outer bast fiber (25–40%), which produces high quality pulp, in the stem. The plant grows to a height of 2.7–3.6mand is harvested for its stalks, from which the fiber is extracted.

**Fig 2.1** Kenaf fiber

## 2.2.4 Kapok fruit fiber:

The word kapok refers both to the tree and to the fibre it produces, which is also known as silk cotton or Java cotton. The hair-like fibres that surround the kapok seeds are best used as a stuffing, where they have several advantages over more commonly used materials. Kapok fibers on their own are not suitable for spinning into yarn, as they are too smooth, slippery and brittle.

Native to Central America, kapok is now widely spread in rainforests around the world and is grown commercially in Java, Thailand and other countries.

Kapok is a majestic rainforest tree that grows up to 60 meters tall and towers over other rainforest trees. This huge tree needs to be stabilized by buttresses, making it very wide and up to 3 meters in diameter. The trunk and large branches often have very large thorns. The canopy supports a large variety of plants and animals.

**Fig 2.2** Kapok Fruit Fiber

## 2.2.5 Sisal Mat:

Sisal, with the botanical name Agave sisalana, is a species of Agave native to southern Mexico but widely cultivated and naturalized in many other countries. It yields a stiff fibre used in making various products. The term sisal may refer either to the plant's common name or the fibre, depending on the context. It is sometimes referred to as "sisal hemp", because for centuries hemp was a major source for fibre, and other fibre sources were named after it. The sisal fiber is traditionally used for rope and twine, and has many other uses, including paper, cloth, footwear, hats, bags, carpets, and dartboards. Sisal plants, Agave sisalana, consist of a rosette of sword-shaped leaves about 1.5–2 metres (4.9–6.6 ft) tall. Young leaves may have a few minute teeth along their margins, but lose them as they mature.

**Fig 2.3** Sisal

## 2.2.6 Fiberglass/GFRP

Fiberglass is a type of fiber-reinforced plastic where the reinforcement fiber is specifically glass fiber. The glass fiber may be randomly arranged, flattened into a sheet (called a chopped strand mat), or woven into a fabric. The plastic matrix may be a thermosetting plastic – most often epoxy, polyester resin – or vinyl ester, or a thermoplastic. Fiberglass is a strong lightweight material and is used for many products. Although it is not as strong and stiff as composites based on carbon fiber, it is less brittle, and its raw materials are much cheaper. Its bulk strength and weight are also better than many metals, and it can be more readily molded into complex shapes. Applications of fiberglass include aircraft, boats, automobiles, bath tubs and enclosures, swimming pools, hot tubs, septic tanks, water tanks, roofing, pipes, cladding, casts, surfboards, and external door skins.

**Fig2.4** Glass fiber

**Table 2.2** Material Properties

| MATERIAL PROPERTIES | ABS PLASTIC | KENAF FIBRE | GFRP | KAPOK FIBRE | SISAL FIBRE |
|---|---|---|---|---|---|
| DENSITY ($KG/M^3$) | 1020 | 1550 | 2100 | 1300 | 1200 |
| YOUNGS MODULUS(GPA) | 2 | 53 | 72 | 4 | 2.91 |
| POISSON RATIO | 0.394 | 0.2 | 0.21 | 0.38 | 0.4 |

## 3.SELECTION OF VARIOUS COMPOSITION

According to the bumper material requirement, the existing model includes only GFRP as the major constituent, but the composition of the GFRP is reduced and it is replaced partially with the natural fibers to increase the impact strength of the material and the alternate composition with pure natural fiber is also tested and the impact strength, flextural property and hardness properties are compared and suitable material for the bumper material is suggested. The main reason for suggesting this composition is to provide an equal weightage for all fibers.

**Table 3.1** Compositions for hybrid and natural fibers

| | GFRB | KENAF FIBER | SISAL FIBER | KAPOK FIBER |
|---|---|---|---|---|
| **COMPOSITION1** | 40 | 20 | 20 | 20 |
| **COMPOSITION2** | 0 | 35 | 35 | 30 |

## 4.PREPRATION OF SPECIMEN USING HAND LAY UP PROCESS:

Hand lay-up technique is the simplest method of composite processing. The infrastructural requirement for this method is also minimal. The processing steps are quite simple. First of all, a release gel is sprayed on the mold surface to avoid the sticking of polymer to the surface. Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product. Reinforcement in the form of woven mats or chopped strand mats is cut as per the mold size and placed at the surface of mold after 12 Perspex sheet. Then thermosetting polymer in liquid form is mixed thoroughly in suitable proportion with a prescribed hardener (curing agent) and poured onto the surface of mat already placed in the mold. Second layer of mat is then placed on the polymer surface and a roller is moved with a mild pressure on the mat-polymer layer to remove any air trapped as well as the excess polymer present. The process is repeated for each layer of polymer and mat, till the required layers are stacked. After placing the plastic sheet, release gel is sprayed on the inner surface of the top mold plate which is then kept on the stacked layers and the pressure is applied. After curing either at room temperature or at some specific temperature, mold is opened and the developed composite part is taken out and further processed. The time of curing depends on type of polymer used for composite processing. For example, for epoxy based system, normal curing time at room temperature is 24 - 48 hours. Capital and infrastructural requirement is less as compared to other methods. Production rate is less and high volume fraction of reinforcement is difficult to achieve in the processed composites. Hand lay-up method finds application in many areas like aircraft components, automotive parts, boat hulls, daises board, deck etc.

**Fig 4.1** Hand lay process

## 5.TESTING OF SPECIMEN

### 5.1 Tensile Test

The tensile test is done by cutting the composite specimen as per ASTM: D638 standard (sample dimension is (216 × 19 × 3 mm). A universal testing machine (UTM) is used for testing with a maximum load rating of 100 KN. Composite specimens with different fiber combinations are tested. In each case, three samples are tested and the average is determined and noted. The specimen is held in the grip and load is applied and the corresponding deflections are noted. The load is applied until the specimen breaks and break load, ultimate tensile strengths are noted. Tensile stress and strain are recorded and load vs length graphs are generated.

**Fig 5.1** Specimen for Tensile Test

## 5.2 Flexural Test

The flexural test is done in a three point flexural setup as per ASTM: D790 standard (sample dimension is 80 × 8 × 3 mm3 ). When a load is applied at the middle of the specimen, it becomes bends and fractures . This test is carried out in the UTM from which the breaking load is recorded and load vs length graphs are generated.

**Fig 5.2** Specimen for three point flex test

## 5.3 Impact Test

The impact test is done in a charpy impact setup as per ASTM: D256 standard (sample dimension is 65 × 12.5 × 3 mm3 ). The specimen must be loaded in the testing machine and allows the pendulum until it fractures or breaks. Using the impact test, the energy needed to break the material is noted and used to measure the toughness of the material and the yield strength. The effect of strain rate on fracture and ductility of the material is analyzed.

**Fig 5.3** Specimen for Impact Test

## 5.4 Hardness test

The hardness of the samples was measured using a Rockwell hardness tester supplied by M/s. PSI Sales (P) Ltd., New Delhi. Test specimens were made according to ASTM D 2240-86. The diameter of the ball indenter used was 0.25 inches and the maximum load applied was 60 kg as per the standard of L-scale of the tester. This test was carried out at room conditions. The readings were taken 10 s after the indenter made firm contact with the specimen. The test was repeated five times for each sample and the average value was reported.

**Fig 5.4** Specimen for hardness test

## 5.5 Water absorption

The water absorption tests were carried out following the recommendations specified in ASTM D5229M-12 (ASTM, 2012). Each composite sample was dried in an air blast oven to remove surface moisture and adhering lubricant before weighing. The weight of the oven dried samples was reported as the initial weight of the composites. The samples were then placed in distilled water maintained at room temperature (25°C); and at time intervals of 24 hours, the composite samples were removed from the water, cleaned using a dry cloth and weighed. The weight measurements were taken periodically at time intervals of 24 hours for up to 168 hours. This was after water saturation in all the composite samples had been noticed.

## 6. RESULT AND DISCUSSION

**TABLE 5.1** Comparison of result

| | GFRP + KENAF + SISAL + KAPOK | KENAF + SISAL + KAPOK |
|---|---|---|
| **TENSILE STRENGTH IN Mpa** | 27.16 | 49.92 |
| **FLEXURAL LOAD IN KN** | 2.17 | 1.98 |
| **IMPACT VALUES IN JOULES** | 18 | 6 |
| **HARDNESS** | 19,20,19 | 28,28,29 |
| **WATER ABSORPTION** | 0.12 | 0.30 |

From the results obtained it is evident that the impact values of the natural composite material is found to be 6 Joules and for hybrid composites it is found to be 18 Joules which is very much greater than the hybrid composites and while comparing the tensile and hardness properties for hybrid composites is very much lesser than the values of natural composites. But for bumper material the major property required is impact energy and thus the hybrid composite material is suggested as the suitable bumper material.

## 6.CONCLUSION

From this experimental method the alternate replacement for abs plastic is found by the analysis GFRP with kenaf, kapok and sisal fibre material take for the experimental analysis Tensile, compression and impact test are taken to take experimentally and get the material strength and impact strain energy of the material is analysed. From the experimental analysis of the GFRP with kenaf, kapok and sisal fiber(hybrid composite) and another composition with kenaf, kapok and sisal fiber(natural composite) in thickness 9.98mm material was prepared and impact test, flexural test and tensile test was taken. The tensile strength of the hybrid composite is found to be 27.16Mpa and for pure natural composites the tensile strength is found to be 49.92Mpa and the flexural load is found to be 2.17KN(hybrid composite) and 1.98KN(pure natural composite) and the impact value is found to be 6 Joules for natural composite and 18 Joules for hybrid composite which is very much greater than the natural composites and the pure GFRP has an impact value of 11Joules and comparitevely the impact value obtained by using hybrid composite is very much greater than the pure GFRP and natural composite. Thus the hybrid composites are suggested as the bumper material.

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