Effect of Stacking Sequences on Impact properties of Kenaf - Areca Hybrid Epoxy Composite

P.Sathyaseelan, Prabhukumar Sellamuthu

***Abstract:** In this research impact properties of the hybrid natural fiber composites made up of areca, kenaf fiber mats with a 10 wt. % of wood dust as the filler materials in six different stacking sequences are studied. The fibers are treated for 30 hours with 10 % of NaOH solution at room temperature to improve the adhesion properties of the fibers. The composites are made-up by hand lay-up procedure using unsaturated polyester resin combined with a catalyst of Methyl Ethyl Ketone Peroxide (MEKP) and accelerator of Cobalt. The fabricated composites are allowed to cure for 24 hours at room temperature by placing a dead weight which gives a compact pressure. After that the hybrid composites are cut as per ASTM D256 standard to carry out the impact test by Izod Charpy impact tester. Five samples in each stacking were tested for the average value. The impact energy absorbed by specimens with six different stacking sequences are compared. The morphological study of the fractured impact specimens are studied using Scanning Electron Microscope images.*

***Index Terms:** Areca, Kenaf, Impact, SEM*

I. INTRODUCTION

In recent years the environmental concerns around the world had made the industries to find a better alternate for synthetic materials in most of its applications. Natural fibers based composites are one such material which is a better alternate for synthetic fibers [1].Compared with synthetic fibers like carbon, Kevlar, glass, etc. natural fibers requires less power for their production and it also have added advantage of low cost, eco-friendly nature and easy availability. They do have equivalent mechanical properties with that of synthetic fibers[2].These good qualities of the natural fiber based composites enabled them to be used in automobile, aerospace and packing industries [3,4]. There are huge number of natural fibers available today which includes both the fibers extracted from plants and animals. In plant, the fibers are extracted from various parts like leaf, bast, fruit, stalk, etc. In which fibers like coir, banana, hemp, ramie, jute, kenaf, areca, etc. are largely used in the research. Among which areca and kenaf fibers have equivalent properties to that of glass fibers. Composites made with kenaf fibers are used as dash boards and bumper beams in the cars [5]. Kenaf fibers are also used along with other synthetic fibers to have improved properties and such composites are used in the manufacturing of furniture, ceiling of the floors and in automobiles as an interior lining materials [6].Likewise, composites prepared with areca fibers which are of less weight and having improved thermal and mechanical properties are employed in manufacturing of marine components, sports goods and in packing industries[7]. Hybridization technique is used to enhance the properties of composites by using two or more fibers in a single composite laminate. Generally, hybridization may be of synthetic fiber with another synthetic fiber. I.e. carbon fiber with glass fiber and so on. Adding of filler materials in the composite further increase their properties. Fillers materials are organic and inorganic in nature. Organic fillers which are extracted from plants and other natural resources. Whereas inorganic fillers are extracted from synthetic sources. Using of filler materials in composite structures had improved their physical, mechanical and reduces the water absorbing properties [8–11].

The properties of the composites made with fibers are determined by various parameters such as the weight and volume fractions of the fibers and matrix materials used. In addition to that surface modification of the fibers, stacking sequences also have some impact on the mechanical behaviour of the composites[12] In similar way the composite made with filler materials are influenced by factors such as weight and volume fraction of fillers, size of the filler particles, shape of it, chemical configuration of the fillers, and the ability of the filler material to disperse in the matrix material [13].

Many research had been done with natural filler materials including rice husk, wheat husk and coconut coir used along with glass fibers. Among the three fillers coconut fillers enhance the mechanical properties [14].The effect of wt. % of filler material was studied by Kumar et al. 2018 [15] where wood dust was used as the filler material with weight percentage of 2.5, 5, 10 and 12.5. It was found from the results that composite made with 10 wt. % has better mechanical properties compared with other wt. %.

In this research work a constant of 10 Wt. % of wood dust particle as filler material in the matrix of unsaturated polyester resin is used to fabricate the composite of areca, kenaf fibers mats in six different stacking sequences using hand lay-up technique. After the fabrication, the composite is allowed to cure at room temperature for about 24 hours. Later the composite is cut into required dimension as per ASTM standard D256. In each stacking sequences five samples are taken and tested for impact properties.

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The average impact energy absorbed by specimens are noted. Finally, the nature of failure of the impact tested composites are studied using Scanning Electron Microscope (SEM) images.

II. MATERIALS USED

Natural fibers like areca and kenaf in the mat format along with unsaturated polyester resin with catalyst MEKP and accelerator cobalt are bought from M/s. Go Green products, Chennai. The filler material wood dust particles with 500 micrometer particle size are collected from nearby sawmill.

III. MERCERIZATION PROCESS

Mercerization process is carried out on the fibers to alter their surface properties and to upturn the bond between the fibers and matrix. There are many alkaline treatment available among which NaOH is most commonly used. Here the fibers are soaked in 10 wt. % solution of NaOH for about 30 hrs. Later the treated fibers are neutralized by using a solution of 2 % of acetic acid. Lastly, the fibers are dried at a room temperature for about 48 hours after washing with a running water in order remove the excess solution. The wood dust particles are also dried for 24 hours in a hot oven at a temperature of 80 ˚C in order get rid of the moisture content.

IV. MANUFACTURING OF HYBRID NATURAL COMPOSITES

Once after the treatment of the fibers and filler materials are done the manufacture of the composite is carried out by utilizing hand lay-up method. For the fabrication a mould of dimension 200 mm x 200mm is used. The areca and kenaf fiber mats are cut into the size of the mould. The filler material of constant 10 wt. % is maintained throughout the fabrication. Unsaturated polyester resin mixed with filler material, catalyst and cobalt are mixed well with a help of stirrer. The top and bottom plates of the mould are applied with shoe wax in order to remove the fabricated composite from the mould easily. The schematic illustration of the fabrication process is shown in the figure 1.

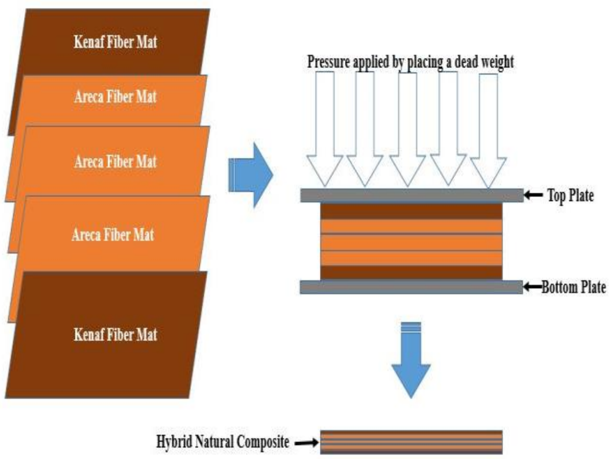

Fig.1. Schematic illustration of the fabrication process

The resin mixture is applied on the bottom plate then the first layer of fiber is placed on the resin layer and pressure is applied by rolling a roller on the fiber layer. After that second coat of resin mixture is applied on the fiber layer later the second layer of fiber is placed and rolling operation is done. Rolling operation is done to confirm uniform spreading of the resin mixture and to remove the voids entrapped in between the layers. Similarly, the remaining layers of fibers and matrix are applied. Finally, the top plate coated with shoe wax is placed on the last layer of the resin mixture and a dead is placed on the composite laminate in order to give a compact pressure to the fabricated composite. The setup is kept undisturbed for 24 hours at room temperature for natural curing.

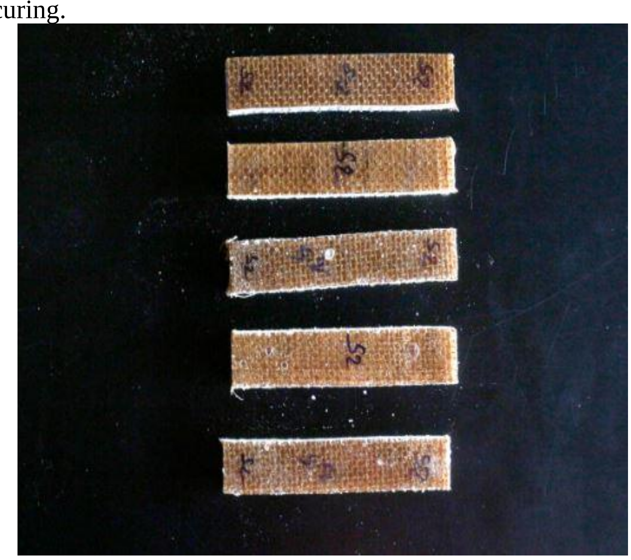

Fig.2. Impact Specimens

Once the composite laminate is cured it is cut down into required dimension as per ASTM standard D256 as shown in figure 2.

V. IMPACT TESTING

Impact test is carried out on the materials to know the amount of energy that can be absorbed by the material when a sudden load is applied. Izod Charpy is the most common method to measure the impact energy. V notch is made on the specimen. Schematic diagram of impact specimen is shown in the figure 3.

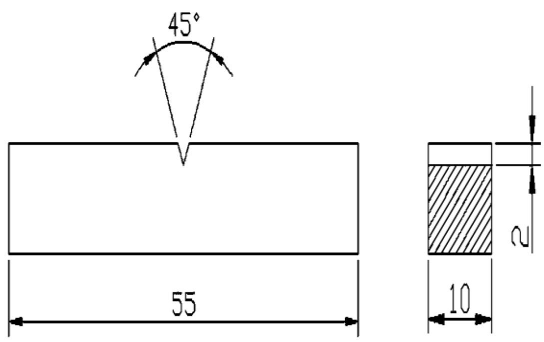

Fig.3. Schematic diagram of impact specimen

The specimen is placed vertically in an impact testing machine as shown in figure 4. The machine is set to zero value on the scale. Later the striker with hammer is released from a known height to strike the vertically placed specimen. The striker hits the test specimen and corresponding impact energy absorbed by the specimen is noted from the scale reading. Five samples in every stacking sequences are tested to get the average value.

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Fig.4. Impact testing of the specimen

VI. IMPACT STRENGTH

The impact strength of the hybrid composite with different stacking sequences was shown in the Figure 5.

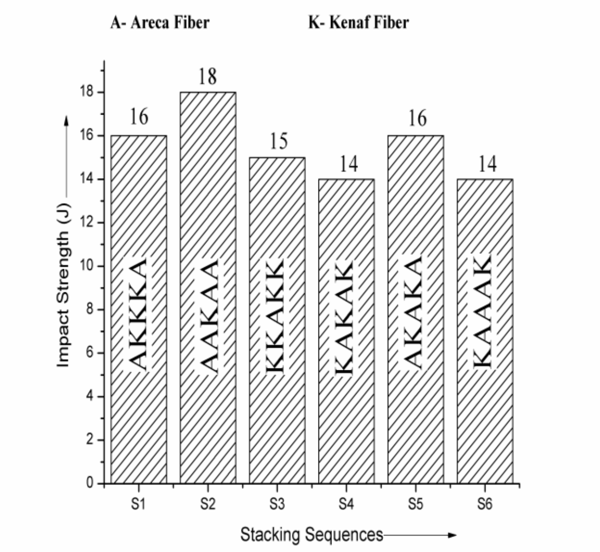

Fig.5. Impact strength of the hybrid composite

It was clear from the result that the specimen (S2) with areca has the top two and bottom two layers have the greater impact strength of 18 J compared with other specimens. Specimens (S1) and (S5) has an impact strength of 16 J followed by specimens (S3), (S4) and (S6) which was having the impact strength of 15 J,14 J and 14 J respectively. Areca absorbs greater impact strength when compared with specimen made with top layers of Kenaf. A similar result was noted by (Padmaraj et al. 2018) was areca fiber absorbed maximum impact energy when compared with coir fiber. There was a better bond among the areca fiber surface and the matrix. Specimens made with top layers with Kenaf fibers absorbs lower impact strength. Specimen (S3) made with Kenaf fibers cannot take more impact strength equivalent to the specimens (S1) and (S5) which was made up of only one layer of areca fibers as upper and bottom layers.

VII. MORPHOLOGICAL ANALYSIS

The morphological analysis of the impact tested specimens are done by using a Scanning Electron Microscopy (SEM). The micrograph obtained are used to know the mode of failure of the fractured specimens. SEM image of impact test specimen is shown in the figure 6.

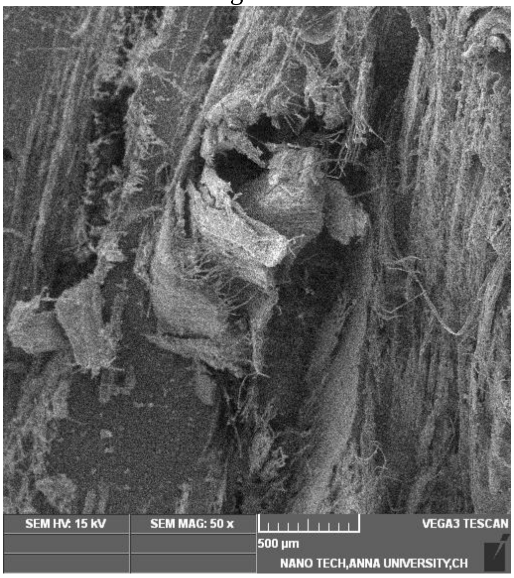

Fig.6. SEM image of impact test specimen

It is clear from the image that the filler material is spread homogeneously in the matrix material. There is a superior bonding between the fibers and matrix material. The filler material is settled in between the fiber layers and enriches the bonding between them. The failure of the specimen is due to the intensity of the impact load. The failure of the composite specimen is in the order of matrix crack initiation, fiber crack, distressing of filler material and then fiber and matrix breakage.

VIII. CONCLUSION

In this research article two natural fibers areca and kenaf in mat format are fabricated in six different stacking sequences with 10 wt. % of wood dust as the filler material. Unsaturated Polyester Resin is used as the matrix along with MEKP and cobalt accelerator. The fabricated natural hybrid composites are tested for impact properties as per ASTM standard D256. Later the SEM images analysis is done on the fractured specimen to learn the morphological behavior. From the test results the following conclusions are made.

The maximum impact strength of 18 J was observed for the specimen (S2) which has top two and bottom layers with areca fibers. Equivalent impact strength was observed in the specimen (S3) made with top two and bottom two layers with Kenaf fibers.

Almost all the specimens from S1 to S6 have nearly equal impact strength. Thus for better impact strength, the specimens can be prepared with top and bottom layers with single areca fibers rather than two Kenaf fiber layers.

The failure of the specimen purely depends on the magnitude of the load.

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