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Original Research

CHARACTERIZATION OF SAGO PALM - CARBON FIBRE REINFORCED EPOXY HYBRID COMPOSITES

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Abstract: Natural fibres are potential alternatives to synthetic fibres. Sago palm is a new type of natural fibre and has the potential same as other existing natural fibres. In this study, the mechanical properties of sago palm/carbon fibre reinforced with epoxy hybrids were studied. Impact tests were conducted to study the impact properties of sago palm-carbon fiber-reinforced epoxy hybrid composites. The hybrid composites contain woven sago palm fibre and carbon fibre reinforced with epoxy resin is produced by the vacuum compaction method. Each sample was prepared with different volume fractions such as 40%, 64% and 91% of composition sago palm fibre. After the preparation of composite material, mechanical properties tests were studied on the prepared sample. In addition, by using Scanning Electron Microscope Tests, the failure mode is investigated. It can be concluded that 40% of sago palm fiber contains to have the best impact behavior compared to the 64% and 91% of sago palm fiber loading because it's high in impact resistance.

Keywords: *Sago palm fibre; carbon fibre; hybrid composites; mechanical properties.*

1. Introduction

Composite materials are also known as material composition or shortened to a composite combination of resin and reinforcements, which when combined gives high strength properties to the properties of the original materials. The new material can be chosen for many reasons that are materials becoming stronger, lighter, and less expensive when compared with the original materials [1-2].

Fibre-reinforced polymer (FRP) is commonly used in composite material. The (FRP) as known as fibres reinforced plastics are hybrid materials made of resin matrix reinforced with fibres. Generally, Kevlar, glass fibre, or Carbon, are used besides other natural fibres such as Jute or Kenaf that are being used. Usually, a polymer epoxy, vinyl ester or polyester thermosetting plastic, and phenol formaldehyde resin is still used. FRPs are commonly used in aerospace, automotive, marine, and construction [3-4].

There are more than one types of fibre that exists. Previous study by Gyanaranjan and Chaitanya, the first one is dispersed fibre. It consists of a mixture of two or more types of resident's continuous fibre line, but randomly dispersed throughout the resin matrix normal. The next one is dispersed random ply. It consists of random or alternating mixture of two or more types of fibre

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layers. The fibre plies may be unidirectional, corner, or built from fibre material spread. Other than that, the fibre skin and core is one another types of hybrid composite Fibre. Its core type consists of cuticle one or more types of fibre laminate used for the core made of other fibre laminate. Both skin and core may be made from materials layered in one direction or angle. The last one is skin fibre and non-fibre core. This kind of hybrid core, which consists of a leather fibre used to foam core, resin filled in, and some kind of honeycomb, solid metal, wood, is often referred to as a sandwich structure [5].

Moreover, based on Haruna et. al hybrid composites are high strength-to-weight ratio. Some materials are very strong and heavy, like steel. Hybrid composite materials can be designed to be both strong and light. This property is composite is used to build airplanes, which require very high strength material in the lowest weight. Couple with that, hybrid composite is good corrosion resistance material and can withstand with damage from the weather and from reaction. Hybrid composites good option where the chemicals being handled or stored [6].

Natural fibres are highly elongated substances produced by plants and animals that can be spun into filaments, thread or rope. Woven, knitted, matted or bonded, they form fabrics that are essential to society [7]. They are plant sources such as; coconut, cotton, sisal, flax, hemp, kenaf, and jute. The use of natural fibres in the industry becomes rapidly growth. This is because in order to improve the environmental sustainability of the parts that is being built, especially in the automotive market, composite material is all the rage [8].

Carbon fibre reinforced epoxy composite exhibits high specific strength, high specific stiffness and an excellent fatigue endurance, that has led to a variety of advanced applications; military and civil aircraft structures, for recreational consumer products [9]. Moreover, the manufacture of composite components and structures enable the integration of design and manufacturing processes, leading to appropriately adapted to the mechanical characteristics and physically [10].

Charpy V-notch tests are named as Charpy impact tests, are standard high strain rate tests that determines the values of energy absorbed by materials during failures. The absorbing energy material measures the strength of given notch and serves as tool to evaluate the ductile / brittle transition temperature-dependent. It is used in the industry, because it is easy to set up, the results could be determined easily and effectively cost [11-13].

In this study impact and morphological properties of sago palm / carbon fibre reinforce with epoxy hybrids were studied. Impact tests were conducted to study mechanical behaviour of sago palm-carbon fibre reinforced epoxy hybrid composites. The hybrid composites contain of woven sago palm fibre and carbon fiber reinforced with epoxy resin is produced by vacuum compaction method.

2. Methodology

The sago palm fronds are collected from local village, Kampung Sungai Mati, Perlis. The leaves of the plant were removing and only the frond was taken. First the fronds were cut to same length. The fronds skin was removed. Then the fronds fibres will be sliced as thin as approximately 1.7mm to 2.8mm and with the area 50cm × 1.5cm each of the slices. After that, the slices fronds fibres were being dried for 5 days under direct sun. After all the fibres are completely dried, the fibres are woven. The raw fibres were then placed in a plastic cover.

2.1. Preparing Composite Sample

The synthetic fibres of carbon fibre are collected from the unused material located at ACM, Bukit Kayu Hitam, Kedah, Malaysia. First, the Carbon Fibre ply is cut by the size needed. After both of the materials are collected, the vacuum bagging process is being done. Next, the vacuum compaction is done on the composite sample. Then, the composite sample undergo hydraulic press process for half an hour with the 350°C in temperature and pressure 50 psi about 344.74 kPa as shown in Figure 1.

Figure 1. Hydraulic Press Process.

2.2. Impact Test

The commonly specimens used for impact test according the ASTM D256 standard with V-notch are done with five replications of specimens. 15 Nm Charpy Impact test equipment from strength of materials laboratory is used to perform this test. First, the average of the datum of the Charpy impact test must be specifying. Then specimen is placed as shown in Figure 2. The impact resistance each specimen is taken for that particular level of sago palm. Same procedure is repeated for all the samples and the average impact resistance of all specimens was taken as the impact resistance recorded for that particular level of sago palm fibre loading.

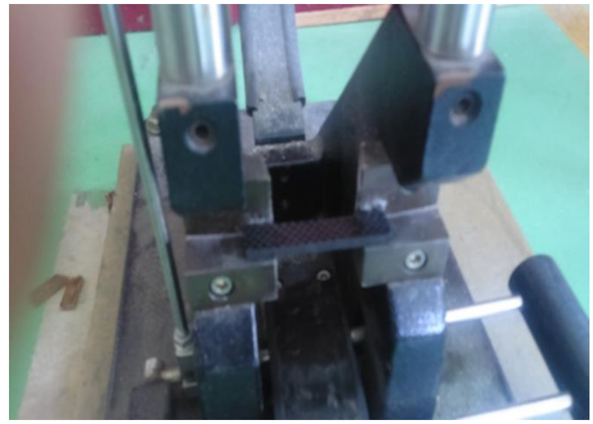

Figure 2. 15 Nm Impact Test Setup.

2.3. SEM Test

SEM test is used to check the failure mode of the specimen. In these cases, 3 specimens are undergoing SEM tests for each fiber content percentage of impact samples. First, the specimen will be cut about 5mm long from the failure area. Next, it will be coat with sputter coating process by using gold material. The specimen is coat because a conductive coating is needed to prevent charging of a specimen with an electron beam in conventional SEM mode which is high vacuum and high voltage. After coating, the specimen is place in the SEM machine.

3. Results and Discussion

Based on the impact strength result in Figure 3 showed the impact resistance of Carbon Fibre increase with the contain composition of the sago palm fibre. From the result, the composition of 40% of sago palm fibre gives the highest value of impact resistance which is 1062.88 J/m compared to 100% carbon fibre which is only 741.667 J/m. Addition with the 64% of sago palm gives the lowest value of the impact resistance compared with addition with 91% of sago palm.

From this result, 40% of sago palm fibre is better for the impact test because the natural fibre contains in the hybrid composite make this material can absorb energy from the surrounding impaction. It can be clearly seen that the 40% of sago palm hybrid had greatest values of impact strength than impacted strength of the 64% and 91% sago palm hybrid composites, even more than the pure carbon composites. This means that 40% of the sago palm hybrids absorbed most energy before failure, whilst the other hybrids absorb the least. In addition, the values of average impact strength of 64% and 91% of sago palm hybrids showed nearly values of the average impact strength. It means that they have similar average impact toughness of the composites. While the values of average impact strength of 100% carbon composite exhibit big difference during tested, approximately 1.5 times that of 64% and 91% of sago palm hybrids. Ultimately, it could be revealed that when using same fibres type, impact strength of composite vary with various sago palms fibres loading. Others have stated [14-16], the fibre content percentages of the composites are accountable for deciding the impact strength of the composites. It should choose the best percentage to take the advantage of the fibers properties, neither increase nor decrease.

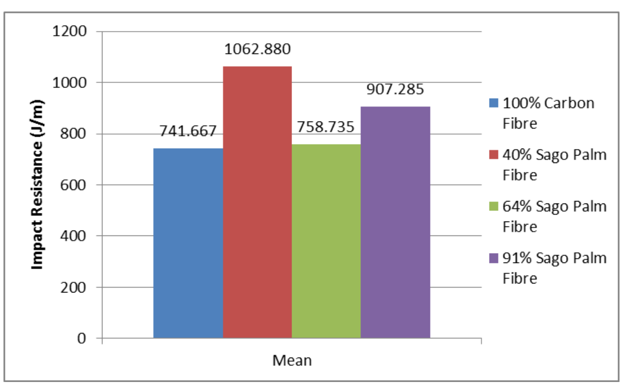

Figure 3. Comparison of Impact Resistance between the compositions of Sago Palm Fibre with 100% Carbon Fibre**.**

Figures 4 to 6 show SEM micrographs of the impact failure surface, to analyze the behavioural changes of the interfacial processes in terms of sago palm fibre. The failure mode had been observed under SEM Micrograph and the observation supported the previous assumption. For the 40% hybrids, the presence of transverse cross / sections of the sago palm fibres ends indicates the absence of sago palm fibres pullout and reflects enhancement in interfacial adhesion, that leads to highly impact resistance. Consequently, both interlaminar delimitation and interfacial strength affect the impact strength of sago palm fibres and epoxy considerably, as reported by others [17].

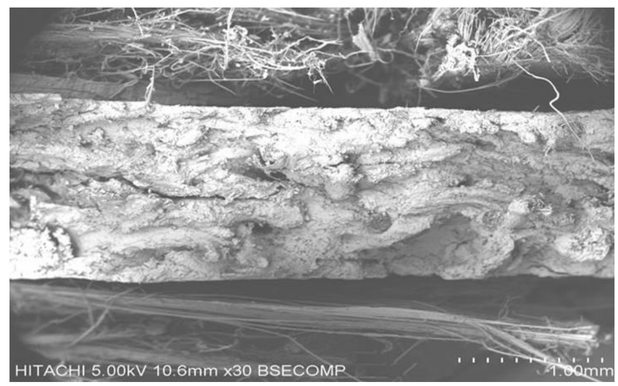

Figure 4. Delamination of Impact Specimen (40%) under SEM Micrograph.

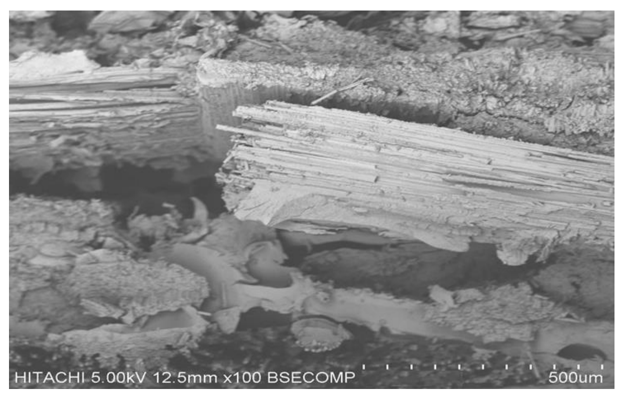

Figure 5. Delamination of Impact Specimen (64%) under SEM Micrograph.

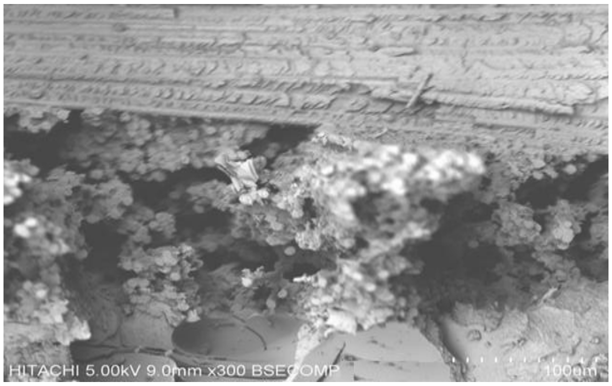

Figure 6. Delamination of Impact Specimen (91%) under SEM Micrograph.

4. Conclusions

Now, it can be concluded that the 40% of sago palm fibre content is better compared to the 64% and 91% of sago palm fibre loading because it's high in impact resistance. Further, the impact resistance of Carbon Fibre increases with the contained composition of the sago palm fibre. It can be seen that 40% of sago palm hybrid had the greatest values of impact strength than the impacted strength of the pure carbon composites. While the values of average impact strength of 100% carbon composite exhibit big differences during testing, approximately 1.5 times that of 64% and 91% of sago palm hybrids. Ultimately, it could be revealed that when using the same fibres type, the impact strength of composite varies with various sago palms fibres loading .

SEM examinations of impact test specimens show that the 40% hybrids composite failed by fibre fracture, because of strong entanglement of the fibres. Sago palm fibres can be a future replacement for existing non-eco-friendly manmade fibres such as glass and Kevlar fibre. A good composite material must have low density and high stress. Based on the result obtained, Sago Palm has all the above mention quality.

Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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