

MECHANICAL PROPERTIES OF COCONUT CARBON FIBRE/EPOXY COMPOSITE MATERIAL

M. M. B. H. SALLEH¹, Z. SALLEH², M. S. ROSDI³ & S. M SAPUAN⁴

^{1,2,3}University Kuala Lumpur, Applied Science & Advanced Technology Section, Malaysian Institute of Marine Engineering Technology, Dataran Industry Technology Kejuruteraan Marin, Bandar Teknologi Maritim, Jalan Pantai Remis, Lumut Perak, Kuala Lumpur, Malaysia

⁴Department of Mechanical and Manufacturing Engineering, University Putra Malaysia, Serdang, Selangor, Malaysia

ABSTRACT

In this research, the carbon fibre developed from komeng coconut coir fibre was reinforced with epoxy resin with difference weight percentage (0wt.%, 2.5wt.%, 5wt%, 7.5wt% and 10wt%) of carbon fibres. All the samples were prepared using the silicon rubber mould (SRM) to produces the specimen with the rectangular shape and dumbbell shape. The mechanical properties using Izod impact test (ASTM 256) and Creep Test (ASTM D2990) were investigated. The characteristics of all composite materials was also investigated and discussed.

KEYWORDS: Komeng Coconut, Carbon Fibre, Silicon Rubber Mould, Izod Un-Notched Impact Test, Work of Fracture (WOF)

INTRODUCTION

An important development in the field of materials engineering applications is the design of new materials to meet stringent requirements relating to energy conservation, safety and anti-pollution standards. Plastic materials, both reinforced and none reinforced, are potentially well-suited to satisfy these new requirements, but the cost and performance of plastics components depends on the strength and process involved. Carbon fibre reinforced thermoplastics are advanced materials for future high-performance composites. Combination of characteristics such as light-weight, corrosion resistance, low to moderate cost, high thermal stability and easy material process ability, make them attractive for many applications especially in automotive industry [1]. High strength, stiffness, and toughness as well as lightness are the most important characteristics of an ideal engineering material. Conventional engineering materials i.e., metals and their alloys are strong and tough, but not light. Certain plastic materials are light but lack strength. Carbon fibre reinforced composites have all the ideal properties, leading to their rapid development and successful use for many applications over the last decade. Our relentless concern on carbon dioxide emissions and petroleum reserves transpire considerable interest in technologies that reduce fuel consumption in passenger cars. In the area of vehicle design, body weight is the most important target for improvement. It has been demonstrated that thermoplastic composites provide a real option for horizontal parts in passenger cars [2-9]. A good case in point is a bonnet, where traditionally a steel skin is used. The material required for this application has to be recyclable, have good impact strength, low weight and high stiffness. It also requires an extremely low coefficient of thermal expansion (CTE) and the ability to bond with steel [10]. Higher utilization of low-density materials such as polymer composites is a prerequisite for the light weight vehicle of the future. Epoxy resins (ER) are one of the most important classes of thermosetting polymers which are widely used as matrices for fibre-reinforced composite materials and as structural adhesives [11-16]. They are amorphous, highly cross-linked polymers and this structure results in these materials possessing various desirable properties such as high tensile strength and modulus,

uncomplicated processing, good thermal and chemical resistance, and dimensional stability [11]. However, it also leads to low toughness and poor crack resistance, which should be upgraded before they can be considered for many end-use applications [11,12]. One of the most successful methods of improving the toughness of epoxy resin is to incorporate a second phase of dispersed rubbery particles into the cross-linked polymer [17–20]. Because the addition of rubbery materials to epoxy resins has been shown to lower their glass transition temperature (T_g) and thermal and oxidative stability, high performance thermoplastics have been employed to toughen epoxy resins in recent years [11,12].

Various research on the application of natural fillers and fibres in composites like pineapple, sisal, coconut coir, jute, palm, cotton, rice husk, bamboo, and wood as the reinforcements in composites have been reported in the literature. Luo and Netravali [21] studied the tensile and flexural properties of the green composites with different pineapple fibre content and compared with the virgin resin. Sisal fibre is fairly coarse and inflexible. It has good strength, durability, ability to stretch, affinity for certain dyestuffs and resistance to deterioration in seawater. Sisal ropes and twines are widely used for marine, agricultural, shipping, and general industrial use. Belmeres *et al.* [22] found that sisal, henequen, and palm fibre have very similar physical, chemical, and tensile properties. Cazaurang *et al.* [23] carried out a systematic study on the properties of henequen fibre and pointed out that these fibres have mechanical properties that are suitable for reinforcing thermoplastic resins. Ahmed *et al.* [24] carried out research work on filament wound cotton fibre reinforced for reinforcing high density polyethylene (HDPE) resin. Khalid *et al.* [25] also studied the use of cotton fibre reinforced epoxy composites along with glass fibre reinforced polymers. Fuad *et al.* [26] investigated the new type wood-based filler derived from oil palm wood flour (OPWF) for bio-based thermoplastics composites by thermogravimetric analysis and the results are very promising. Schneider and Karmaker [27] developed composites using jute and kenaf fibre and polypropylene resins and they reported that jute fibre provides better mechanical properties than kenaf fibre.

Coconut (*Cocos Nucifera*) is one of the most important natural fillers produced in tropical countries like Malaysia, Indonesia, Thailand, and Sri Lanka. Several researches have been devoted to the use of other natural fillers in composites in the recent past. Coconut filler is a potential candidate for the development of new composites because of their high strength and modulus properties. Composites of high strength coconut filler can be used in the broad range of applications as, building materials, marine cordage, fishnets, furniture, and other household appliances. From the review of the literature, there are a few reports regarding the coconut carbon fibre composite material for engineering application especially from komeng coconut carbon coir fibre. It was reported that komeng coconut coir fibre shown the good strength compared with other types of coconut coir fibres [28]. The objective of this paper is to study the impact test and creep test properties of komeng coconut carbon coir fibre/epoxy resin composites.

METHODOLOGY

Preparation of Materials

The following materials were procured prior to starting the experimental work: komeng coir fibre, resin, hardener, silicon rubber mould for dumbbell-shape and roller and rectangular-shape. komeng Coir fibre was produced from the coconut farm district of Manjung Perak. The komeng coir fibres firstly were weighed using digital weighing machine; then they were cleaned with fresh water and lastly dried at room temperature. The diameter of woven coir fibre was measured was in the range 3mm – 7mm. After that all the coir fibres were burnt in the oven with temperature $\sim 80^\circ\text{C}$ until 5 minutes so that it become coal or powdered ash. Epoxy resin and hardener were used from fibreglass workshop of Universiti Kuala Lumpur MIMET Lumut Perak. The resin used was epoxy resin 3554A with the density of 1.15 g/cm^3 . Figure 1 shows the komeng coir fibre before it was burnt in the oven and Figure 2 shown the komeng carbon coir fibre after burning process and finally it become coaled type.



Figure 1: Woven of Komeng Coconut Coir Fibre



Figure 2: Carbon Coir Fibre of Komeng Coconut

Preparation of Komeng Coconut Carbon Fibre/Epoxy Composite Materials

Moulds used in this study were made from silicone rubber mould (SRM). Two types of sample were prepared one sample for Izod impact test and another sample for the creep test. The open mould type was used with rectangular shape according standard (ASTM D256) for Izod impact test and dumbbell-shape samples follow the standard ASTM D2099 for creep test. Total number of samples for each mould can produce maximum until 15 specimens in one time. Each mould has a cavity to accommodate the composite samples. Epoxy and hardener were mixed in a container and stirred well for 5–7 minutes. Before the mixture was placed inside the silicon rubber mould (SRM mould), the mould was initially polished with a release agent or wax to prevent the composites from sticking onto the mould upon removal. Finally, the mixture between komeng coconut carbon coir fibre and epoxy resins were poured into the mould and left at room temperature for 24 hours until the mixture was hardened. Figure 3(a) shows the Open Silicon Rubber Mould (SRM mould) filler with komeng coconut carbon coir fibre/epoxy resin composite for Izod impact test and Figure 3(b) mould for creep test.



Figure 3(a): SRM Open Mould for Izod Impact Test Samples

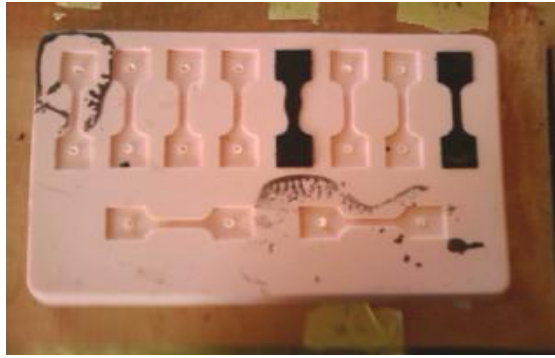


Figure 3(b): SRM Open Mould for Creep Test Samples

Mechanical Properties Using Izod Impact and Creep Test

In order to measure the work of fracture (WOF), the Izod impact test was carried out. Impact bars were obtained by cutting specimens with rectangular shapes. These rectangular specimens has dimension of thickness 3 mm, width 12 mm and length 62 mm according to ASTM D256. Izod impact tests were conducted on an Izod impact tester using 7 replicates for each specimen. The test was carried out with impact energy of 5 J and a span length of 60 mm at angle 30°. The average value of un-notched Izod impact energy was obtained from each group of 7 specimens. Figure 4 show the overview specimen located at Izod impact tester. When a material like steel is plastically deformed at ambient temperatures, its strength is increased due to work hardening. This work hardening effectively prevents any further deformation from taking place if the stress remains approximately constant. Annealing the deformed steel at an elevated temperature removes the work hardening and restores the steel to its original condition. However, if the steel is plastically deformed at an elevated temperature, then both work hardening and annealing take place simultaneously. A consequence of this is that steel under a constant stress at an elevated temperature will continuously deform with time, that is, it is said to "creep". The SM106 Creep Measurement Apparatus shows at Figure 5 whereas location of specimen at sample holder.



Figure 4: Specimen at Sample Holder of Izod Impact Tester



Figure 5: Specimen at Sample Holder of Creep Tester

RESULTS AND DISCUSSIONS

The WOF of komeng coconut carbon fibre/epoxy resin composites based on the un-notched Izod impact test is presented in Figure 6 and show that the un- notched impact energy increased by the addition of carbon fibres to epoxy resin. It indicated that the fibres played a dominant role in terms of fracture energy. On the other hand, the composite impact energy would increase with increased average komeng coconut carbon fibre contents (0 wt%, 2.5 wt%, 5.0 wt%, 7.5 wt% and 10 wt%). It was confirmed that with 10 wt% carbon fibre content shows the highest impact strength among all the samples. Figure 7 shows a photo of specimen with 7.5wt%carbon fibre after performed Izod impact test. All the samples showed that the location of fracture is always in the middle of the specimen.

It was agreed with previous report stated that mechanical properties of the natural fibre composites depend on several factors such as the stress–strain behaviours of fibre and matrix phases, the phase volume fractions, the fibre concentration, the distribution and orientation of the fibre or fillers relative to one another [29]. The low impact strength of shorter fibres composites may also be due to the presence of too many fibre ends within the composites, which could induce crack initiation, hence increased potential of the composite failure.

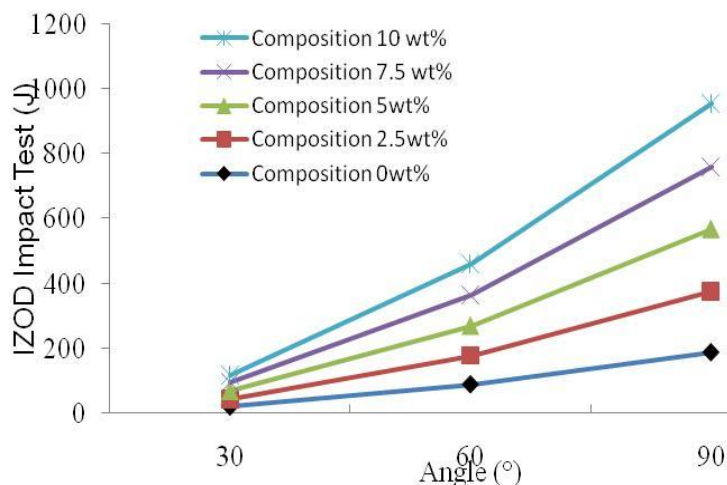


Figure 6: Izod Impact Testing for Different Angle with Difference wt% of Carbon Fibre



Figure 7: Photo of Specimen after Izod Impact Test

Stress concentrated at regions around fibre ends, areas of poor adhesion, voids, cracks, notched and other regions where fibres are in contact with one another. Results showed that elongation is increase with the time. The creep test of komeng coconut carbon coir fibre composites are presented in Figure 8. It is observed that the creep test the komeng coconut carbon coir fibre elongation obtained depends on the time taken.

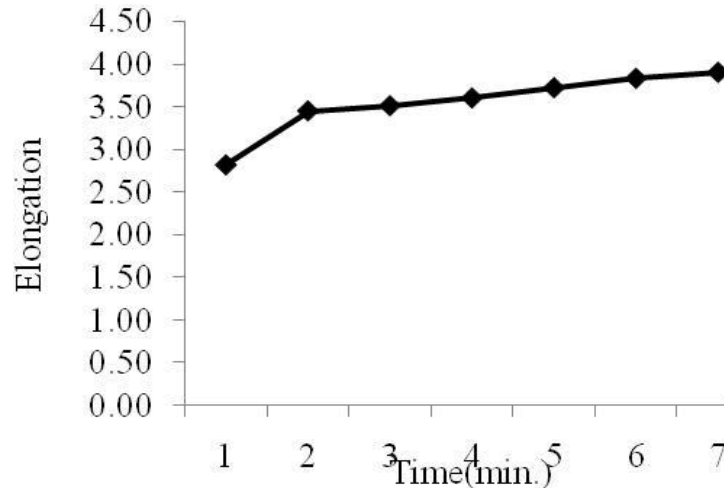


Figure 8: Creep Test Elongation-Time (min.)

The impact property of a material is its capacity to absorb and dissipate energies under impact or shock loading. The impact performance of fibre-reinforced composites depends on many factors including the nature of the constituent, fibre/matrix interface, the construction and geometry of the composite and test conditions. The impact failure of a composite occurs by factors like matrix fracture, fibre/matrix de-bonding and fibre pull out. Even though, fibre pull out is found to be an important energy dissipation mechanism in fibre reinforced composites [30]. During creep test the load capacity 2N has been used with temperature 60°C. The applied load transferred by shear to fibres may exceed the fibre/matrix interfacial bond strength and de-bonding occurs. When the stress level exceeds the fibre strength, fibre fractured occurs at end of elongation with time 7 minutes. High strain rates or impact loads may be expected in many engineering applications of composite materials. The suitability of a composite for such applications should therefore be determined not only by usual design parameters, but by its impact or energy absorbing properties. Figure 9 shows the photo of specimen after creep testing where (a) Initial length of specimen and (b) Length after the creep testing. The initial length was 115cm and the final length was 118cm, an increase of 3cm.

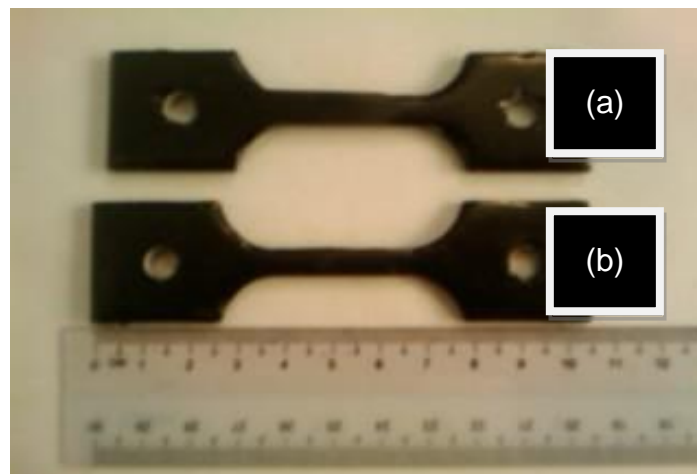


Figure 9: The Differences in Length of Specimens after Creep Testing

CONCLUSIONS

The investigation on mechanical properties of komeng coconut carbon fibre reinforced epoxy composites achieves the following results. In this work the successful fabrication of a komeng coconut carbon fibre reinforced epoxy composites with different komeng coconut carbon fibre weight percentage is possible to produce by using SRM mould. Then, it can be seen that the elongation of samples are increasing with the increased in komeng coconut carbon fibre

contents started from 2.5wt%, 5.0 wt%, 7.5 wt% and 10 wt%. From the result, specimen with 10 wt% give tremendous impact strength compared with other samples. While from the creep testing result, it also can be seen that the material will continue to deform slowly with time indefinitely or until rupture or yielding causes failure. From the Fig.7, it was shown the primary region is the early stage of loading when the creep rate decreases rapidly with time. Then it reached a steady state which is called the secondary creep stage followed by a rapid increase (tertiary stage) and fracture area.

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