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Study on Impact Properties of *Arenga Pinnata* Fibre Reinforced Epoxy Composites

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ABSTRACT

Natural fibre composites have gained their importance in the recently in some non-structural and semi-structural components in engineering due to their acceptable strength and stiffness in addition to their low cost, abundance and renewable. Therefore, there is some interest to intensify the study of new types of natural fibres and one of them is *Arenga Pinnata* fibre. Although, the study of *Arenga Pinnata* fibre composite is quite new, there are some work reported in the literature on the tensile and flexural properties. However, up till now, there is no work carried out on the impact properties of *Arenga Pinnata* fibre composites. A study on impact properties of *Arenga Pinnata* or *ijuk* fibre reinforced epoxy composites is presented in this paper. The epoxy resin was impregnated with the long and chopped fibre separately in an open mould and then compressed to get the desired thickness. Test samples were cut from the composite laminates and impact tests were carried out in accordance with ASTM D256 - 54T. Impact strengths of the fibre reinforced composites improved from 28.8 J/m (without reinforcement) to 67.26 J/m (chopped) and 114.27 J/m (long).

Keywords: Impact properties, Izod tests, *Arenga Pinnata*, Epoxy composites, Natural fibre composites

INTRODUCTION

In the recent years, there is a rapid growth in the study and use of composite materials. The main driving force in using composite materials is due to the development of study of high performance reinforcing materials such as Kevlar, glass and carbon fibres in appropriate polymer composites. However, these materials are expensive and non-renewable resources. Because of the uncertainty in the supply and price of high performance fibres, it is very important to come up with new types of fibres such as natural fibre composites (George et al., 1993). Natural fibre composites are preferred in certain applications due to the advantages such as low cost, low density, no health risk when inhaled and availability as renewable resources.

Impact is defined by Hancox (2000) as the relatively sudden application of an impulsive force, to a limited volume of material or part of a structure. Impact properties are the capacity of a material to absorb and dissipate energies under impact or shock loading. Polymer matrix composites are likely to fail as a result of impact because they do not undergo plastic deformation. If the stress within the component exceeds a certain limit, permanent damage, due to structural weakening, takes place (Hancox, 2000).

According to Murphy (1994) impact strength is probably the most widely quoted (and least understood) of all tests on plastics. Three basic types of impact tests can be carried out namely tensile impact, flexural impact on supported or cantilever beams and multi-axial impact on supported plate specimen. Tensile impact is not usually applied to composites. In flexural impact tests, the specimen is freely supported and loaded centrally (Charpy) or it can take the form of a cantilever beam (Izod) and in both cases, the impact is by a pendulum. Specimens can be tested either notched or unnotched (Murphy, 1994). This approach is adopted in this study. In multi-axial impact testing, a projectile cuts a plate supported on an annulus (Murphy, 1994).

The use of natural fibres as reinforcement in composites such as coconut coir (Lai et al., 2005), pineapple leaf (Arib et al. 2006), kenaf (Guzman et al., 1982), banana pseudo stem (Sapuan et al., 2005), jute (Dash et al. 2002) has attracted the attention of various researchers in the recent years. One of main reasons for selecting natural fibre composites is due to their low cost. Sufian (2005) recently carried out a study of the cost aspect of natural fibre composites. The fibres (Figure 1) from the *Arenga Pinnata* palm tree or locally known as *ijuk* has been traditionally used make ropes, threads, upholstery, brushes and roof thatch. It is the interest of this study to ascertain that *ijuk* fibre is one of the viable materials that can be used as reinforcement in polymer composites.

In the past, the work on tensile and flexural properties of *Arenga Pinnata* have been investigated. Sastra et al. (2005) studied the flexural properties of *Arenga Pinnata* fibre reinforced epoxy composites. Another study of Sastra et al. (2006) is concerned with the tensile properties of *Arenga Pinnata* fibre reinforced epoxy composites.

Figure 1: *Arenga Pinnata* palm tree showing the fibres

Various work in the past have been devoted on the study of impact properties of polymer composites. Cheng et al. (2002) studied the impact properties of the hybrid knitted inlaid fabric reinforced polypropylene composites. Carbon and aramid fibres are used as the reinforcement in the composites. The impact resistance of the knitted fabric composites was determined by means of drop-weight impact test as specified in ASTM D3029-78. From this study it was concluded that the impact resistance of the knitted fabric composite is higher than the composite laminates.

Bassett et al. (1999) reported that the study on impact properties of glass fibre reinforced thermoplastic composite automotive bumper beam. The composite bumper has I section. Higher impact performance and improved dimensional stability have been achieved through the implementation of composite bumper beam compared to traditional plastic bumper beam.

In the work by Cheon et al. (1999), the impact energy absorption characteristics of glass fibre reinforced hybrid composites were studied using the Charpy impact test method. The impact energy absorption capability of the hybrid glass/Kevlar reinforced epoxy composites was 80% higher than pure glass fibre reinforced epoxy composite.

However, there is no work reported on the study of impact properties of *Arenga pinnata* fibre reinforced epoxy composites and therefore, this paper presented such study. In this paper, the potential of *Arenga pinnata* fibre reinforced epoxy composites in terms of their impact properties have been evaluated. Attempt is made to understand the complex nature of *Arenga pinnata* fibre reinforced composite fracture.

MATERIALS AND METHODS

Arenga pinnata fibres were obtained from Aceh, Sumatra, Indonesia. The fibres were provided in the form of random and long fibres. The matrix used was epoxy resin (Epoxy BBT-7893A) and epoxy hardener (BBT-7893B), supplied by Berjaya Bintang Timur Sdn Bhd. Retting process was applied to separate the stalk from the core of the *Arenga Pinnata* fibre. In this process bundles of *Arenga Pinnata* fibres were soaked into water tank until the dirt vanished from the core section and the stalk was separated from the core. The fibres were dried for two weeks under the room temperature.

The specimens were prepared according to ASTM D256 - 54T. This standard is meant for standard impact test methods for unreinforced plastics but can be adopted for fibre reinforced composite materials (Schwartz, 1997). Long and chopped fibre arrangements have been studied with weight fraction of 15 wt%. The epoxy and hardener were mixed in an open mould and then impregnated with the *Arenga Pinnata* fibres. Another layer was applied after 1 hour and the ply was compressed to get the desired thickness of about 10 mm. The resin without the fibre mixture was also prepared in the mould as a control. Impact test samples were cut from the laminate composites. The Izod method of impact testing was performed by carrying out the cantilever-beam tests on the notched specimens using TMI Monitor X impact tester machine with pendulum weight of 5.5J. Minimum of five samples were tested for each test run and the average value was recorded.

RESULTS AND DISCUSSION

Figure 2 shows the effect of fibre arrangements such as random chopped and long fibres on the average impact strengths based on Izod impact testing of the *Arenga Pinnata* fibre reinforced epoxy composites. The results are also compared with virgin epoxy resin.

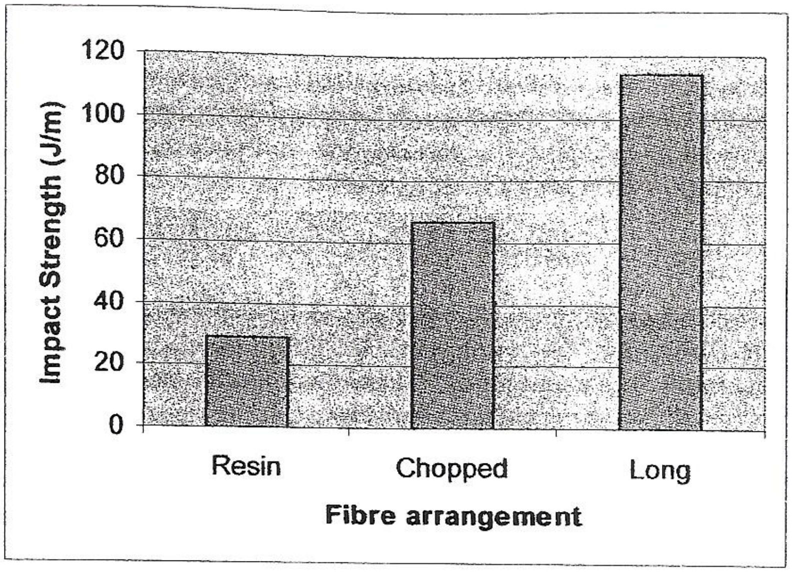

Figure 2: Effect of fibre arrangement on the average impact strength of the *Arenga Pinnata* fibre composites

Increasing the aspect ratio (L/D) of the fibre increased the impact strength of the *Arenga pinnata* reinforced composites. The long fibres were able to absorb a significant amount of impact energy compare to the short chopped fibres. This is mainly due to extensive delamination between the long *Arenga Pinnata* fibre plies. In short fibre plies, the applied impact load is not dispersed effectively into the overall laminate and the stresses are localized in the laminate due to fibre breakage.

According to Hancox (2000) composites are generally strong, and have reasonable impact resistance, if the applied stress is in the fibre direction. In other directions they tend to be weak and to have a low impact resistance. Composites are prone to impact damage because of its lack of plastic deformation. Once a certain stress level is exceeded permanent damage, resulting in local or structural weakening, occurs. These results are in agreement with the results of glass fibre composites reported by Mazumdar (2001) where he stated that long glass fibre provides three to four times improved impact properties than short glass fibre composites. Long fibres exhibits higher impact strength compared to short ones. The results from this study are consistent with the results reported by Abu Bakar, et al. (2004).

Impact tests were very important tests conducted for polymer composite materials. In general, two types of tests namely Charpy and Izod tests are carried out and in this study, the latter was adopted. The samples are normally prepared at different fibre to matrix ratios and they are proportioned at some increments according to weight or volume. Through experience, the weight fraction of the maximum of 30% of fibre is recommended. Beyond that, reliable results cannot be ensured. In this study, the fibre weight content was only 15 %. It is recommended that further study should be conducted to use several percentages of fibre contents. A work should also be conducted to compare the chemically untreated fibre composites with the treated samples.

CONCLUSIONS

It can be concluded from this study that *Arenga pinnata* fibre has a good potential to be used as reinforcement material in polymer composites to improve the impact resistance. Long fibres exhibits higher impact strength compared to short ones. Impact strengths of the fibre reinforced composites improved from 28.8 J/m (without reinforcement) to 67.26 J/m (chopped) and 114.27 J/m (long).

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