Fabrication of hybrid oil palm empty fruit bunch and kenaf reinforced epoxy composite panels at varying fiber layering sequence

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ABSTRACT – Hybrid natural fiber composites offer many advantages especially in achieving balance between mechanical performance and cost as compared to single natural fiber-matrix composites. In this paper, the fabrication process of preparing novel hybrid oil palm empty fruit bunch (OPEFB) and kenaf fibers reinforced epoxy composite panels is explained. Four varying fiber stacking sequences were applied to prepare the hybrid composites panels, at thermoset epoxy matrix between 58.1 wt% until 68.6 wt%. Three types of fibers were used in the composites fabrication, which are short fiber (sf) OPEFB, short fiber (sf) kenaf and woven kenaf mat. The hybrid composites fabrication involved fiber crushing (to form short fibers at fiber length between 1 mm to 3 mm), and compression moulding (at 25 psi and room temperature). All panels were fabrication based on steel mould with fix length x width x height of 200 mm x 200 mm x 3 mm. End of fabrication process showed that high quality compressed hybrid composites panels with very low porosity were successfully obtained for fiber layering sequence of kenaf_sf/OPEFB_sf/kenaf_sf and kenaf_mat/OPEFB_sf/kenaf_mat. In the other hand, the final hybrid composite panels which consist of fiber layering sequence OPEFB_sf/Kenaf_sf/OPEFB_sf and OPEFB_sf/Kenaf_mat/OPEFB_sf yielded high porosity at the end of the fabrication process. The results obtained showed that hybrid composite panels which are fabrication using higher kenaf fiber weightage were able to yield good quality panels with very low porosity compared to panels fabricated using higher OPEFB fiber weightage, which indicated good wettability between the epoxy matrix and the kenaf fibers.

1. INTRODUCTION

Hybridization technique is one of the solutions to improve single fiber-matrix system in natural fiber composite product development [1]. The prominent advantage of the hybridization technique is the ability to achieve a balance between performance and cost between the two combined fibers, which are usually made from fiber with low mechanical properties but low cost and fiber with high mechanical properties but high cost [2].

Up to date, there are several studies on the effect of layering sequence on the hybrid natural fiber reinforced thermoset composites performance such as by Jawaid et al [3] using hybrid oil palm empty fruit bunch (OPEFB)/jute reinforced epoxy composites and by Yahaya [4] using kenaf/Kevlar reinforced epoxy composites. Their studies showed that varying layering or stacking sequence between the plies affected the final composites mechanical properties.

In this project, a novel hybrid natural fiber reinforced thermoset epoxy composites was developed, using the combination of locally and abundantly available OPEFB fibers, and kenaf fibers. The objective of the project was to determine the final hybrid composites quality in term of porosity, by varying the layering sequences between the OPEFB fibers and kenaf fibers. Compression moulding process was utilized for the hybrid composites sample preparation, and all hybrid composites formulation were pressed up to 25 psi of pressure into 3 mm thick window-framed panels.

2. RESEARCH METHODOLOGY

2.1 Raw Materials

Kenaf bast fiber (short fiber and mat) was obtained from Lembaga Kenaf dan Tembakau Negara (LKTN) Malaysia, while the OPEFB fiber was obtained from Kilang Kelapa Sawit Kempas, Melaka. Neat epoxy resin (CP360 Part A) and amine hardener (CP360 Part B) with resin to hardener ratio of 2:1 was used as matrix for the hybrid composites.

2.2 Sample Preparation

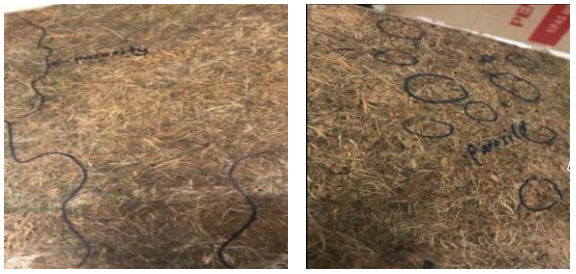
Four varying fiber stacking sequences were applied to prepare the hybrid composites panels, at thermoset epoxy matrix between 58.1 wt% until 68.6 wt%, as shown in Table 2.1. Three types of fibers were used in the composites fabrication, which are short fiber (sf) OPEFB, short fiber (sf) kenaf and woven kenaf mat. The hybrid composites fabrication involved fiber crushing (to form short fibers at fiber length between 1 mm to 3 mm), and compression moulding (at 25 psi and room temperature). All panels were fabrication based on steel mould with fix length x width x height of 200 mm x 200 mm x 3 mm. The compressed panels were left to cure at room temperature for 24 hours.

Table 2.1 Summary of hybrid OPEFB/kenaf reinforced epoxy composite panels layering sequence

Layering Sequence	Composition (wt%)		
	OPEFB	Kenaf	Epoxy
OPEFB_sf/Kenaf_sf/ OPEFB_sf	28.9	13	58.1
OPEFB_sf/Kenaf_mat/ OPEFB_sf	34.5	4	61.5
Kenaf_sf/OPEFB_sf/ kenaf_sf	14.9	26	59.1
Kenaf_mat/OPEFB_sf/ kenaf_mat	21.6	9.8	68.6

3. RESULTS AND DISCUSSION

Figure 2.1 shows the final hybrid composite panels fabrication at the end of the project, while Table 2.2 summarized the final results obtained through visual inspection on the compressed panels. It can be observed that that high quality compressed hybrid composites panels with very low porosity were successfully obtained for fiber layering sequence of kenaf_sf/OPEFB_sf/ kenaf_sf and kenaf_mat/OPEFB_sf/kenaf_mat. In the other hand, the final hybrid composite panels which consist of fiber layering sequence OPEFB_sf/Kenaf_sf/ OPEFB_sf and OPEFB_sf/Kenaf_mat/OPEFB_sf yielded high porosity at the end of the fabrication process**.**



(a) OPEFB_sf/Kenaf_sf/ OPEFB_sf

(b) OPEFB_sf/Kenaf_mat/O PEFB_sf

(c) Kenaf_sf/OPEFB_sf/ Kenaf_sf

(d) Kenaf_mat/OPEFB_sf/K enaf_mat

Figure 2.1 Compressed hybrid composites panels

The results obtained showed that hybrid composite panels which are fabrication using higher kenaf fiber weightage were able to yield good quality panels with very low porosity compared to panels fabricated using higher OPEFB fiber weightage, which indicated good wettability between the epoxy matrix and the kenaf fibers. In addition, the compression methodology applied to fabricate all samples was also able to produce good panels without any fiber distortion. This allowed even fiber distribution across the panel surface hence creating high strength properties for all samples.

Table 2.2 Final observation on the compressed hybrid OPEFB/kenaf reinforced epoxy composite panels.

Layering Sequence	Visual Observation	
	Porosity	Fiber Distortion
OPEFB_sf/Kenaf_sf/ OPEFB_sf	High	No
OPEFB_sf/Kenaf_mat/ OPEFB_sf	High	No
Kenaf_sf/OPEFB_sf/ Kenaf_sf	Low	No
Kenaf_mat/OPEFB_sf/ Kenaf_mat	Low	No

4. SUMMARY

In conclusion, the results obtained showed that hybrid composite panels which are fabrication using higher kenaf fiber weightage were able to yield good quality panels with very low porosity compared to panel fabricated using higher OPEFB fiber weightage. This indicated good wettability property between the epoxy matrix and the kenaf fibers compared to epoxy and OPEFB fibers. Further research shall be carried out to reduce the porosity on panels with high OPEFB fiber contents such as through modifying the compression moulding pressure scheme and applying fiber treatment process using sodium hydroxide (NaOH) on both kenaf and OPEFB fibers.

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