PULTRUDED NATURAL FIBRE REINFORCED COMPOSITES: Preparation, Properties and Applications

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Introduction

Environmentally friendly composites are today highly required by utilizing natural fibers as reinforcement combined with biodegradable polymer as matrices. Depending on the natural fiber used, the composite exhibited specific properties equivalent to the properties of glass fiber reinforced composites. This makes the natural fibers such as sisal, coir, jute, ramie, pineapple leaf (PALF), and kenaf are appropriate alternative candidates to replace glass or other traditional reinforcement materials in composites [1]. Manufacturing high performance composites from natural fibers is currently being pursued by researchers across the globe. The ecological benefits of this material are clearly saved valuable resources which are environmentally sound and do not cause health problems [2-3]. Therefore, the intention of this project is to study the locally available kenaf fiber within Malaysia which is much cheaper than synthetic fibers such as glass, aramid and carbon fibers in an attempt to reduce the cost of producing composites and hence become more competitive than conventional materials such as galvanized steel and etc.

Experimental

Processing

The rapidly expanding usage of composite components in automotive, construction, sports and leisure has attracted attention on continuous production techniques with the optimum properties. One of the techniques for manufacturing structural profiles from composites is pultrusion process. Pultruded composites are traditionally manufactured using thermosetting resin systems. These profiles are produced by pulling a carefully specified mass of wetted-out reinforcement material through a heated metal die containing a cavity of the desired cross-section [4].

Materials and Procedures

Kenaf raw fibers used in this work was supplied by Lembaga Tembakau Negara (LTN) Malaysia and came in straight long fibers. Kenaf fiber was further processed into yarn with Tex unit of 2200 g/km. Unsaturated polyester resin (Reversol P-9941) for pultrusion grade was obtained from Revertex (Malaysia) Sdn. Bhd. The curing temperature for this process was 120^{o}C with the pulling rate of 12mm/min.

Properties and mechanical testing

Density was measured using digital density meter (pycnometer) in accordance to ASTM D 792. The rod profile specimens with the diameter of 12.7 mm and length 10 mm are weighted first to the nearest 0.0001g. Three-point flexural test of pultruded composites was carried out in accordance to (ASTM D 4476-03). Specimens were cut into two parts so that the cross section of each part is smaller than a half-round section and the span was 100 mm.

Results and Discussion

Table 1 shows the effect of varying fiber loading on density of composites density in comparison to the theoretical density calculated from measured density of UP (1.12 g/cm3) and kenaf fiber (1.44 g/cm3). It is apparent from Table 1 that theoretical and experimental density of PKFRC increased with increasing fiber loading. This is anticipated as the density of PKFRC is higher than neat UP itself. It is also notable that experimental density values are slightly lower than theoretical density values. This can be attributed to presence of voids in the fiber-matrix interface.

Table 1 Measured densities of PKFRC at different fiber loading.

Fiber Loading (%)	Theoretical Density (g/cm3)	Actual Density (g/cm3)	Void Content (%)
Neat UP	-	1.12	-
50 %	1.28	1.26	1.56
60 %	1.31	1.293	1.29
65 %	1.33	1.317	0.97
70 %	1.34	1.33	0.74
75 %	1.36	1.342	1.32

Figure 1 reflects the effect of kenaf fiber content at 50%, 60%, 65%, 70% and 75% of volume fiber on flexural properties of the composites, respectively. The flexural properties of neat unsaturated polyester resin (UP) were used as references. Mechanical properties of composite increased with the increase of fibre content. The maximum value of flexural properties was exhibited at the fibre content of 70% v/v. Pothana et al., 2003 [5] states that, when the fiber concentration is lower, the packing of the fibers will not be efficient in the composite. This leads to matrix rich regions and thereby easier failure of the bonding at the interfacial region. When there is closer packing of the fibers crack propagation will be prevented by the neighboring fibers. The decreasing of mechanical properties for the composite with the fibre content above 70% is due to the insufficient filling of the matrix resin and it was represented by composites with 75% of fiber volume content.

Conclusion

The development of high performance composite structures using pultrusion process has been demonstrated using locally available kenaf fibers in Malaysia.

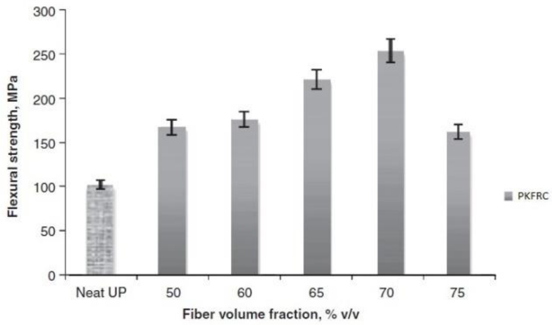

Figure 1 Comparison of flexural strength of PKFRC

From the results and discussion above, it can be concluded that the addition of higher amount of fiber loading results in higher flexural properties of the kenaf fiber–reinforced polyester composites, with 70% of fiber volume fraction give maximum performance.

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References

1.Bledzki, A. and J. Gassan, *Composites reinforced with cellulose based fibres.* Progress in polymer science, 1999. **24**(2): p. 221-274.

2.Sreekala, M., et al., *The mechanical performance of hybrid phenol-formaldehyde-based composites reinforced with glass and oil palm fibres.* Composites Science and Technology, 2002. **62**(3): p. 339-353.

3.Varma, I., S. Anantha Krishnan, and S. Krishnamoorthy, *Composites of glass/modified jute fabric and unsaturated polyester resin.* Composites, 1989. **20**(4): p. 383-388.

4.Meyer, R., *Handbook of pultrusion technology*. Methuen, Inc, 733 Third Ave, New York, New York 10017, USA, 1985. 180, 1985.

5.Pothan, L.A., Z. Oommen, and S. Thomas, *Dynamic mechanical analysis of banana fiber reinforced polyester composites.* Composites Science and Technology, 2003. **63**(2): p. 283-293.