STUDY ON TENSILE STRENGTH AND ADHESION INTERFICIAL PHENOMENA OF TROPICAL WOOD FLOURS IN REINFORCED COMPOSITES

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ABSTRACT

Mechanical properties of epoxy matrix filled with a variety of wood fillers has been studied, particularly for tensile strength and adhesion interfacial phenomena. The wood flours used in this experimental work are from different wood species and there are, Meranti, Merbau, Keruing, and Seumantok. The concentration level adapted for each species of wood filler in the matrix are 4.5%, 9%, and 13.5%. The results from the experiments indicates that mechanical properties, particularly tensile strength are affected by different particles wood sizes and species of wood filler. Generally tensile strength will increased with minimum size of particle wood, and medium concentration level of wood filler (9%), particularly for Meranti wood species. The standard of particles wood sizes are 0.40 mm and 0.315 mm of diameter and is adapted from mesh standard DIN 4188.

The study also focused on morphological properties, particularly to identify characteristic of adhesion interfacial phenomena between matrix and fiber using Scanning Electron Microscopy (SEM). The substitution of wood filler into matrix particularly, for WFRC affect the reinforcing agent in epoxy and the function of filler as a bonding strength phenomena at the interface between wood filler. Epoxy and fiber plays an important role in determining the strength of wood filler composite reinforcement. Likewise for WFCR, voids were found to be distributed all over the surface, this condition affects the adhesion between matrix and wood filler where interaction between there will be less significant.

Keyword:
Tensile strength, wood species, particle size, percentage of filler, Epoxy matrix, Adhesion interfacial phenomena, reinforced composites. Scanning Electron Microscopy.

INTRODUCTION

The use of wood flour as a filler is a choice offering an economical solution for the increasing costs of wooden products and construction material. There is a considerable commercial interest in thermosetting composites filled with wood flour, due to potential opportunities combining the attractive characteristics and properties of both components [2]. The product developed has the aesthetic appearance

of wood and the processing capability of thermosetting. The material can considered as an easily attainable (natural) option, is comparative as far as price is concerned and convenient for a wide range of application.

Fillers in thermosetting are intended for two main purpose: to increase the final product volume to reduce costs of materials, on the one hand, and to change mechanical properties of the materials on the other. These changes frequently far from reaching theoritically predicted values.

Normally, cellulosic materials of the forestry and agricultural product can be used as substitution material in the producing of Epoxy composite. Due to lower density, easy processability mean flexibility during processing with no harm to the equipment, biodegradability [6]. Availability as renewable resources and as a by product from shawmill industries, and ready in the nature locally (Maulida. A) Combined with a better cost/performance ratio, inorganic materials show good potential as fillers in the thermosetting, these organic materials show good potential alternatives in the engineering application [2].

However, wood filler suffer from various drawbacks such as: degradation by moisture [8]. Poor surface adhesion to hydrophobic polymers, susceptibility to fungal and insect attack, poor surface dispersion of fiber in matrix [12]. The introduction of suitable tropical wood flour in the polymer matrix obtainable positive effect on bonding strength because the hydrophilic nature of wood filler affects to adhesive of polymer matrix, and Epoxy-wood filler can produce material which are both strong and reduce a cost.

In practice, the full strength and improved adhesion at the interface can be achieved by graft co-polymerization of wood fibers by the use of suitable coupling and bonding agent [3]. But limited application of wood fibers as fillers in thermosetting may be due to the poor dispersion, this constraint will be present during mixing processes between matrix and wood filler.

Other theoritically according [7], most of the properties of polymers are intrinsic ones-that is, characteristic of or fundamental to the specific matrices. Many times, however, it is necessary to modify the mechanical, chemical, and physical properties. Foreign substances called additives (include filler) are intentionally introduced to enhance or modify many of these properties. And according to [13], a wide variation of mechanical properties can be developed through an appropriate compounding of polymer an filler. Filler are added into the polymer matrix with the aim of improving thermal and mechanical properties. There are, however, some adverse effects: addition of high modulus wood fiber to a polymeric matrix usually results in increased brittleness.

In the recent researches conducted in UPM related to the use of tropical wood flours as filler in PE composites have shown that the particle size of the wood flour was affected the tensile strength of the composite, and it is believe that the strength of the composite could increase significantly [5]. This view is based on consideration to improved adhesion at the interface can be achieved by graft co-polymerization of wood flour and matrix..

EXPERIMENTAL

In this experimental the wood filler was focused to four types of wood species includes; meranti (Shorea Leprosula); Merbau (Insia hijuga O.K); Kerueng (Dipterocarpus hasseliti); Seumantouk (Eusideroxylon Zwageri T.R) [2,3], The physical characteristic of the wood flours are; The effects of wood filler parameters on the mechanical properties of Epoxy matrix composites will be examined includes; wood particles sizes; various level of wood filler (%) in the matrix, and type of wood species. All of above parameters were adapted both for fiber composite

The pretreatment of wood flour was done through treatment procedure of wood flour were adapted by heating from traditional system drying exposure of material on air, this procedure for eliminate moisture content in wood flour. The present of water (percentage maximal of moisture content) in wood flour will affected on the poor dispersion of particle wood flours in matrix, and particle wood tend be agglomerated [5].

The Matrix using in this experimental type of Epoxy from type 215, because this type most widely used for material composites. The properties data of this matrix such as; tensile strength is 85 Mpa; tensile failure strength is 5%; compression strength is 130 Mpa; and heat distortion is occur at the temperature 110 C, Young modulus 1.2 Gpa, specific grafity 1.5 and compressive strength 130 Mpa mixing ratio A/B 100:25. And the fiber using in this work from type of E-Glass

The filler wood flour was used as fillers in this research is from local tropical wood such as Meranti, Merbau, Keruing, Seumantok, with properties includes density of 0.84 g/cm^3 for Merbau; of 0.52 g/cm^3 for Meranti; of 0.70 g/cm^3 for Kerueng; and of 1.04 g/cm^3 for Seumantok [1]. Also, in this experiment has been used two different parameters sizes of wood flours as a filler such as; 0,40mm; 0.315mm diameter of wood flour, this procedure were adapted from mesh standard of DIN 4188.

Compounding of Epoxy wood flours and fiber was carried out in hand lay-up processes system for preparation of composite for material specimen testing in the laboratory. Usually wood flour was mixed with matrix (4.5%, 9%, and 13.5% by weight of matrix) for 10-15 minutes with frequent remixing of the mixture for better dispersion of wood flour in the matrix and fiber. The sample was slowly coaled to room temperature with the pressure maintained during the process and then conditioned overnight (a round 24 hrs) at room temperature of 25C and relative humidity (RH=70)

Finally, Mechanical testing in this research only the tensile strength test has been studied according to procedure for materials testing of plastic type of ASTM D-3039-81, D638-99 . An average of five samples were tested, the properties reported were measured at peak load and graphical paper showed by tester machines. The results is calculated by using formula for composite structural, the average co-efficient of variation for tensile strength includes load maximum, modulus elasticity, elongation break (%) of the composites was studied by using tester Instron Machine Model 4801 load max 5 KN, and testing process was taken at Polymer Laboratory of Malaysian Institute for Nuclear Technology (MINT), Bangi, Selangor D.E, Malaysia.

RESULTS AND DISCUSSION

This study was focuses on the mechanical properties especially a tensile strength of wood flour in Epoxy matrix-composite. Where, the tailoring of treatment wood flour has been well established for eliminate moisture content in wood flour will be affected on the poor dispersion of particle wood flour in matrix and particle wood flour tend be agglomerated

The use of wood flours as filler in epoxy was bring on results where, the tensile strength generally decrease with the increase in the particle wood size or random of particle wood size in higher concentration level of wood filler in the matrix. However, decreasing in

the strength shown that wood flour has a little effect as reinforcing agent in Epoxy. The increase in modulus elasticity is linear with the decrease of wood filler concentration in the Epoxy matrix. Beside that, Epoxy matrix with wood flour matrix produced superior in modulus values especially, in minimum particle wood size and maximum concentration level of wood flour in the orthophthalic matrix

According to data were treated from table, where the results present in figure.1 and figure.2, shown that screen analysis of wood flours size (0.40 mm, 0.315 mm) corresponding with percentage levels of wood flours (4.5%, 9% and 13.5%) in Epoxy matrix, and the major volume fraction of Glass fiber in epoxy–wood flour matrix composite is 80%.

If Epoxy filled with untreated wood flour it will be poor dispersion of wood flour in matrix, that condition will be effect on poor tensile strength and also effect on wood flour-Epoxy interface. Because of the bonding at the interface plays an important role in determining the strength of composite materials. Furthermore, improvement in strength was achieved with the incorporation of coated fiber in the Epoxy matrix. The better performance of isocyanate is attributed to the formation of a chemical bond between the isocyanate and the hydroxyl groups on the wood surface and the addition of Epoxy wax aids in better dispersion of fiber in polymer [3].

The result presented in figure.1 shown that tensile strength decrease in filled with random particle wood size and maximum percentage level of filler (4,5%) in matrix. But in the minimum particle wood size (0,315 mm) and the same level of filler concentration (13,5%) in the matrix was shown that a maximum the value of tensile strength is obtained. Figure.2, shown that the minimum value of elongation is obtained in the particle wood size of 0.40 mm and level of filler concentration is 9% in the matrix. However, the maximum value of elongation is obtained in the minimum of filler concentration level (4.5%) corresponding with same level of particle wood size of 0.40 mm.

The tensile strength for wood flour composite reinforcement (figure 1) show that, the minimum particle wood size (0.315 mm) with 4.5 % portion of wood flour particularly, for meranti, merbau and balau kuning, has been show that the strength are relative in same level. But, higher than 0% of portion of wood flour. Also, in 9 % of concentration of filler for minimum particle size particularly for meranti, merbau and kruing the strength is higher than o% of wood filler. In 13.5% of concentration of filler except, only balau kuning wood species with minimum particle wood size the strength relative same with 0 % portion of filler.

Generally, the figure has been show that, the tensile strength for WFCR is increases with increasing of concentration level of filler. However, according to this result, increasing in this strength shown that wood flour. Affected as reinforcing agent in epoxy, where a function of wood flour in matrix especially as a bonding strength at interface between wood flour, epoxy and fiber plays an important role in determining the strength of wood flour particularly, for composite reinforcement [3].

In the other hand, the maximum (0.40 mm) of particle size both for all wood species will reduce the tensile strength, where the above phenomena caused by the maximum particle wood size will be affected on the poor dispersion of particle wood flour in matrix and particle wood flour tend be agglomerated. Moreover, compounding of glass epoxy wood flour and fiber was carried out in hand lay-up processes system for preparation of composite specimen tests.

Figure.1 Tensile strength Vs % of filler (WFCR)

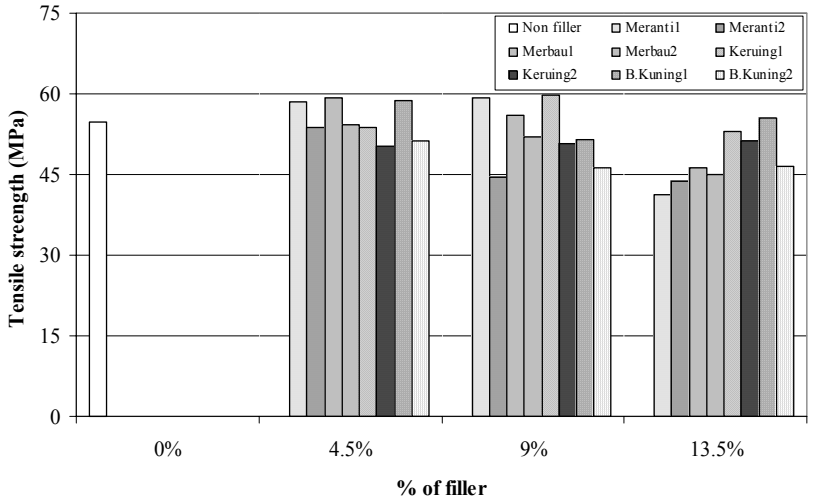
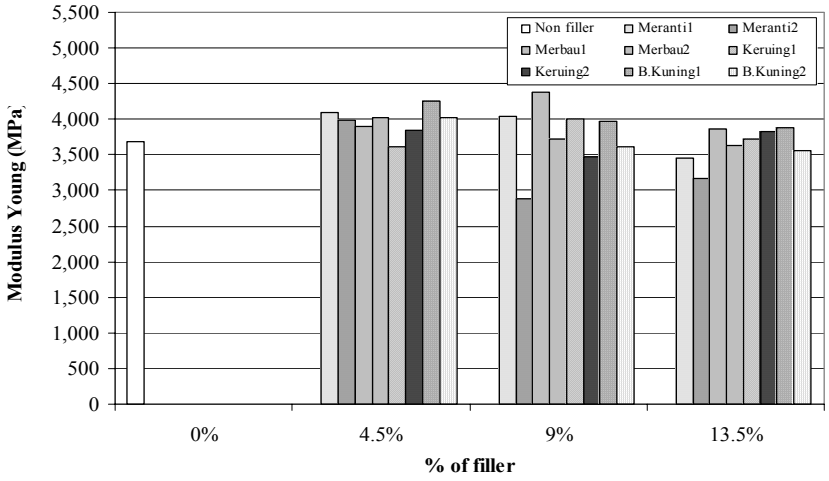


Figure 2 Young's modulus Vs % of filler (WFCR)



Scanning Electron Microscopy

Figure 4.5 shows a specimen of wood flour filler non reinforced composite for Meranti wood filler with 9% filler content and 0.315 mm of particle size taken under a scanning Electron Microscopy. The figure shows that voids are distributed all over the surface. This indicates the low interaction adhesion between matrix and wood filler.

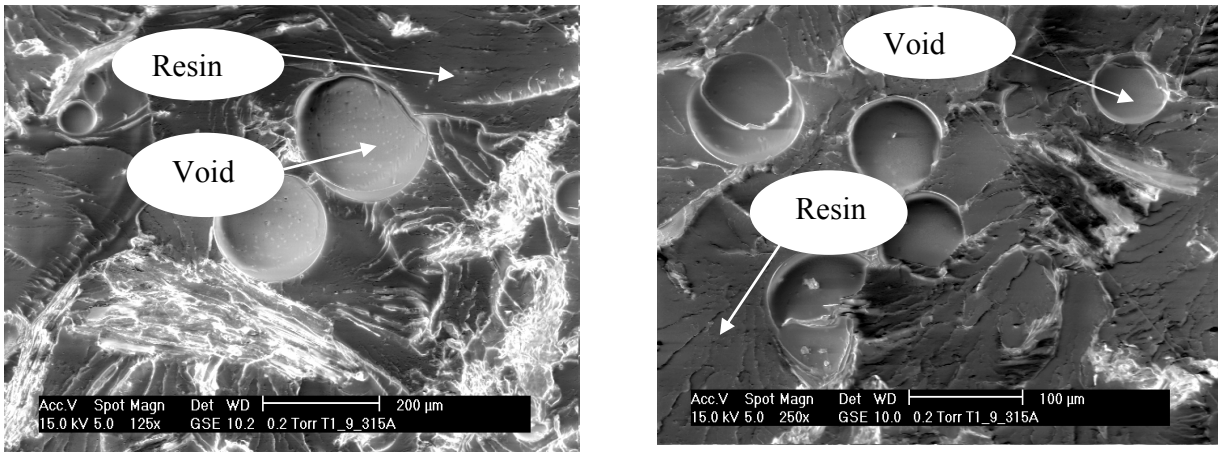


Figure 4.5: SEM of WFCR (Meranti of mesh 0.315, % of filler 9%)

It was shown that the reinforced above phenomena is caused by presence of large number of voids. The voids may be due to present of moisture content at high level that is which exceed 12% [1].. The presence of the voids may also be due to imperfect fabrication process and also the atmosphere of the surrounding room condition.

The above phenomena will decrease the strength of composite. That condition normally happens when fabrication processes was done by hand lay-up process. The composite strength was high particularly, for Merbau wood flour with particle 0.40 mm and 13.5% portion of filler. This causes strength stress concentration and only small part the cracked are plotted as a function of the interfacial shear stress (Figure 4.6).

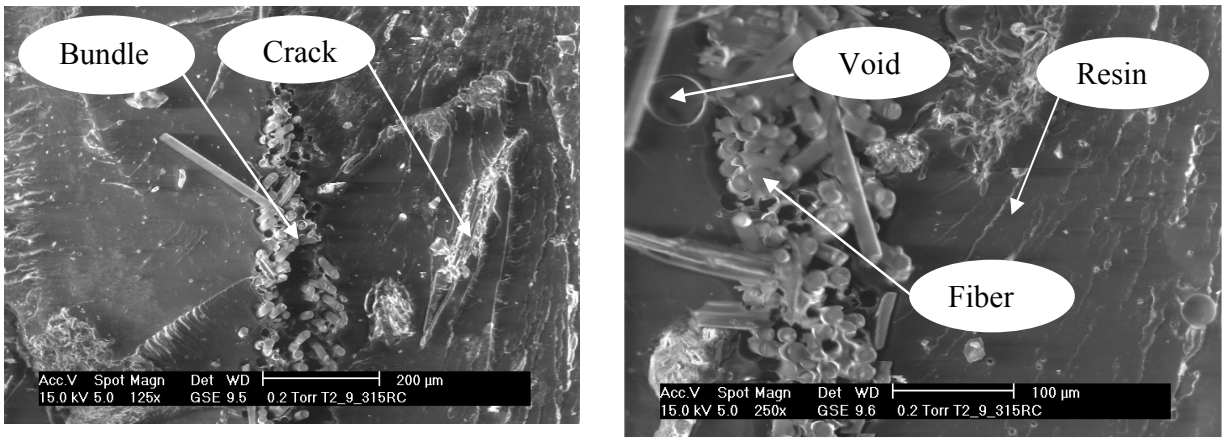


Figure 4.6: SEM of WFCR (Merbau of mesh 0.315, % of filler 9%)

As shown in Figure 4.6 for reinforced composite with 9% portion of filler for *Merbau* type of wood, the results show that show that the interfacial bonding strength was high (higher than 13.5% of filler). This result cause by the stress concentration tendency pass through large bundles of fibers without much deviation.

Finally, Figure 4.6 shows deviations in the bundles of fiber such as cracks and shear concentration between matrix and fiber to each other and also the presence of void on surface. The above problem results in a negative effect to the bonding strength. That phenomenon shows the presence of an adverse environment (such as fabrication system, room work condition). It will dramatically reduce the fiber strength (relative to interfacial strength) and hence cause high planers fracture and void distribution on the surface.

CONCLUSIONS

The improvement of mechanical properties particularly, the tensile strength will be obtained by substitution a minimum particle size of wood filler especially, for wood flour composite reinforced (WFCR). The maximum particle wood size (for all wood species) will reduce the tensile strength. Where, that reducing caused by a maximum particle wood size will be affected on the poor dispersion in to matrix, and particle wood flour tend be agglomerated. Moreover, compounding of epoxy wood flour and fiber was carried out in hand lay-up processes system in preparation of composite specimen tests

Generally, the tensile strength for WFCR will increase with increasing of concentration level of wood filler (maximum 9%). However, according this result, increasing in strength show that, wood filler were substituted in matrix affected as reinforcing agent in epoxy. Morever the function of filler in matrix especially as a adhesion strength at interface between wood flour, epoxy and fiber. Particularly, fiber plays an important role in determining the strength of wood flour composite reinforcement.

Finally, reinforced composite with 9% portion of filler, particularly for *Merbau* type of wood filler indicate that the interfacial bonding strength was high, this result cause by the stress concentration tendency pass through large bundles of fibers without much deviation. But, deviations in the bundles of fiber will be presence such as cracks and shear concentration between matrix and fiber to each other and also the presence of void on surface. The above problem results in a negative effect to the bonding strength.

This research has given us the good ideas to the future, where substitution a wood filler in varieties of wood species is possible in the reducing of epoxy volume. It can be combined with a better cost/performance ratio. And the result of this research also can be applied particularly, application as a

interior material for shipping boat, automotive, train, etc. Furthermore, the abandon resources ready available particularly in tropical of nature locally of Nanggroee Acheh Darussalam.

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