THE EFFECT OF KAOLINITE ON TENSILE AND FLEXURAL BEHAVIOR OF SALACCA FIBER - REINFORCED EPOXY/KAOLINTE HYBRID COMPOSITES

Vixaichidxiong Juevaxaiki[1*], Heru SB Rochardjo,[2*] Muhammad Waziz Wildan[3*]
Mechanical and Industrial Engineering Department,
Faculty of engineering
Universitas Gadja Mada

[1*] vixaichid1010@gmail.com
[2*] heru-sbr@ugm.ac.id
[3*]m_wildan@ugm.ac.id

Abstract- The use of filler in composite materials is emerged as a result of increasing demand for the advancement in material properties to satisfy the market necessities. This study presents the effects of kaolinite inclusion on tensile, flexural and characteristics of Salacca fiber/kaolinite reinforced composite laminates. The laminates were fabricated by hand layup and moulding. Kaolinite particles having four different weight fractions as 1, 3, 6 and 9 by volume percentages were used for fabrication of composite laminates. The specimens were prepared according to ASTM D638 and D790 standards for tensile and flexural tests, respectively. Results obtained from specimens having Kaolinite particles showed the serious improvement on the tensile strength, flexural modulus and flexural strength values compared to specimens without kaolinite inclusion.

Keywords: Kaolinite, Salacca Fiber, Epoxy, Tensile, Flexural

A. INTRODUCTION

In Indonesia, Salak (Salacca Zalacca) palms are cultivated throughout the islands and the fruit is widely used as fresh fruit. Salacca production in Indonesia has increased from 423.5 t in 2000 to 862.5 ton in 2009 [1] fresh Salacca fruits have been exported to Singapore, Middle-East, Malaysia, HongKong, and China. There are 30 cultivars of Salacca, which distribute across the Indonesian islands the availability of superior quality fruit from selected cultivars, such as “Pondoh” from Yogyakarta and “Gula Pasir” from Bali. “Pondoh” is cultivated in the sub-district of Sleman of Yogyakarta special region[2]. Natural resource can be beneficial for people, especially for poor smallholders, to add incomes and escape from economy problem[3].

Economic and environmental situations of the recent years have triggered many companies and researchers to develop and improve technologies aimed to reduce or decrease industrial wastes. As a result, many attempts have been expended in different areas, including the industrial and agricultural production, a large amount of industrial and agricultural wastes or by-products build up each year[4]. The recycling of waste materials has attracted the attention worldwide due to high environmental impact. Thus, the biodegradable materials are considered to be useful as they are not considered as waste anymore[5].

Plant fibers are biodegradable materials that can be spun into useful elements such as filament, thread, further be woven, matted or bound for other useful products such paper, cloth, automotive parts and etc. The applications of natural fibers are growing in many sectors such as automobiles, furniture, packing, and construction[6]. This is mainly due to their advantages compared to synthetic fibers such low cost, light weight, less damage to the processing equipment, improve the finished surface of molded parts composite, good relative mechanical properties, abundant and renewable resources[7].

Kaolinte is an inorganic chemical material, commonly known as clay or Aluminum silicate. It has ultrafine micrometer size range between 0.1 and 12 µm and effects the mechanical behavior of the materials seriously. There are many studies about effects of Kaolinte amount on the mechanical behaviors of composite ceramic and composite in literature examination. [8].The study covers the effect of kaolin clay particles on the mechanical, morphological and processing features of PS/HDPE blends. Incorporation of organo modified kaolin clay increase interfacial adhesion with the matrix. Tensile strength and tensile modulus is found to increase with 2% clay loading. Impact strength is found to increase at 3 % of filler loading. Flexural strength is found to increase with increase in filler loading.

The analysis is found to decrease at filler loading beyond 1% which indicates the penetration of polymer chains at the inter layer space of clay particles. The improvement in mechanical parameters for modified clays can be related to a good dispersion of mineral particles in the polymer matrix, amino modified clays shows overall better performance as revealed by the morphology. Thus low cost kaolinite clay can be used as a suitable modifier of plastics.[9]

This is motivated in the field of natural fibre composite due totheir many advantages over the synthetic fibre composite and huge application in the automobile, aerospace, insulating materials etc.This research work deals the mechanical behavior such as tensile,flexural and invrstigate the properties of Salacca+epoxy+ Kaolinite by SEM in the composite.

Nomenclature

E	: Neat epoxy
E+F	: Epoxy + Salacca fiber
E+F1	: Epoxy + 1% of Salacca fiber
E+F+K	: Epoxy + Salacca fiber + Kaolinite
E+F15+K3	: Epoxy + 15% of Salacca fiber + 3% of Kaolinite

B. MATERIAL AND METHODS

2.1 Material

Three main component as Salacca fiber, Epoxy resin, Hardener and Kaolinite were used to fabricate composite laminates. The Salacca and Kaolinite were used as reinforcement to the composite. In this work the Salacca fibre, epoxy and hardener were purchased product from germany. Epoxy has the viscosity and lap shear at 25 °C, 13000 mPa.s, density 1.17 g/cm^3 and 2.6 g/cm^3 of kaolinite respectively.[11] The mechanical, physical and chemical properties of Salacca fibres are given in Table 1.

Table1. Mechanical, physical and chemical properties of Salacca fibre [10]

Properties	Salacca fiber
Diameter (μm)	300-350
Density (g/cm^3)	1.17
Cellulose (%)	51,50
Hemicellulose (%)	74,09
Lignin (%)	31.49
Wax (%)	8
Tensile strength (MPa)	275

2.2 Preparation of composites

Salacca fibre were cut in the length of 150 mm, and 200 mm. Fabrication of different composite sheets manufactured by hand lay-up method. Epoxy resin & hardener use as the brand of Eposchon A and B were mixed in ratio of 1:1 by weight asrecommended. A wood mould with size dimension 250 mm × 110 mm × 3 mm was used to prepare the composites. The different type of composite has been fabricated with different fibre lengths. Each composite has constant fibre content 15% by Volume. Release agent wax was used to facilitate the easy removal of composite from the mould. In the composite curing was done at room temperature under the pressure 5 MPa for 24 hours. After that the composite was cut according to the ASTM standard for tensile and flexural test.

2.3 Mechanical testing

Tensile, flexural test were carried out with the five separate specimens for each test and the averagevalue was reported.

2.3.1 Tensile test

Tensile testing was performing on SERVOPULSER the machine at Materials Laboratory Department of mechanical and industry Engineering UGM. (bi-axial testing machine, Setting loads 2 tons) with 2 mm/min crosshead speed.Tensile testing specimens were having dimensions165 mm×20 mm×3.2 mm accordance to standard ASTM D 638-03 with gauge length 53 mm. The shape of tensile testing specimens was double-dumbbell as shown in Fig. 1.

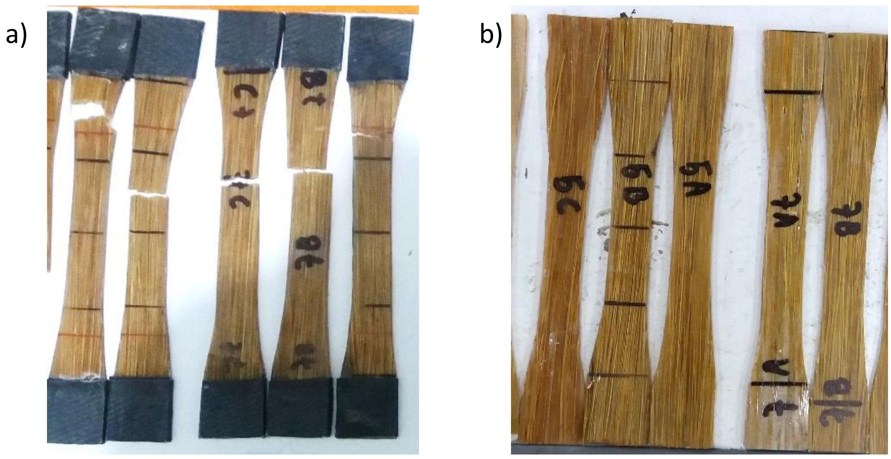

Fig. 1. Tensile specimen E+F15 a) before tensile test (b) after tensile test.

2.3.2 Flexural test

Flexural testing specimens were prepared as per standard ASTM D 790-03. The dimensions of the rectangular shaped flexural specimens were 127 mm×12.7 mm×3.2 mm with span length 48 mm. Fig. 2 shows the specimens of flexural test specimen in composite.These specimens were tested on the Pearson Panke machine at Materials Laboratory Department of mechanical and industry Engineering UGM. (bi-axial testing machine, load capacity 20 kN) with 2 mm/min crosshead speed. The flexural testing was done using a three point bending test. Flexural strength and flexural modulus were calculated and report.

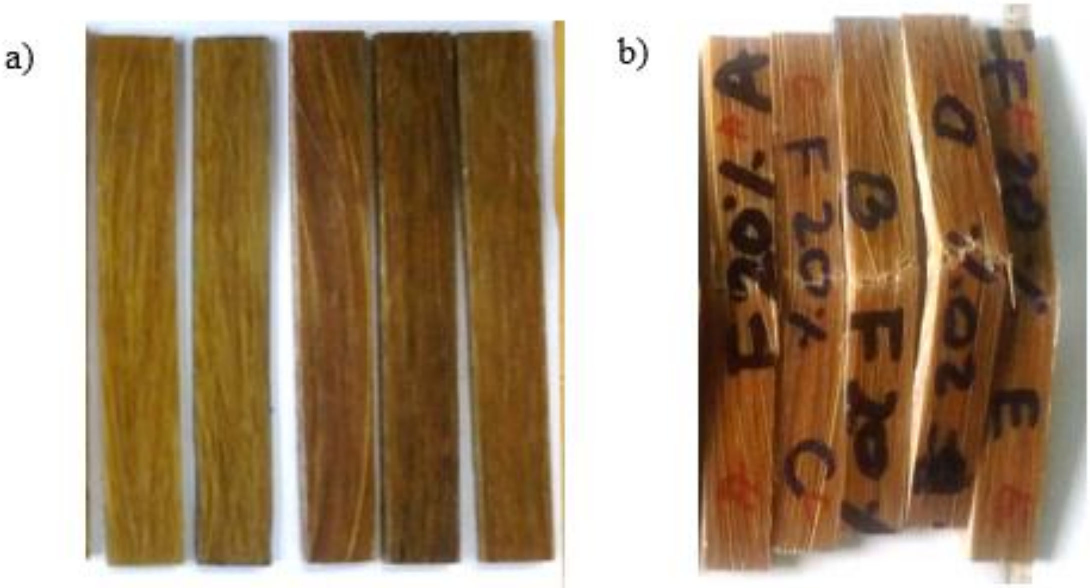

Fig. 2. Flexural test Specimens a) before flexural test b) after flexural test.

C. RESULTS AND DISCUSSIONS

3.1 Tensile test.

The variation of tensile strength values of the specimens are given in Fig.3. For the specimens having Neat epoxy, 0%, 1%, 3%, 6% and 9% of Kaolinte inclusion, increases of 24%, 78%, 84% and 60% respectively were obtained when compared to the E+F15 specimens. The maximum tensile strength value was obtained from 6% Kaolinite filled beam specimen as 153.84 MPa. As can be seen in figure, the tensile strength values have increased up to certain amount of Kaolinte, after 6 vol% kaolinite the effect of addition decreasing happens. This can be explained as kaolinite addition can improve tensile properties of Salacca fiber between 3 % to 6 vol%.

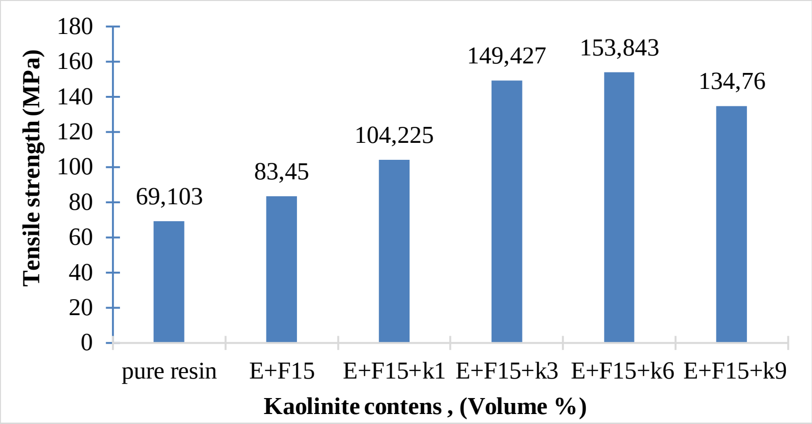

Fig.3. Variation of tensile strength according to kaolinite content.

The stress-strain diagram of filler kaolinite to the fiber reinforced composite beam characteristics obtained from tensile tests are given in Fig. 4. According to tensile test results, the best performance as maximum tensile strength and strain can be seen for the specimens having E+F15+K6% or at 6% of kaolinite.

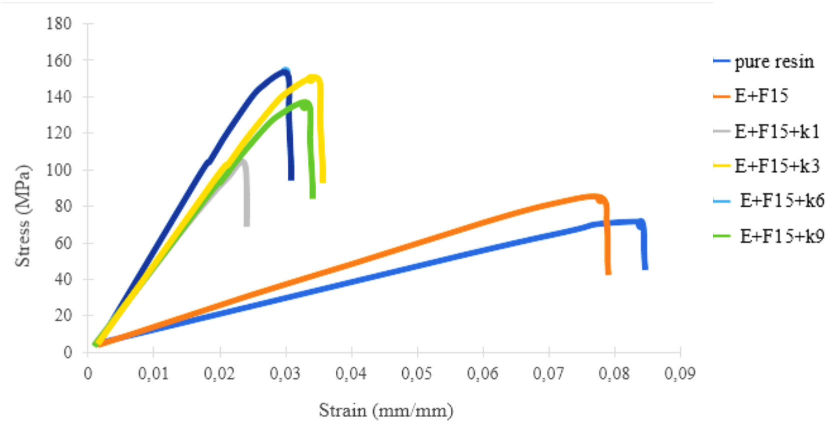

Fig.4. Tensile stress-strain curves of the composites.

3.2 Flexural test.

The variation of flexural modulus and flexurals trength values of the E+F15+K composite beam specimens having different kaolinite content are presented in Fig. 5 and 6, respectively. The achieved increase in the flexural modulus were taken as 1%, 3%, 6% and 9% kaolinite filled Salacca fiber reinforced epoxy composites, respectively. The maximum value was observed for the specimen having E+F+K or 3% kaolinte volume contentas 7.38 GPa. For the specimens having 6 and 9% Kaolinte amount, there is a decreasing compared to specimen without kaolinte. This can be related to agglomeration of kaolinite in matrix structure or nonhomogeneous mixture of epoxy resin and kaolinite powder.

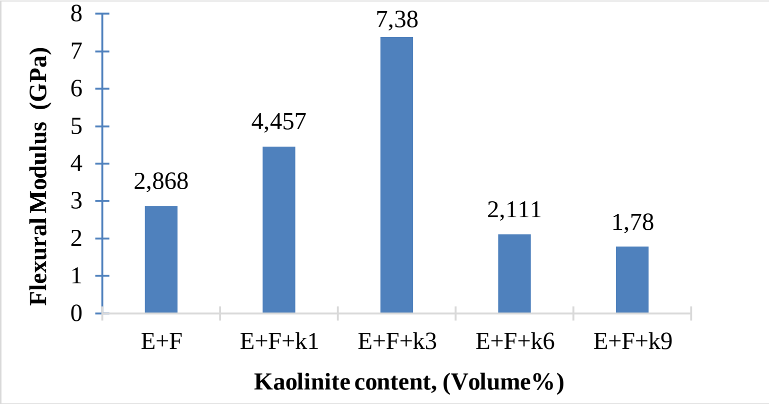

Fig.5. Variation of flexural modulus according to kaolinte content.

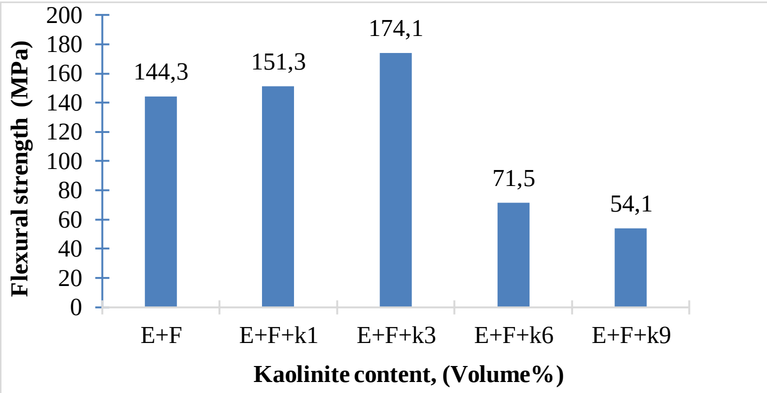

Fig.6. Variation of flexural strength according to Kaolinite content.

For the flexural strength values of the specimens, maximum value was obtained for specimens having E+F15+K3 or 3% kaolinite as 174.1 MPa. Differently from flexural modulus results, the 1% kaolinite amount effected the flexural strength as a little increasing. This can be explained as weak interaction between kaolinite and epoxy resin. Also, the load-displacement curves for E+F15+K reinforced composites having different kaolinite amount are shown in Fig. 7. The initial load height parts of all curves are similar, but the yield displacements, failure manners, and maximum loads are different. At 3 Vol% content of kaolinite, its curve showed the highest maximum displacements is the E+F or non-kaolinite.

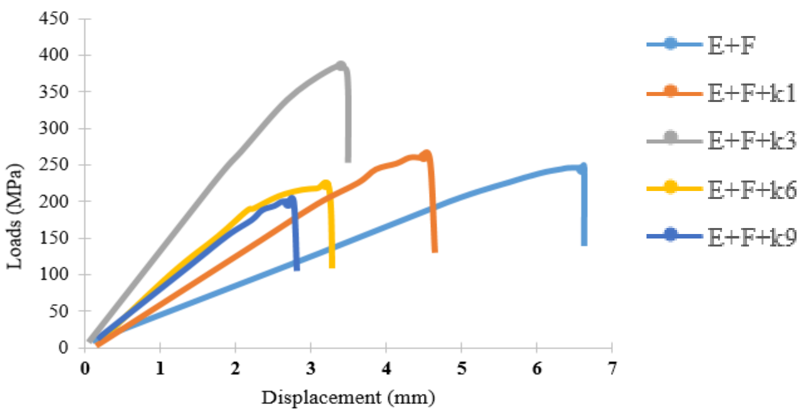

Fig.7. Flexural load-displacement curves of the composites.

D. CONCLUSIONS

The experimental study of the effects of kaolinte amount on tensile and flexural properties of Slacca fiber/kaolinite reinforced composite laminates was performed in this work. The composites were prepared by adding different volume percentages of kaolinite as 1 vol%, 3 vol%, 6 vol% and 9 vol% into epoxy resin/Salacca fiber. In the tensile test, the addition of kaolinite provided an improvement in the tensile strength regardless of kaolinite content. The improvement in the tensile strength was increased to the maximum by 84% at 6 vol% Kaolinite content. In the three-point bending test, the flexural strength from composite laminates starts to decrease by adding 3 vol% kaolinite. From E+F up to E+F!%+3 or 3vol% kaolinite flexural strength reached its maximum value which is 174.1 MPa. The improvement in flexural strength was reached by 4.8 and 20% compare to E+F at E+F15+K1 up to E+F15+K3 contents of kaolinite, respectively. The improvement in flexural strength was reached by 1% at 3 vol% kaolinite content. After that, when increasing the content of kaolinite to 3 vol% the flexural strength come back in the decrease trend. The results showed that the mechanical properties of Salacca fiber/kaolinite reinforced composite laminates could be improved by the addition of varying amounts of kaolinite. It is also revealed that composite laminates with kaolinite can be exhibited better performance than laminates.

E. ACKNOWLEDGMENT

This work has been supported by ASIAN University Network/South-East Asia Engineering Development (AUN/SEED-Net). My high appreciation grateful to the staff of Laboratory of Material and PAU, Universitas Gadjah Mada.

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