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Utilization of Coconut Fiber Waste in Mattress Industries and Its Accessories in North Sulawesi

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Abstract

In North Sulawesi, one of natural material types which have the potential to be used as mattress industrial raw materials and its accessories is waste of coconut fiber. Waste coconut fiber is abundant, but the functions and utilization are limited. In addition, not developed by craft and design industries yet cause limited of product functionality and weaken product design creations. The result of all that problems causes coconut fiber craft products are not able to reach a wider market, so abandoned by local artisans because they are not prospective and less promising for the future. As a result, the researchers are required to innovate in order to obtain craft products and new designs by utilizing the potential of local natural resources as raw material. One effort that has been done is mattress production research of coconut fiber mixed with a latex compound. From the research that has been done, coconut fiber mattress is extremely strong, lithe, environmentally friendly, made from natural fibers so it is interesting and prospective to be developed.

Keywords: fiber, coconut coir, mattress, accessories, strong, lithe, comfortable

INTRODUCTION

Craft and design industries are creative industry subsector which is dynamic along with the eras. Therefore, the creative industries in this subsector are required constantly innovating in order to build new designs of craft products and typical according to the tastes of the eras. Handicraft and design which follow the eras can be

done by exploiting the potential of local natural resources by creating unique products of craft industry from natural material as raw material.

In North Sulawesi, one of natural material types that have the potential to be used as mattress industrial raw materials and its accessories is waste of coconut fiber. Waste of coconut fiber is abundant, but the function and utilization are still limited, that are only used as ropes, brooms and fuels. The main problem that causes underdevelopment of craft and design industries are the limited functionality of the produced product and weaken design product creations. Because of the craft of coconut coir are not able to reach a wider market, so abandoned by local artisans because they are not prospective and less promising for the future.

One of the strategic efforts needed to solve the problem of coconut fiber waste is building a waste processing industry of coconut fiber to produce various kinds of bedding products, accessories mattresses, pillows, souvenirs, as well as the application of variation motif of North Sulawesi in order to increase the local artistic value. The success of these efforts will not only be good for floating craft byproduct of coconuts in North Sulawesi, but also very significant in the search for solutions of coconut fiber waste into useful superior products. If these efforts can be done well, then it will hopefully be able to grow the interest of young people to be creative to develop local products made from coconut fiber that will be in demand by the consumer society.

RESEARCH METHOD

Materials Research

The materials used in this study are: coconut fiber, liquid latex, zinc-diethyl-dithiocarbamate (ZDEC), zinc-mercaptobenzothiazole (ZMBT), zinc oxide (ZnO), butylated hydroxytoluene (BHT) or ionol, sulfur (S), lauric acid $CH_3(CH_2)_{10}COOH$, sodium hydroxide (NaOH).

Research Tools

The equipment used in this study are chemistry glassware, analytical balance *AND GR-200 SER.14214919 Japan*, *Triple Beam Balance 700 series 2610 g OHAUS*, pycnometer, thermometer, magnetic stirrer, magnetic sticks, oven *ELBANTON Laboratoriumapparatuur Ultingstraat 18.5331 EJ KERKDRIELLantelijk ERKEND Installateur*, *Zwick Material Testing BasicLine table-top-test machine DO-FBO.5TS*, *Universal Testing Machine type: S AMU-CAP-DE: 5 Tont Tokyo MFG.CO.LTD*, *Scanning Electron Microscopy* (SEM), the mold wood, and 1 set of tools air compressor.

Making Wavy Coconut Fiber (WCF)

Making WCF was done by spinning the coconut straight fiber (SF) to became mine and then rolled. To get a good WCF, then spun coir fiber has to have a strong coil. Mine was dried in an oven at a temperature of 100 - 105^{o}C for about 4 hours, until the color changes from yellow gold mines to brown. After roasted, the mine was cooled at room temperature over 24 hours in order to keep the mine coil remain strong and not easily broken. The cooled mine was then opened and parsed to obtain random shape WCF. Thus, the WCF was immediately put in plastic bags and stored in a dry place.

Making Dispersion Mixture

Making the dispersion mixture was done by making a mixture of chemicals made by 1:1 of 200 g of dispersed with 200 g of dispersing agents. The duration needed to mix them both shown in Table 1.

Table 1. The duration of mixing dispersed with dispersing agents.

Material	Dose (part/gram)		Mixing Duration (hour)
	Dispersed agent	Dispersing agent	
Sulfur dispersion 50%	Sulfur 200	Water 200	36
ZDEC dispersion 50%	ZDEC 200	Water 200	24
ZMBT dispersion 50%	ZMBT 200	Water 200	36
Ionol dispersion 50%	Ionol 200	Water 200	36
ZnO dispersion 50%	ZnO 200	Water 200	24
Potassium laurate, solution 20%	K-laurate 80	Water 320	2
Potassium hydroxide, solution 10%	KOH 40	Water 360	1

Latex Compound Manufacture

Mixing the dispersion into the latex mixture started from K-laurate, KOH, ZDEC, ZMBT, ZnO, BHT and sulfur (S). Dispersion-Latex mixture was then stirred slowly until the mixture was homogenous and certainly there is no foam formation. Before using, it is better the latex compound to be stored in advance for 2 to 3 days. During the deposition of storage will likely occur dispersion of chemicals. To prevent this

possibility, then every day the latex compound had to be stirred slowly for 10-20 minutes. Ways of making latex compound formula shown in Table 2.

Table 2. Latex compound formula

	Material	Latex compound formula (psk)
1	Latex	100
2	K-laurate 20%	1
3	KOH 10%	0,5
4	ZDEC	2
5	ZMBT	3
6	ZnO	2
7	BHT	1
8	Sulfur	3

Mattresses Manufacture

Prepared of mattress mold tool pillowed with wire ram length 40 cm, width 40 cm and height 5 cm (A) and 7.5 cm (B). WCF was stocked and prepared as best as possible within the mold. Latex compound was sprayed to WCF surface using air compressor and spraying process was performed in three stages. Spraying latex compound in the early stages of the process was a process of wetting the WCF and spraying the second and third stage were the coating process on whole WCF mattress surface until the inside. Mattress A and B were vulcanized in an oven at a temperature of 90°C for 30 minutes. Vulcanized A and B were removed from the oven, the mold is pressed slowly until it reaches a vulcanize thickness of 5 cm (A) and 7.5 cm (B). A and B vulcanize were vulcanized continuously at a temperature of 90°C for 5-6 hours. A and B vulcanize were removed from the oven, cooled at room temperature for 24 hours. Vulcanize or mattresses A and B with a thickness of 5.0 cm and 7.5 cm respectively were coded with (MA) and (MB).

Vulcanize Characterization

Characterization of MA and MB included: mass density, elongation break test, compression test and analysis of Scanning Electron Microscope (SEM).

RESULTS AND DISCUSSION

Research results of making WCF show that the shape of SF can be transformed into wavy fiber such a random spiral or one-dimensional SF size can be transformed into three-dimensional WCF size. The shape changed SF into WCF shown in Figure 1.

a). SF **b). WCF**

Figure 1. Shape changed from SF into WCF

After the WCF was formed, the fiber then was put in plastic bags and stored in dry place to keep the shape of WCF unchangeable. If the WCF is not saved and left in the open space, the fiber will metamorphose into SF. Changed shape from WCF into SF is due to coconut fiber character is hygroscopic. The higher vapored water is absorbed, the faster WCF transformed into SL. WCF is shaped-spiral fibers, have large and small cavities with the size of the cavity is not homogeneous.

Chemicals as a dispersion substance have to be dispersed first with water. Water as a dispersing agent serves to moisten all the chemicals in the form of powder which insoluble in water. Comparison of dispersing and dispersed materials were made up 1:1. The process of making dispersion solution should be shaken not too slow and not too fast so that dispersed substances can be spread equally. The stirring duration of mixed dispersed and dispersing materials depend on the characters of the materials used. The dispersion mixing process was stopped when the dispersion solution had mixed up evenly with water and none found of rough parts from dispersed substance. To check the dispersed substance in the dispersion mixture can be done by taking a drop of dispersion solution, then put into a small tube containing water. If the droplet dispersion is then mixed with water evenly, it demonstrates good dispersion mixture.

Mixing process of dispersion materials into latex was conducted in sequent from K-laurate, KOH, ZnO, BHT, and sulfur, then the mixture was stirred slowly until the mixture became homogeneous. Stirring the mixture of latex compound Had to be done carefully and slowly to avoid the formation of clots and foam of latex. The manufacture of latex compound formula shown in Table 3.

Table 3. Latex compound formula

	Material	Latex compound formula (psk)
1	Latex	100
2	ZDEC	2
4	ZMBT	3
5	ZnO	2
6	BHT	1
7	Sulfur	3
8	K-laurate 20%	1
9	KOH 10%	0,5

Latex compound formula as shown in Table 3, is highly dependent on the purpose and the physical properties of the desired product. Physical properties of the products included tension stress, tensile strength, flexibility, heat resistance, and adsorption properties. Knowing the physical properties of the product is needed as a consideration in the use of chemicals that will be used. The use of vulcanize materials, accelerator, activators and fillers have to be set according to purposes, especially with regard to the vulcanization process. To produce a product with good physical properties, then before using, latex compound mixtures need to be stored in advance for two to three days. After one day stored, immediately removes the appeared air bubbles that float on the surface of the latex compound. To prevent the deposition of dispersed substance and agglomeration latex, then the mixture should be stirred every day for 5 to 10 minutes. The purpose of the storage of latex compound is to mix the dispersing substances with latex evenly so that the mixture of the compound becomes more stable and homogeneous (Anom, et al., 2012). The maximum storage of latex compound will affect the physical properties of the mattress, that are elasticity character and hardness.

The process of making the MA and MB mattresses were done in three stages. The first stage, spraying latex compound on the surface of WCF was a third of the provided compound. Based on observations in laboratory studies, a third amount of provided latex compound was enough to wet the surface of the LCS. The second and third stage aimed to coat the surface of the mattress so that the latex compound can bind the entire surface of the WCF and spread evenly to the inside of the mattress. MA mattress with a thickness of 5 cm was vulcanized for 5 hours, whereas MB mattress with a thickness of 7.5 cm was vulcanized for 6 hours. From the research that has been done, the best temperature of mattresses vulcanization was obtained at a temperature of 90°C. Vulcanization temperature is needed to enhance compound latex

reaction with sulfur. Vulcanization temperature must continuous for a certain period of time. Too high vulcanization temperature is not good because it will decrease the elasticity and degrades the crosslinking properties so that the mattress becomes damaged. A way that can be conducted to maintain the mattress stability because heat effect was by adding BHT antioxidant material into the latex compound. BHT is a derivative of toluene which commonly used as a preservative and how it works as an antioxidant. Antioxidants are substances that can capture free radicals which itself are also a free radical (Mashuri et al., 2005). The velocity of vulcanizing latex compound is defined as a change in physical properties of the compound per unit time. Vulcanization level was determined by measuring the tensile strength, tensile brake, strain, or other physical properties of the sample of compound that had been vulcanized. Vulcanization time for a particular compound is constant and only depends on the influence of chemical compound (Kartowardoyo, 1980; Chan et al., 2006).

To improve reaction speed and efficiency of sulfur vulcanization, chemicals were added as an accelerator and activator reaction to the elastomeric material. The crosslinking structure that occurred depend on the character of rubber or elastomer, sulfur ratio, accelerator materials, activator materials, and vulcanization temperature. Proposed mechanisms of free radical reactions that may occur between the reaction of sulfur, ZMBT, ZnO and rubber are shown in Figure 2.

Vulcanization begins with the formed of sulfurization species which is zinc accelerator group that is zinc-2-merkaptobenzothiazol (ZMBT) accelerator interacts with the S_8. Sulfurization reaction was followed by insertion of sulfur as molecules -S-S- or sulfurization reaction occurs repeatedly through the inserted sulfur atoms. In the absence of zinc, sulfurization reaction can only occur through a radical mechanism involving benzothiazole radical which takes sulfur from a longer series of radical.

Sulfurization species causes the formed of precursor crosslinking through reaction with the rubber. The crosslinking precursor can be either zinc-free or zinc-bound species. The crosslinking precursor was converted into the crosslinking by (a) direct reaction of the precursor with other rubber molecules through intermediate persulfenil or (b) with two crosslinking precursors between the precursor and the radical persulfenil. Crosslinks precursor were formed when the polysulfide accelerator reacts with rubber chains, which resulting R-S_x-S-Benzothiazole consisted of polysulfide accelerator pendant groups bounded on the rubber molecules (R-H). The existence of this crosslinking precursor based on rubber system (R-H), activator (ZnO), ZMBT accelerator, and sulfur (S). Proposed mechanism of the reaction is based on the reaction of free radicals in the formation of sulfur crosslinks with rubber is shown in Figure 2.

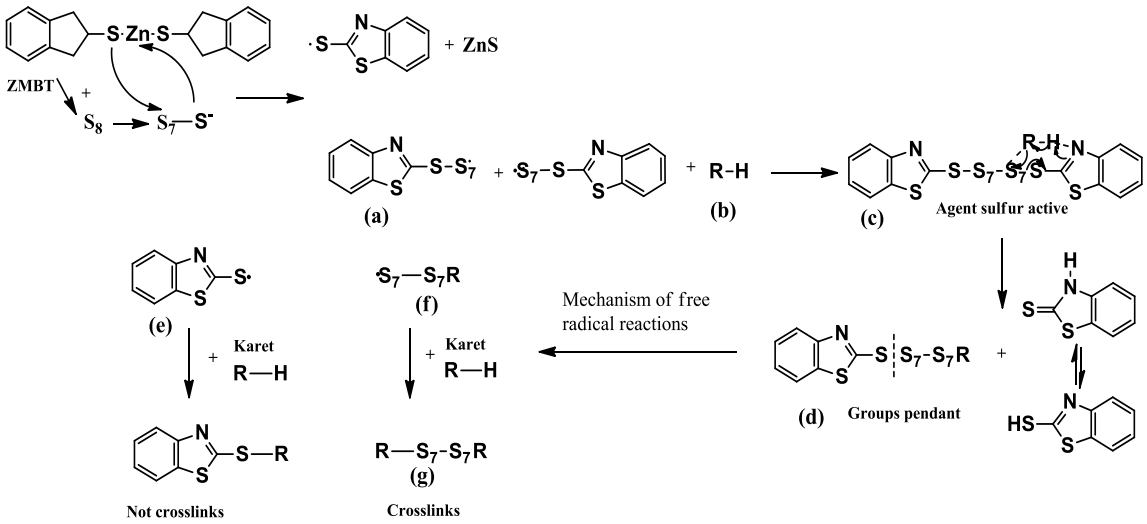


Figure 2. Proposed mechanisms of free radical reactions in the formation of sulfur crosslinking with rubber using accelerator and activator ZnO ZMBT

The result of polyurethane foam (PF) mass density test used as a comparison and mass density of latex (LT) latex compound LC, coco feber (CF), mattresses A (MA) and mattresses B (MB) shown in Figure 3.

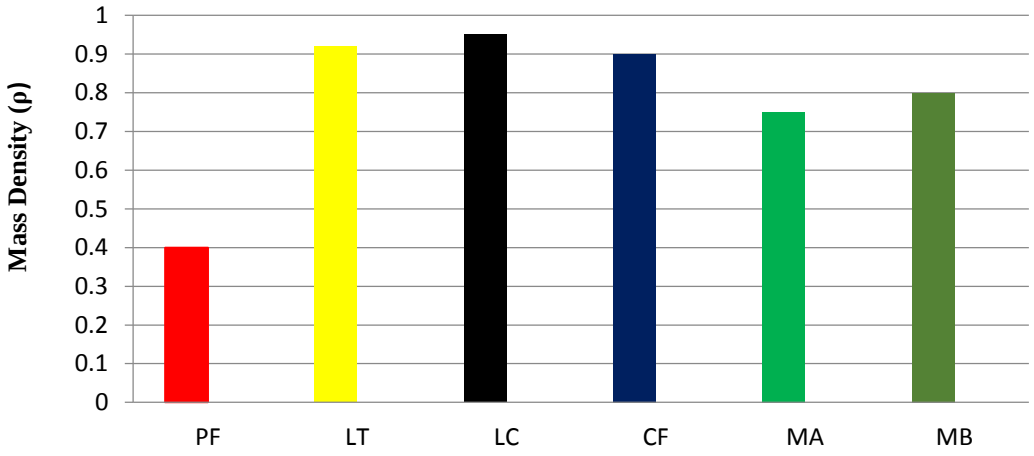


Figure 3. Mass density graphic of PF, LT, LC, CF, MA, MA and KB

The results of mass density test show that the mass density of PF = 0.40 g/cm^3, LT = 0.92 g/cm^3, LC = 0.94 g/cm^3, CF = 0.90 g/cm^3, MA = 0.75 g/cm^3 and MB = 0.80

g/cm^3. The influence of the addition of chemicals into the latex causes compound concentration concentrated or more viscous so that its mass density rising. Based on the mass density, MA and MB have mass density under the mass density of coconut fiber coir and latex compound. A decrease in mass density can be caused by filler material factor which is WCF. The combination of WCF fiber and latex compound will produce mattress that has no uniform cavities. The more cavities are formed, the lighter mattress resulted. In addition, differences in mass density of mattress can also be caused by the amount of latex that is not distributed evenly on the mattress, it is because the bad process of spraying the compound.

Mattress is a composite with properties closer to porous polymers like high-density foam had a relative density of between 0.4 to 0.8 (Mills, 2007; Anggaravidya 2008; Najib et al., 2009). Composites are solid materials resulted from the combined two or more different materials to produce better physical properties that can not be obtained from each of the components (Wijaya, 2001). Type of phenolic foam has a mass density of between 0.40 to 0.42 (Ben, 2003).

Tensile strength test is one test of physical strength parameter of a product mattress. The test results showed that the tensile strength values of PF = 0.12 N/mm^2, MA and MB = 0.16 = 0.19 N/mm, shown in Figure 4.

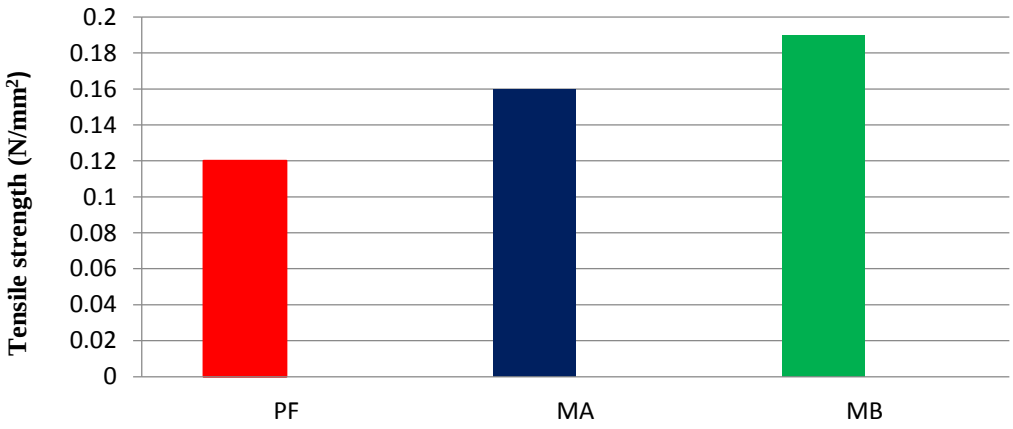


Figure 4. Tensile strength graphic of PF, MA and MB samples

The tensile strength values of each mattress are affected by its mass density. The greater the mass density of the mattress, the value of its strength is also getting bigger. The treatment of mattress thickness variations affects the value of its strength although the effect is not too big, but has bigger impact on the length of the mattress vulcanization process. The mattress with a thickness of 5 cm takes vulcanization for 5 hours and a mattress with a thickness of 7.5 cm takes vulcanization for 6 hours at 90°C temperature vulcanization.

The test results of tensile strength show PF = 82.67%, MA and MB = 42.73% = 48.88%. The value of the tensile strength of MA and MB mattresses are more influenced by the orientation of the LCS which is not spread evenly and not uniform of cavities mattresses. Cavities mattresses were not uniform will give a variation of the tensile strength. The lack of a homogeneous fiber orientation causing interfacial bonding fibers with latex will be weakened. In addition, not uniformed mattress cavities will also affect the deformation and break the interfacial bond with coconut fiber coir. The tensile strength of the PF, MA and MB samples are shown in Figure 5.

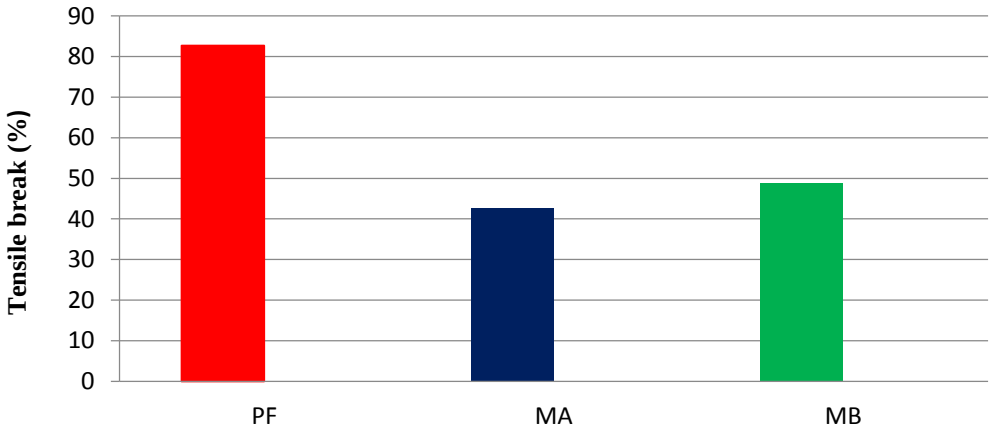


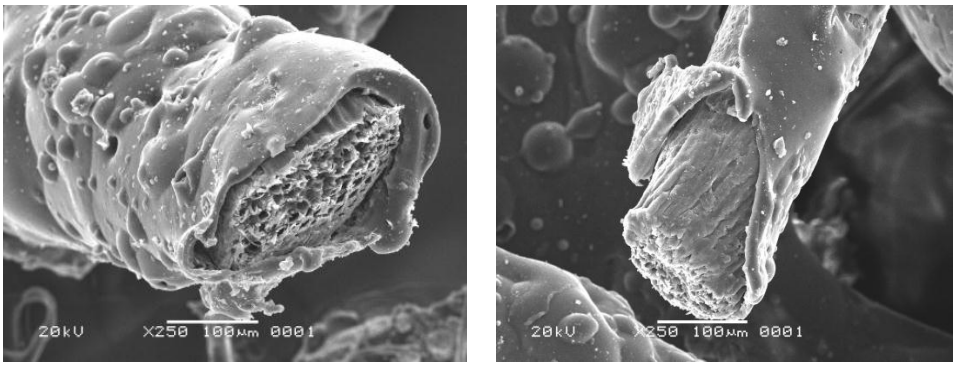
Figure 5. Tensile break graphic of PF, MA dan MB samples

One of elasticity tests on mattress manufacture is conduct fixed compression test. Pressure will give effect to the compression strength which increases the compaction and will increase the compression strength (Rusianto, 2005). Fixed compression testing was performed at room temperature for two hours. Average chart of fixed 50% compression test values of PF, MA and MB are shown in Figure 6.

Figure 6. Fixed 50% compression graphic of PF, MA and MB samples

From Figure 6, it can be explained that at the compression treatment in same time shows differences on each mattress compression values. The differences on compression values could be caused due to the length of compression which will decrease the power of the mattress and then the value of the compression becomes larger. Fixed 50% compression value of PF = 0.72%, MA 8.82%, and MB = 8.90%. If the mattress is compressed to provide greater pressure, then the formed air cavities will change shape or deform. Compression value is the percent change in mattress thickness caused by occurred temporarily pressure loads during heavy load giving and will back to initial form when the mattress is not given load (Anom et al., 2010; 2011; Ifa, et al., 2008). If the compression value of PF compared with the compression value of MA and MB, turns the compression value of PF is smaller. This could be implied that the elasticity properties of the rubber polyurethane foam better and stronger in holding heavy loads when compared with the mattress.

SEM morphology showed that the surface cavities of MA and MB have almost the same compactness. Compactness degrees illustrates the strength of interactions that occur between coconut fibers with latex compound forming a heterogeneous mixture. Compactness, in this case, means that the compound latex is not distributed evenly because the surface of the mattress appeared latex compound clumps spread unevenly. Coconut fibers also appear did not spread evenly so that the cavities of the mattress seem not uniform. The SEM photographs of MA and MB mattresses are presented in Figure 7.



a) MA b). MB

Figure 7. SEM photographs of MA and MB mattress, an enlarged image 250 X

SEM image of MA and MB showed the present of clumps or granules in a variety of cavity size which was not homogeneous. Microstructure surface of each MA and MB mattress describe almost the same compactness. The strength of the interactions that occur between coconut fibers with latex compound looks not compact which means latex compound was not uniformly distributed on the surface of MA and MB and it was clear that all the mattresses showed a large and not uniform air cavities.

CONCLUSION AND RECOMMENDATION

1. The mattress made from a blend of coconut fiber coir with latex compound is a mattress made of natural materials, environmentally friendly and has bending properties which are high enough so that it prospective to be developed.
2. PF foam is lighter than MA and MB mattress because the mass density of PF is smaller than MA and MB.
3. The tensile strength and tensile break of the MA and MB mattress are influenced by its mass density, fiber orientation which is not spread evenly and mattress cavities which are not uniform.
4. PF foam stronger in hold heavy loads if compared with MA and MB mattress because of PF compression value is smaller than the MA and MB.
5. SEM microstructures of MA and MB are not compact because latex compound is not uniformly distributed on the surface of MA and MB and shows air cavities which are not homogeneous.

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