ENVIROMENTAL FRIENDLY COMPOSITES FROM FIBERS OF OIL PALM EMPTY FRUIT BUNCH AS BULLET PROOF COMPONENTS FOR ARMOURED VEHICLES

[1]ANDY CAHYAPUTRA ARYA, [2]RULLY ARIO DEWANTO SOERIAATMAJA, [3]DORINA HETHARIA, [4]INDRA SURJATI, [5]BARLIAN NASUTION, [6]REVINA DEVI RUBIJONO, [7]YOHANES PRIADI

[1,3,4]Fakultas Teknologi Industri, Universitas Trisakti, [2]Fakultas Seni Rupa dan Desain, Universitas Trisakti
Kampus A, Jl. Kyai Tapa No. 1, Grogol, Jakarta 11440, Indonesia
[5, 6, 7]PT. Regasis Dana Asia, Rasuna Office Park – LR 0.3, Jl. H. R. Rasuna Said, Kuningan,
Jakarta 12960, Indonesia
E-mail: arya@trisakti.ac.id

Abstract- Increasing world population is one factor which causes the growing vegetable oil production in the world. The most produced vegetable oils in the world are such as cottonseed oil, palm oil, rapeseed oil, soybean oil, sunflower oil. In year 2012, palm oil was the most produced vegetable oil with world production by 53,3 million tons. Indonesia is the most producer of crude palm oil (CPO) in the world with production by 26,9 million tons in 2012. By palm oil industry biomass will be generated in plantation and at the palm oil mill. Empty fruit bunch of oil palm (EFB) is one of biomass which is generated at palm oil mill. The amount of EFB and the production of CPO is proportional. It means there were about 26,9 million tons of EFB available in 2012 in Indonesia or 53,3 million tons in the world. Nowadays, only small amount of EFB would be utilized for different purposes such as as animal feed, compost, briquettes, particle boards. From 100% EFB can be gained about 50% fibers of EFB. After fiberizing stage the EFB to be fibers, followed by fibers screening stage, the fibers will be raw material which can be processed furthermore to be prepregs and finally to be composites. In this research the natural binding agent of starch of potato will be used. With composition of 1:1 between the fibers and the binding agent. They will be mixed and prepregs will be produced. At next, the prepregs will be hot pressed with temperature by 180 ^{0}C, pressure by 40 bar and press duration by 15 munites to be enviromental friendly composites. According to standard DIN 53 457 (the 3 points bending) the material have strengthness about 7 GPa. 5 layers of these composites were prepared for ballistic test at distances of 5, 10 and 15 m and they showed good results. It is possible to implement environmental friendly composites from fibers of oil palm empty fruit bunch mixed with starch binding agent from potato to be bullet proof components for armoured vehicles.

Keywords- Armoured Vehicle, Binding Agent, Bullet Proof, Composite,Empty Fruit Bunch, Oil Palm, Potato, Prepregs, Starch

I. INTRODUCTION

Increasing world population is one factor which causes why vegetable oil production is growing rapidly from year to year in the world. Its demand grows constantly up. The most produced vegetable oils are such as cottonseed oil, palm oil, rapeseed oil, soybean oil, sunflower oil. In year 2012 the palm oil was the most produced vegetable oil with world production by 53,3 million tons. Since 2008 Indonesia is the most producer of crude palm oil (CPO) in the world with production in 2012 by 26,9 million tons [1]. Along with the increasing vegetable oil production of CPO, the amount of waste palm oil industry and at palm oil mill which will be generated are increasing as well. In 1992 the CPO production in Indonesia was about 3.6 million tons. Through expansion of oil palm plantations Indonesia could increase its CPO production and since 2008 has been the most CPO producer in the world. In 2007 the areas of oil palm plantation in Indonesia were about 6.85 million hectares with a production of CPO by 17.80 million tons. In 2011 the plantation would be increased to 9.10 million hectares with 24 million tons CPO production and in 2012 by 26.9 million tons CPO production. [2]

At palm oil industry the wastes in form of gas, liquid, solid will be generated, in plantation as well as at the palm oil mill. Empty fruit bunch of oil palm (EFB) is one of biomass (solid waste) which is generated at the palm oil mill. The amount of EFB and the production of CPO is proportional. It means, there were about 26,9 million tons of EFB available in 2012 in Indonesia or 53,3 million tons in the world. Unfortunately this big amount of availability of renewable ressources still can not contribute an added-value and have the economical or financial meaning for the palm oil industry itself, society and government. Nowadays, only small amount of EFB would be utilized for different purposes such as for animal feed [3], compost [4], briquettes [5], particle board [6]. From 100% EFB can be gained about 50% fibers of EFB. It means, there were about 14 million tons of EFB fibers available in 2012 in Indonesia or more than 26 million tons in the world. After fiberizing stage the EFB will be processed to be fibers, followed by fibers screening stage, finally the fibers will be raw material which can be processed furthermore to be prepregs and at the end to be composites. The interest on using the biomass for the commercial and technical products is continually growing because of the restricted availability of non-

renewable raw materials and the increasing ecological issues. As biomass, EFB are available throughout of the year and related to statistic it amount increases. To utilize the EFB fibers as industrial raw material, there are two stages are required, firstly the preparation stage (the fiber preparation) with the aims to process the EFB biomass to be valuable fibers as an appropriate industrial raw material, and secondly the processing stage (the fiber processing) where the pre-product and end-product will be carried out. [7]

II. LITERATURE REVIEW

Nowadays the composite material consists of 2 (two) main components: reinforcing component and the filler component (in the form of adhesive/binding agent). The components used for composites so far are still from non-renewable raw materials such as metals, minerals, polymers (synthetic).

There are many inventions to get understanding how composites can be produced by utilizing non-renewable raw materials such as from aluminum [8], glass, carbon fiber [9], ceramics [10]. Typically, the adhesives or binding agents will be used are polymer based adhesives such as urea, melamine, phenol formaldehyde condensate polymer or other formal dehyde [11], phenol aldehyde resin in the form of granulate or powder [12], thermoplastic resins such as polyolefin, polyvinylchloride (PVC), polystyrene (PS), polyethylene terephthalate (PET), High Impact Polystyrene (HIP), Acrylonitrile-Butadiene-Styrene (ABS), nylon [13], polyester copolymer [14]. Even if renewable materials are used for producing composites, but still unfortunately the stuffs are not easily biodegradable such as natural rubber/latex [15]. The difference in comparasion to the above inventions, at this research a natural binding agent which is biodegradable will be used. It is starch based binding agent produced from potato. Considering the availability, there are two categories of raw materials non-renewable raw materials and renewable raw materials. Industrial solid waste has great potential to be used as a component of composite material reinforcement. The combination between natural fibers gained from solid waste such as EFB and natural binding agent from starch such as potato will produce composites which are renewable and environmentally friendly (biodegradable). [16]

Acording to the microscopic cross cut structure of EFB fiber, this natural fiber shows that it has a honeycomb structure (structure of lightweight construction). The main principe of the lightweight materials is high technical strength with less weight. That is why, it is important to keep this natural structure in producing composites by using this fibers so that the products will have strength with less weight. The fiber structure can be observed by using a microscope with technology of Scanning Electrone Microscope (SEM). It would be discovered that the EFB fiber has diameter ranges at 200-600 μm. [17]

III. MATERIALS AND METHODS

Materials
- Raw materials
  The oil palm empty fruit bunches are originated from Malimping, Indonesia.
- Binding agent
  The binding agent is potato starch in form of powder.
- Coating materials: bee wax, carnauba wax, craft glue, laminates sheet (plastic).

Firstly the EFB will be fiberized to gain its fibers and unused components of EFB as well as burnt fibers will be seperated. The good fibers will be mixed with binding agent from potato. The mixed fibers and binding agent will be formed to be prepregs (pre-product). The composites will produced by using hot press machine with temperature by 180 ^{0}C, pressure 40 bar and press duration by about 15 munites. The composites must be cutted at all sides and the coated with biodegradable materials: bee wax, carnauba wax and synthetic materials as well: craft glue and laminates sheet (plastic). [18]

Methods
The methods used are as followed:
- SNI 03-2105-2006 Papan Partikel [19] to produce the samples for 3 points bending test. 4 classes of samples are produced: plain composites without any coating material, coated with bee wax, coated with carnauba wax, coated with craft glue, laminated with plastic each class 20 samples.
- DIN 53 457 for 3 points bending test [20] where the test place is climated at 50% humidity, 24 ^{0}C room temperature by using climatic room equipment. The test parameter of 3 points bending test according to DIN 53 457.

To gain the test result in unit of GPa as Modulus Elasticity the formula as followed will be used

$$E = \frac{1}{4}\frac{F}{f}\frac{l_v^3}{b\,d^3} \qquad 1)$$

where
F: Force in N; l_v: Span in mm; f: Deflection in mm; b: Width in mm; d: Thickness in mm.

The mechanical strength (bending test) of the composites runs by using test equipment with type of Zwick Machine. This equipment can be used for tensile testing and press testing as well. The datas generate the force and the deflection which can be monitored on display connected with a PC, and by using software testXpert V. 11.02. The datas will be

recorded. In the display the movement testing in the form of a graph is shown and research datas will be stored as database. The databases can be converted into other file format such as .xls or others for further data processing. The test results by 3 points bending test to gain the modulus elasticity of composites according to DIN 53 457 will be processed furthermore by using Gauβ-Distribution [21]. Where the data is located on the outside position by 5% will be declared as invalid.

IV. RESULTS AND DISCUSSIONS

The results showed that the average strength of the samples are about 500 N. It means, a environmental friendly composite with dimension 50x10x2 mm^3 will be firstly deformed and finally broken by maximal load at about 50 kg. The coating processes have less influences to the strength of composites. It is to know that the strongest composites are the composites which are coated by bee wax. The results showed that the its samples are about 22% higher than plain composites. As the composites would be tested by pre-ballistic test by using pistol gun Sig Sauer caliber 9 mm. 5 layers composite is bullet proof. It means, it is possible to implement the environmental friendly composites from fibers of oil palm empty fruit bunch with binding agent from potato. This option of product can reduce the weight by 50-95%. Nowadays, the steel plates will be install at vehicle as bullet proof. For example: a steel plate with size 20 x 10 x 2 cm^3 has weight 3174 g, composites with the same size is only 150 g.

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