Effect of Binder on Combustion Quality on EFB Bio-briquettes

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Abstract: Energy demand in various sectors in Indonesia has increased in line with the rate of population growth and the national economy. Fulfillment of energy needs can be obtained from various energy sources such as fuel oil, solar, biomass, wind, water and others. So far, energy sources used in Indonesia are still using many non-renewable energy sources, such as fuel oil. The utilization of waste from empty palm oil bunches into bio-briquettes has helped the government in overcoming the problem of EFB waste. The availability of biomass has prompted researchers to utilize biomass waste that includes Agricultural and Forestry waste, to be processed into briquettes as an alternative energy substitute for fuel oil. This research aims to improve the utilization of waste of Palm Oil Bunches through the manufacture of bio-briquette as alternative fuel and determine the appropriate binder material for briquette making so as to produce optimal combustion value. The binders used for the manufacture of briquettes are pine sap and starch flour. The test result showed that the highest value of calorific was found in the mixture of 50% EFB composition with fibre size ± 1-5 mm with 50% pine resin which is 6331.7 cal/g. Meanwhile, lowest value on EFB ± with fibre size 5-10 mm composition EFB 60% and 40% starch flour binder that is 2295.7 cal/g. The results of a flame test study of several points that are known to turn on until it emits a flame for ± 30 seconds, it takes 22.2 minutes for the burnt-out briquette (to ashes). Based on visual observations that the fire colour of bio-briquette with finer fibre on the EFB composition 50% pine gum binder produces a bluish red fire colour. It is generally assumed that pine resin glues produce better fuel value compared to starch binder. Besides that, fibre particles size also affects the combustion quality produced.

Keywords: EFB, bio-briquette, calorific value, binder.

1. Introduction
Increasing environmental and energy dependency concerns have been the motivation for the increased use of bioenergy as a substitute for fossil energy in both space heating and electricity generation. The development of biomass has been an important issue for the past several decades and would remain to be attractive in the future due to its clean, renewable, and carbon-neutral properties [1]. Energy and fuels are the important links in the civilization and human development. The issues associated with the use of the fossil fuel, demand and supply gap, ever increasing prices, global warming and other environmental issues made the world to think for alternate sources of energy like solar, wind, ocean and biomass which are the only indigenous renewable energy sources capable of replacing large amount of solid, liquid and gaseous fossil fuel [2].

Reserves and production Petroleum fuels in Indonesia decrease 10% annually while the average oil consumption rate is up 6% per year [3]. Energy demand in various sectors in Indonesia has increased in line with the rate of population growth and the national economy. Fulfillment of energy needs can be obtained from various energy sources such as fuel oil, sun, biomass, wind, water, and others. So far, energy sources used in Indonesia are still using many non-renewable energy sources, such as fuel oil. This could trigger high subsidies to be issued by the
government if world oil prices are experiencing a surge in prices as it is today that is almost reached US $ 100/barrel. According to data from British Petroleum Indonesia will experience a petroleum crisis in 2024 if no new oil reserves are found in large quantities. From the data is needed alternative energy that is renewable to reduce community dependence on petroleum. The solid waste biomass of the palm oil industry is one of the renewable alternative energy that has not been widely utilized in Indonesia. Industrial solid waste Oil palm can be used as alternative fuel in the form of briquettes [4], [7].

One of the steps that can be taken to overcome the problem is the utilization of alternative energy sources, especially renewable energy sources. The transfer of energy sources from oil to renewable energy sources is expected to reduce the level of dependence on petroleum, especially considering its abundant potential in Indonesia. One source of renewable energy that can be utilized is biomass. Biomass potential in 2004 was equivalent to 49.81 GW, but installed capacity was only 302.4 MW (www.esdm.go.id). Biomass is the result of photosynthesis of plants and their derivatives. The selection of biomass as fuel has more value because it is green energy. Burning biomass is considered not to disturb the environment because biomass can be replanted (renewable) and the combustion CO will be reabsorbed by the plant (zero emission). Biomass waste can be obtained from by products from a plantation industry, agricultural products, or industries that utilize raw materials derived from forests.

In Indonesia, coal is the main fuel in addition to diesel fuel which has been commonly used in many industries, in terms of economical coal is much more efficient than diesel oil, with the following comparison: diesel oil Rp 0.74/kilo calorie while coal only Rp 0.09/kilo calorie, (based on industrial diesel price of Rp 6.20/liter). In terms of quantity of coal including the most important fossil energy reserves for Indonesia. The amount is very abundant, reaching tens of billions of tons. This amount is actually enough to supply electrical energy needs for hundreds of years into the future. Unfortunately, Indonesia is unlikely to burn the coal out and turn it into electrical energy through the PLTU.

In addition to polluting the environment through CO2, SO2, NOx and CxHy pollutants this way is considered less efficient and less high added value, which is a special spotlight especially with the issue of global warming [5]. Oil palm is a plantation/industrial plant in the form of a straight tree from Palmae family. The main product of oil palm trees utilized is the fruit bunches that produce oil from the flesh and kernel (palm kernel). After doing the processing of oil palm, in the end leaving empty bunches of palm oil that is generally not processed by palm oil processing factory. The remaining empty bunches cause problems for the place and its disposal transport resulting in additional production costs for the processor. In the place of disposal is usually EFB burned, this also cause problems of environmental damage that is air pollution and odor. Biomass waste can be directly used as fuel, converted first into charcoal or hammered first into briquettes. The purpose of forging is to obtain better combustion quality and ease of use and handling. Optimization of adhesive and biomass waste on briquette production is an important factor in the production of briquettes. The addition of adhesive on briquette production will increase the calorific value of the briquette due to the addition of carbon element. Waste of EFB can be seen in Figure 1.

**Figure 1.** Waste of empty fruit bunches after boiling process
Based on several problems in background discussions and see the potential of environmentalists, EFB waste must be managed wisely in order to demand the use of renewable alternative energy biomass, biomass utilization technology and produce environmentally friendly heat energy. The development of agricultural wastes for solid fuels is also triggered by the current condition, where fossil fuels which have been a mainstay for households or industries have increased prices. For household fuels such as kerosene has risen in price. Given the fact, the waste is very potential to be a solid fuel that is relatively cheaper and is expected to minimize environmental problems during the resulting waste handling. One alternative solution is to treat the agricultural waste into briquettes, a solid alternative fuel, cheap and meet the technical specifications, namely by the pressure on the mold.

2. Method

2.1 Raw Material
The results of the study will produce bio-briquette from palm oil waste. Palm wastes are obtained from the oil palm industry located in Taluak Kuantan - Riau Province. Waste obtained is after going through the process of enumeration with the engine so that the palm fibre are obtained that are rougher and still fresh.

![Image](a). Empty Fruit Bunch (b). EFB fiber

2.2 Tools and material
Mold briquettes is one of the supporters of experiment. The mold of briquettes in use is formed by determining the mold classification. The process of this mold is one part pressed to get the density. Figure 3 is a cylindrical sample dimension with dimensions of 4 cm in length, Ø 5.5 cm and Ø 1.5 cm hole. The fiber are fed into the mold then pressurized to a pressure of 40 kg/cm². The volume of briquettes is determined by the equation:

\[
\text{Volume} = \frac{\pi}{4} D^2 \cdot t \tag{1}
\]
Density bio-briquettes in part on briquette technology processes produce bio-briquettes with densities above 1000 kg\(^3\), where briquettes will be immersed in water as quality testing. The highest physical density for lignocellulosic materials is between 1500 kg\(^3\). The highest pressure processes (such as mechanical pistons and compression of pellets or screw extruders make briquettes become compact from densities between 1200-1400 kg\(^3\). Briquettes punched hydraulic pistons which make briquettes less dense, sometimes below 1000 kg\(^3\). Making briquettes to be solid is ineffective, as it will likely affect the resulting combustion properties [3]. In the above experiment, the density is determined by the equation:

\[
\frac{D}{\rho} = \frac{B}{V} \\
(2)
\]

Where: \( \frac{D}{\rho} = \) density (g/cm\(^3\)), \( B = \) Initial briquette mass (g) and \( v = \) volume (cm\(^3\)).

3. Results and Discussion

The availability of biomass has prompted researchers to utilize biomass waste that includes agricultural and forestry waste, to be processed into briquettes as an alternative energy substitute for fuel that is now increasingly scarce and its availability is dwindling. Briquettes made from oil palm empty bunches need to be utilized to help the government overcome the waste problem that has caused environmental pollution [8]. In the manufacture of briquettes, it should be known that the enumeration process must use the enumerator machine to make the resulting product more smooth and evenly, and there needs to be mixed variation between the raw material and the adhesive which aim to know the optimum and minimum calorific value. The mixed variations used consisted of 12 mixtures with EFB ± 1-5 mm and EFB ± 5-10 mm, ie:

Figure 3. Dimensions of briquette

Figure 4. Molds of briquettes and samples
1. (EFB ± 1-5 mm pine resin binder 30%, 40% and 50%)
2. (EFB ± 1-5 mm binder starch 30%, 40% and 50%)
3. (EFB ± 5-10 mm pine resin binder 30%, 40% and 50%)
4. (EFB ± 5-10 mm binder starch 30%, 40% and 50%)

From this variation can be known the value of effective caloric briquettes to be used as a reference in the manufacture of briquettes empty palm bunches using pine sap and starch. From the above mix it can find the optimum and minimum calorific value by conducting calorific value test. Testing the calorific value using oxygen bomb calorimeter tool, with this tool is known that the optimum calorific value is owned by the composition of 50% EFB 1-5 mm binder pine resin 50% that is equal to 6331.75 cal/g, and minimum calorific value is owned by EFB 5-10 mm 60% 40% binder ie 2295.70 cal/g.

In addition to the heat value test, flame testing is also conducted to determine the performance/flame resistance. From the test results of flame to turn on until the flame arises in need time 30 seconds. For ash combustion briquette ash from beginning of EFB fine pine adhesive 50% by weight of briquettes before burning 81.01 g when finished burning to 7.34 g. Based on the graph of the picture 5 starch binder calorific value which has the highest calorific value is the fine fibers of pine resin glues with the binder composition of 40% (3137.83 cal/g). Compared with crude fiber with pine resin binder of 50% (2891.54 cal/g.) binder composition, this is because the fine fibre at combustion inside the Unit Bomb Oxigen Calorimeter are perfect in comparison with crude fiber at the time of combustion in Unit Bomb Oxigen Calorimeter. Based on the graph, the highest heating value is owned by EFB ± 1-5 mm with the composition of 50% EFB 50% pine binder ie 6331.75 cal/g. Lowest value is owned by EFB ± 5-10 mm with the composition of EFB 60% binder starch flour 40% that is equal to 2295.70 cal/g.

![Graph calorific value of starch flour vs percentage of binders](image)

**Figure 5.** Graph calorific value of starch flour vs percentage of binders

Figure 6 is a graph of the relationship between the heating value of the pine resin glues and the percentage of each binder. Based on the graph of figure 6, the heating value of pine sap gum which has the highest heating value is a fine fibre pineapple binder with a 50% (6331.75 cal/g.) adhesive composition compared to crude fiber with pine resin binder 30% (3607.31 cal/g.) This is because the fine fibre at combustion in the unit of the oxygen calorimeter bomb are perfect in comparison with the crude fibre at the time of combustion inside the Bomb Oxigen Calorimeter unit. Based on the graph of fire ignition with pine resin glue shows longer burning value on fine fibres with a 50% (22.23 min) adhesive composition, compared with coarse fibre with a 50% (21.14 min) binder composition. The lower combustion value of briquettes is found in coarse fibre with a composition of 30% (16.32 min). This is due to the fibre factor used at the time of combustion.
Figure 6. Graph of the relationship between the flame of pine resin glue and the percentage of each binder

Figure 6 shows a graph of flame binder starch with the percentage of each binder. Based on the graph of flame ignition on starch flour adhesive which has the longest burning value on coarse fiber with 50% (9.55 min) binder composition, while which has the lowest burning in fine fibers with 30% (1.27) binder composition. Fine fibres with 40% binder composition and 50% briquette combustion process have little difficulty in ignition.

Figure 7. Graph of the relationship between flame starch glue binder with the percentage of each binder

In general, briquettes change or increase in length when removed from the mold. This is due to the fibres having elasticity when removed from the mold, this greatly affects the binder and particle size of EFB fibers in each material [6]. The length of each briquette produced did not show any significant difference between one another.

Figure 8. Ignition of briquettes, (a). Pine sap binder with fine fibre 50%, (b). Flour binder starch fine fibre 50% (incomplete combustion)

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4. Conclusion
Testing the heating value obtained the highest result is in mixed composition 50% EFB ± 1-5 mm binder pine resin 50% that is equal to 6331,75 cal/g. The lowest value is generated by EFB ± 5-10 mm with the composition of EFB 60% binder starch flour 40% that is equal to 2295,70 cal/g. The advantages of EFB use the perfect pine sap gluing, high heating value, while the shortcomings at the time of burning produce smoke. The advantages of EFB using starch binder that is not smoke, while the shortage of ignition initially difficult. The highest test result of carbon values was found in mixed EFB ± 1 - 5 mm 40% pine sap granules (40,27), the lowest carbon value was produced by EFB ± 1-5 mm 30% starch binder composition (16,42).

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