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Potential of Palm Oil Solid Waste as Steam Power Fuel (Case Study at XYZ Palm Oil Mill)

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ABSTRACT

The company's Palm Oil Mill (PKS) that produces the main products are Crude Palm Oil (CPO), Palm Kernel Oil (PKO) while the byproducts are solid waste in the form of fiber, shells, and Empty Fruit Bunches. Palm oil mill solid waste in the form of fiber and shells has the potential to become fuel for Steam Power Plants (PLTU). Fresh Fruit Bunch (TBS) Material Balance from Palm Oil Mill production output: Shell: 7%, Fiber: 13%, Empty bunches: 22% which can generate the total available Heat Calor of 28.936×10^{6} kcal/hour, and Total Total Power can be generated as much as 3.9 MW from the Palm Oil Mill Solid Waste which produces a thoughtput of 50 tons/hour.

INTRODUCTION

The power crisis that occurred in the world, especially from fossil fuels that cannot be renewed due to the depletion of petroleum reserves. This resulted in an increase in fuel prices [1-3]. This condition triggers an increase in living costs and rising production costs. Therefore it is necessary to look for alternative fuel sources that can be renewed [4-5].

The world is suffering from fever using biofuel as a substitute for fuel oil [6]. Biofuels are oils that can be extracted from plant products and biomass waste [7]. There are several plants that can be used as biofuel, namely: jatropha plants, cassava plants, sorghum plants, oil palm plants and others [8-9].

In 2006 the Government of Indonesia through Presidential Regulation No. 5 of 2006 concerning the National Power Policy which aims to develop power that can meet the needs of the community in a cheap and affordable manner. The business world is expected to compete in domestic and foreign markets.

Utilization of biofuel or fuel from this plant as a renewable alternative power [10]. As one of the Palm Oil Mills (PKS) located in West Bangka Regency which is part of a province that was recently formed, PKS XYZ is also aware of the problem. One of the things that became the discourse was the increasing demand for electricity for the community and industry in the area. Therefore, PT. XYZ utilizes PKS waste to develop power that is environmentally friendly and renewable.

PKS produces solid waste in the form of fiber, empty elongation, palm shell and liquid waste, which is the byproduct of production processed in the waste pool [11]. Simply put, liquid waste is treated and applied as fertilizer to plantation land [12]. Whereas solid waste consisting of shells, fibers and empty fruit bunches is generally only used as fertilizer on plantation land and road hardener after part of it is used as fuel for PKS power plant [13]. The

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shell and fiber are not used entirely as boiler fuel. There is a remnant from the process that is considered as waste. Therefore, the waste can be utilized as something more economical, namely to use the solid waste as fuel for the biomass Steam Power Plant (PLTU), which will generate electricity and meet the needs of the community.

Steam Power Plant is a unit process that produces electricity by utilizing natural resources (BBM) and other materials in the form of waste/biomass which can be burned as fuel and generate heat [14]. The heat generated from burning fuel (BBM, Waste, Biomass, and flammable materials) changes the water in the boiler, then is heated into pressurized steam as a driving force for electric power by moving steam turbines and generators to produce electricity. Steam power plants usually use the Rankine cycle as the main cycle with the main equipment being pumps, boilers, steam turbines and condensers [15].
Basically, the electricity generation system at PT. XYZ is the same as other power plants. But the difference is the fuel used, namely biofuels, namely PKS XYZ solid waste. The process is as follows:

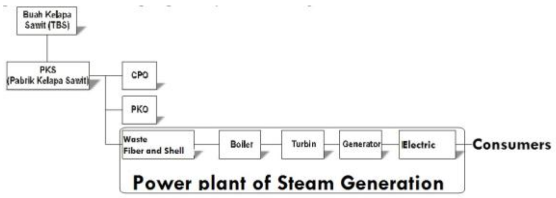

Fig. 1. Scheme of the Process of Palm Oil to be as Power plant type PLTU

Electric power that can be generated by PT. XYZ is used to meet the domestic needs of XYZ VFD and is supplied to PLN to meet the electricity needs of the community and industry. The type of turbine used has an installed capacity of 6 MW.
Type : Condensing Steam Turbine
Brand : Hangzhou Steam Turbine
Year of Manufacture: 2004
Type No. : N6-27
Power Generation : 6,000 kW
Round : 3000 rpm
Critical Rotation : 1600 rpm
Vapor Pressure Input: 27 kg/cm^2 (a)
Vapor Pressure Out : 0.075 kg/cm^2 (a)
Steam Inlet Temperature: 390 ^{o}C

EXPERIMENTAL METHOD

The methodology used by the author in conducting this research process is a case study that took place at the XYZ Palm Oil Company. This company has great potential in waste utilization. For the methodology the author does is as follows:

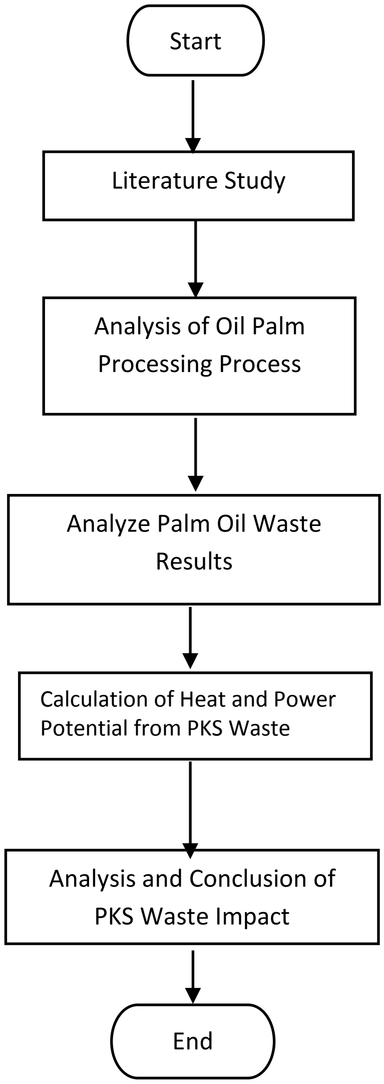

Fig. 2. Flowchart of experiment

RESULTS AND DISCUSSION

Material Balance and Calorific Value of Solid Waste

In palm oil processing, PKS produces three types of solid waste, including shells, fibers, and empty bunches. However, some of the solid waste is used as power plant fuel to generate electricity which will be used to run plant and domestic operations. The fuel used by the Sawindo Kencana PKS boiler is fiber

and the residual shell of processing. The following is the amount of solid waste generated by PKS XYZ with a throughput of 50 Tons/hour:
Shell = 7% × 50,000 kg/hour =3500 kg/hour
Fiber =13% × 50,000 kg/hour = 6500 kg/hour
Empty bunches =22% × 50,000 kg/hour = 11000 kg/hour
Each material above has a heating value that greatly affects the heat that will be generated. Based on research that has been done, the heating value of each material in PKS XYZ is as follows:

(a)

(b)

(c)

Fig. 3. PKS Solid Waste, Palm Oil Shell (a), Palm Oil Fiber (b), Empty Fruit Bunch (c)

Table 1. Waste and Tonnage Composition

No	Waste	Composition	Percentage (%)	Weight (kg/hour)	Tonase (kg/hour)
1	Shell	Water	24,5	3.500	85.750
		Non Oil Solid (NOS)	74,9	3.500	262.150
		Oil	0,6	3.500	2.100
2	Fiber	Air	46,8	6.500	304.200
		Non Oil Solid (NOS)	48,6	6.500	315.900
		Oil	4,6	6.500	29.900
3	Empty Fruit Bunches	Water	69,45	11.000	763.950
		Non Oil Solid (NOS)	2,69	11.000	29.590
		Oil	27,86	11.000	306.460

The Non-Oil Solid (NOS) value of the calorie meter can be seen in the following graph:

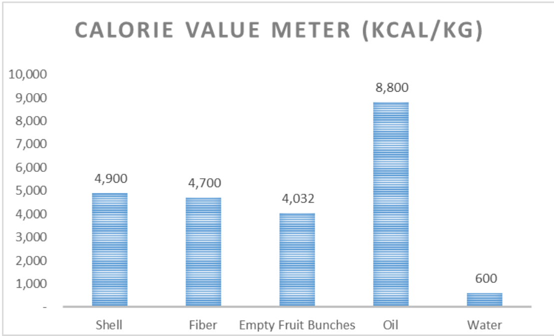

Fig. 4. Non-Oil Solid Calorie Meter (NOS) Graph

The calorie value (NO) contained in solid waste fuels includes:

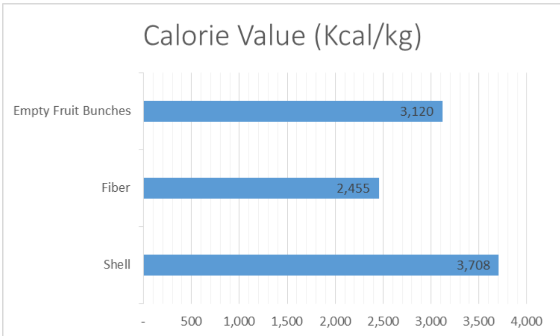

Fig. 5. Graph of Waste Heat Value

$$\text{Shell Equations} = \frac{(\text{Shell} \times \text{NOS}) + (Oil \times \text{NO } oil) - (\text{Water} \times \text{NO water})}{\text{MB}} \quad (1)$$

Based on the above calculation, the calorific value of shell, fiber, and empty bunches are 3708.2 kcal/kg, 2455.2 kcal/kg, and 3119.5 kcal/kg, respectively.

According to the results of the study, the power needed by PKS XYZ for operations can be seen in Table 2.

Table 2. Total Power Needs of PKS

No.	TBS Process (Kg)	Total Power (KW)	Power/ Ton TBS
1.	563.784	12.450	22.08
2.	366.863	9.950	27.12
3.	443.385	9.300	20.97
4.	480.025	11.850	24.69
5.	575.652	12.700	22.06
6.	713.735	16.450	23.05
7.	396.493	10.250	25.85
	3.539.937	**82.950**	**23.43**

Source: Power House Log sheet and PKS Production Report for 2010.

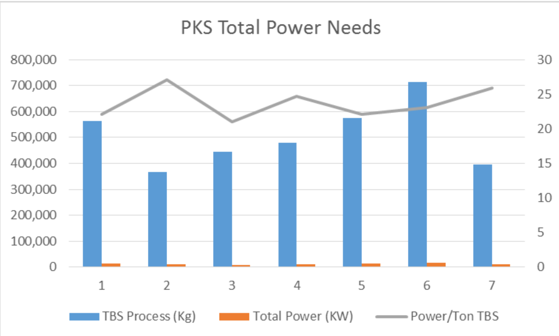

Fig. 6. Graph of Total Power Needs of PKS

Based on the data above, it can be seen that to process each ton of FFB, the average power needed is 23.43 kW. According to the PKS turbine specifications, to generate 1 kW 15 kg of steam is needed. So that it can be obtained, for PKS XYZ with a throughput of 50 Tons/hour, as much steam is needed:

$$\text{Steam requirement} = 23.43 \times 15 \times 50 = 17.572.5 \text{ kg of steam}$$

The fuel used by PKS boilers only uses fiber and shells. So that the total heat available is:
Shells: 7% x 50,000 kg x 3708.2 kcal/kg = 12,978 x 10^6 kcal/hour
Fiber: 13% x 50,000 kg x 2455.2 kcal/kg = 15,958 x 10^6 kcal/hour
Total Available Calories = 28,936 x 10^6 kcal/hour
The use of fiber and shells in PKS as fuel fuels only <50% of the available fuel. In Sawindo Kencana PKS, the fiber used as PKS fuel is around 60% of the fibers produced, while the rest uses dry shells derived from Light Tenera Dry Separating (LTDS), which is 30% of the total shell produced. So, with the amount of fuel Incoming, the total heating value that can be produced is able to meet the steam demand of the PKS boiler.
Fiber: 60% x 6500 kg/hour x 2455.2 kcal/kg = 9.576 x 10^6 kcal/hour
Shells: 30% x 3500 kg/hour x 3708.2 kcal/kg = 5,192 x 10^6 kcal/hour
The total heat produced = 14,768 x 10^6 kcal/hour
With this amount of material, the composition of PKS boiler fuel is 65% fiber and 35% shell. And the total heat produced is 14.768x10^6 kcal/hour, enough to meet the needs of the PKS of 11.756x10^6 kcal/hour.

Utilization of Solid Waste Remaining

From the results of the previous description, it is known that there is excess fiber and shell availability. 60% of the total fiber and 30% of the total shell produced by PKS XYZ has been used as boiler fuel. Then, there is the remainder which is then part of the PKS waste, namely solid waste of:
Fiber: 40% x 6500 kg/hour = 2600 kg/hour
Shells: 70% x 3500 kg/hour = 2450 kg/hour
In general, excess shells and fibers from processing are used as fertilizer or road hardener. This is considered not economical enough and does not provide more investment to the company. Therefore, PT. XYZ uses the solid waste as fuel for Steam Power Plants (PLTU).

(a)

(b)

Fig. 7. Waste from PKS Production, Palm Oil Shell (A), Oil Palm Fiber (B)

As For Other Reasons, PT. XYZ Include:

A. Increasing Demand for Electricity for Local Communities
B. Increasing the Value of PKS "Waste" As Fuel, In Addition to Utilization as Fertilizer.
C. Job Creation and Supporting The Progress Of An Area

PT. XYZ utilizes the shell as the main fuel, this is because the heating value contained in the shell is quite large compared to fiber. Fiber fuel is used as a backup fuel, if the supply of shell fuel is running low. In addition to the shell and fiber, empty fruit bunches are also used as fuel at PT. XYZ Empty bunches are a backup if the fiber fuel is almost gone. For fuel empty bunches will be pressed using a manumuncher engine that aims to smooth the empty bunches into fibers. But not all empty bunches are used, because some empty bunches are also still needed as fertilizer on plantation land.

Fig. 8. Ex-manumuncher Empty Bunches

With this system, the value of power that can be produced with different fuel use compositions is as follows.

Table 2. Comparison of Power and Amount of Fuel

No	Composition of Fuel	Power Raised (MW)	Amount of Fuel (Ton)	Ratio
1.	100% Cangkang	1	1.6	1:1.6
2.	100% *Fiber*	1	3	1:3
3.	Cangkang + *Fiber*(50:50)	1	2	1:2

From the data above, we can know how much power can be generated by the availability of fuel from PKS. With 80% turbine efficiency, the power that is able to be generated is 4.8MW. But with the availability of fuel from PKS XYZ, the power that can be generated does not reach the expected target (Table 2). In this case, the assumption of empty bunches used as fuel is 40% of the empty bunches produced (PT. XYZ Process Assistant interview). The use of blended empty bunches is not distinguished from fiber, so the value of the power generated from the use of empty bunches is the same as fiber.

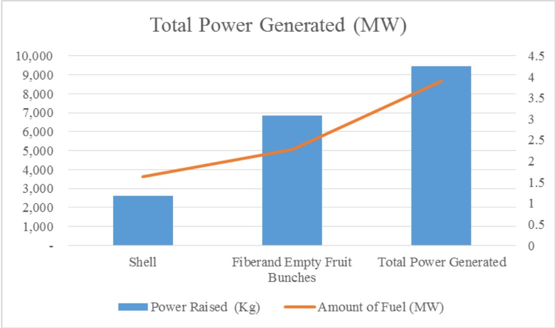

Fig. 9. Total Power Raised Graph

With the amount of solid waste generated by PKS XYZ, the power it can produce is 3.9 MW. While based on the turbine working system, the power that can be generated is 4.8 MW. Thus, PT. XYZ experienced a supply shortage of 1.44 tons/hour. This is one of the obstacles experienced by the company. Therefore, PT. XYZ adopted a policy of buying shells from other PKS to meet fuel needs.

CONCLUSION

From the results of the study, there is a large amount of available solid waste in the form of shells, fibers, and empty bunches originating from the Palm Oil Mill, which is about 50% of the total solid waste produced. The availability of solid waste has quite good potential as a biomass plant fuel for PT. XYZ Utilization of solid waste as biomass fuel for PT. XYZ provides considerable benefits for the company, as well as having a positive impact on the surrounding community, in the form of job creation and meeting electricity needs in the West Bangka area.

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