Study of distillation waste by clove for alternative fuel power plant: A review

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Abstract. Today, fuel source energy is increasing demand in Indonesia, such as petroleum and coal. Fuel source energy is exhausted and cannot be renewed, therefore renewable energy is one solution for highly energy demand. Innovations of renewable energy like as biopellet from clove leaf refining waste is important for fuel power plant in Indonesia. This research is discuss about characteristics and quality of biopellet from clove leaf refining waste for alternative fuel in electricity generation. The clove leaf is dried up to moisture content from 15% to 30% then made of mesh size 20 and 40 with a milli hummer. then the clove leaf powder was mixed with glue or molasses with a ratio of 80% powder and 20% molasses then printed. Heated of temperature is 90°C, the second specimen is 110°C and the third specimen is 130°C, after it has reached the specified temperature the powder in the mold on the press or pressed with a pressure of 93 kg / cm². The specimen have been printed and pressed for about 20 minutes. Biopellet can be an alternative fuel solution in Co-firing systems with coal that has been this is the main fuel for steam power generation.

1. Introduction
The government to look for alternative energy reserves by considering with renewable and environmentally friendly because high cost of exploration fuel.

The biomass energy is one solution for alternative energy [1]. This energy does not cause an increase in greenhouse gases and carbon dioxide emissions, and can function as carbon neutral [2]. The wood pellets are widely used as renewable energy and more are being developed. The Deforestation make the forest become bare and reforestation period will take a long time to re-collect wood from the forest as a wood pellet base [3]. Therefore it is necessary to find alternative raw materials that are cheaper and easier to obtain and environmentally friendly.

Alternative fuel in European countries and America is wood pellets due to the world oil crisis. Plant biomass is the solution, such as wood pellets undergoing the pressing process. The price of wood pellets is quite affordable, meanwhile the demand for wood pellets is higher due to policies from countries in the world to reduce the effects of global warming and alternative energy utilization [4,5].

Biomass is organic material produced through photosynthesis biomass for energy materials with low economic value after primary products [6]. Indonesia has the potential of biomass energy around 50,000 MW by coconut waste palm oil, rice milling, plywood and other agricultural wastes [7]. Around 320 MW has just been utilized, or about 0.64% from all potential energy [8].

Besides wood, the other type of biomass is leaves. Leaves have great potential to be used as raw material for biopellets. In some districts clove leaves are utilized as a source of essential oils and refined leaves are generally deciduous. The economic value is cheaper and does not damage the main plant.

The benefits of biomass as renewable energy can be in the form of charcoal or biopellet. The process of making charcoal requires with a long process and requires more tools and materials than...
biopellets. Therefore, biopellet is chosen for renewable energy materials, therefore it is necessary to do further research so that the biopellet characteristics produced are of an international standard.

The need for essential oils in the world is supplied by 85% of the Indonesian state, essential oils in recent years have received considerable attention from the Indonesian government especially from the agriculture ministry program [9]. Therefore clove leaf is a potential raw material for making essential oils, thus the distillation of clove leaf can be used as the main raw material for biopellet due to considerable waste and containing oil.

As an illustration, at present the yield of clove oil is around 1.5 - 2% of the raw material of dried clove leaves or an average of 1.75%. This means that every 1 ton of dry clove leaf raw material will produce 17.5 kg of clove leaf oil. In other words, to produce 4,810 tons of clove leaf oil which is equivalent to the amount of export of clove oil in 2011, dry clove leaf raw material is needed as much as 274,857 tons. If this is illustrated, then the number of leaves of this size is equivalent to 134,428 trucks (1 truck contains 2 tons). A very large amounts (bulky) for the size of raw materials [10].

2. Base theory
2.1. Clove Leaf
As we have often heard that clove leaf refining waste can be used as fuel for power generation by making the clove leaf waste into biopellets. This is due to the development of biomass to produce renewable energy as alternative energy fuel to replace fossil fuels.

2.2. Clove Plants
Clove is a tropical plant native to Indonesia and can grow in various regions in Indonesia, both in the lowlands, near the coast and mountain areas at an altitude of 900 meters above sea level. Clove plants can grow well if they get enough water and direct sunlight [11]. Therefore clove plants grow well in areas that have rainfall of 2210 - 3607 mm/year and air temperatures ranging from 24 – 39°C [12].

2.3. Characteristics of Clove plants
Clove plant have characteristic such as [13]:
- Tree height reaches 5-10 meters
- Having a taproot.
- Generally it has a conical shape and its branches are very numerous and tight
- Clove leaves are very thin and measuring 2.5 - 5 cm long and 6 - 13.5 cm wide, when the leaves begin to age the leaves are slippery and shiny because they contain oil

2.4. Benefits of clove plants
Clove plants have some benefit:
- Starting from the roots, stems, leaves until the flowers contain essential oil
- The remaining distillation from clove leaves is used as biopellet as an alternative fuel for power generation

2.5. Biopellet
Biopellet is a pellet biomass fuel, that has a uniform size, shape, humidity, density, and energy content [14]. In the process of making biopellet, biomass is fed into a pellet mill that has dies with a diameter of 6-8 mm and a length of 1012 mm [15]. There are 6 stages of the biopellet manufacturing process, namely: pretreatment of raw materials (pretreatment), drying, size reduction, printing biopellet (pelletization), cooling (cooling), and silage [16]. Forest residues, sawmills, agricultural crops and energy crops can be identified as pellets. The pelletization process can increase the specific density of biomass more than 1000 kg/m³ [15, 17].

The co-firing method is the mixing of coal fuel in the power plant with biomass energy sources. In this case, State Electric Company (PLN) has conducted trials in the form of waste pellets, wood (wood pellets) and palm shells. The co-firing trial is already carried out by two PLN subsidiaries, namely
Indonesia Power (IP) and Java-Bali Power Plant (PJB). The six power plants that have been tested, the co-firing method has been proven to be able to mix coal with pellets, without disrupting the performance of the power plant.

Co-firing is the use of fuels from bio-mass and garbage for electricity generation quickly without the need to construct a plant. According to President Director of PJB, the wood type forest products is equated with the amount of electricity to be used as wood pellets 1335 MWe, this energy potential is spread on the island of Sumatra, Kalimantan Island 44 MWe, NTT and NTB 19 MWe. This shows the potential of biomass is very important for the future of the Indonesian people in the field of renewable energy.

3. Methodology

The process of processing clove leaf raw materials into biopellets can be processed using the following methods:

3.1. Raw material treatment

Clove leaf distillation raw material is used as a sample by first drying, it with a moisture content of 15% to 30%. So that it can be ground into powder using a hammer mill then sifted and dried. After that the powder is filtered with a filter size of 22 and 40 mesh, the powder to be used must pass the size filter 22 but retain at the size of 40 mesh.

3.2. Process of Biopellets

Clove leaf powder is mixed with molasses or glue as an adhesive with a ratio of 80% powder and 20% adhesive then printed in a pellet machine and heated to a temperature of around 90°C, 110°C, 130°C, then allowed to stand for about 20 minutes then press or press with pressure 93 kg/cm². Process of biopellets as depict in Fig.1.

3.3. Observation Variable

- Until water, the paste is dried in an oven at 105°C – 110°C for 24 hours until the water content is constant, and cooled in a desiccator. Moisture content can be formulated as follows

\[ \text{Until water} = \frac{B_a}{B_{k t}} \times 100\% , \text{ where:} \]

\[ B_a = \text{heavy before drying} \quad B_{k t} = \text{dried weight} \]

- Density, comparison between biopellet weight and volume can be formulated as follows:

\[ \text{Density} = \frac{M}{V} , \text{ where} \]

\[ M = \text{Massa (g)}, \quad V = \text{Volume (m}^3) \]

- Ash rate, the determination of ash content was done by inserting a coil into the furnace at 800 - 900°C for 6 hours and then cooling for about 45 minutes and then weighed to a fixed weight. Can be summarized as follows:

\[ \text{Ash rate} = \frac{X_1 - X_2}{X} \times 100\% , \text{ where:} \]

\[ X = \text{Weight before being dumped} \quad X_1 = \text{Weight plus cup after being blended} \]

\[ X_2 = \text{empty weight} \]

- Heating value, measurement of the heating value using a peroxide side bomb calorimeter.

- Ignition time and duration of burning, the sample is prepared and the sample is pricked with a pin and the measurement time lasts until the sample lights up

- Burn test, the measurement time lasts until it burns out and the timer is activated when the sample starts to burn.
4. Results and discussion

Observation and calculation of water content, density, ash content, heating value, ignition time and burning time of biopellet from clove leaf refining waste. Biopellet standards in several countries as describe in Table.1

4.1. Biopellet quality

Quality of biopellet in clove leaf distillation waste is important to energy source. Some countries (Sweden, Austria, France, and Germany) has standard about quality of biopellet, as seen in Table.2.

4.2. Until water

Water content greatly affects the quality of biopellets so that a good drying system must be carried out by heating the biopellet at high temperatures and pressing so that biomass particle can fill each other empty pores and reduce the water molecules that can occupy these pores [20].

| Parameter (Unit) | Sweden | Austria | France | German |
|------------------|--------|---------|--------|--------|
| Density (kG/dM)  | >0.6   | >1.2    | >1.15  | 1.0 – 1.4 |
| Distance (mM)    | <3.81  | 5 x d   | 10/1   | <50    |
| Heating (%)      | >19.08 | >18     | >16.9  | 17.5-19.5 |
| Water (%)        | <10    | <10     | ≤15    | <12    |
| Diameter (mM)    | 6.35 – 7.94 | 4 – 10 | 6 – 16 | 4 -10 |
| Ash (%)          | <0.7   | < 0.50  | ≤ 6    | <1.50  |

Figure 1. Process of Biopellet
Table 2. Quality of Biopellet in clove leaf distillation waste.

| Characteristic / Unit | Treatment | Average | Standard Sweden | Austria | France | German |
|-----------------------|-----------|---------|------------------|---------|--------|--------|
| Diameter (mm)         | 6.77      | 6.55    | 6.83             | 6.717   | 6.35-7.94 | 4-10   | 6-16   | 4-10   |
| Distance (mm)         | 31.22     | 30.21   | 31.85            | 31.093  | <3.81  | 5 x d  | 10/1   | <50    |
| Density (kg/dm³)      | 0.55      | 0.65    | 0.58             | 0.6     | >0.6   | >1.2   | >1.15  | 1.0-1.4|
| Water (%)             | 9.8       | 8.3     | 6.7              | 8.26    | <10    | <1.0   | ≤15    | <12    |
| Ash (%)               | 3.9       | 5       | 3.3              | 4.06    | <0.7   | <0.50  | ≤6     | <1.50  |
| Heating (MJ/kg)       | 17.52     | 17.47   | 17.53            | 17.50   | >19.08 | >18    | >16.9  | 17.5-19.5|
| Ignition (second)     | 4.0       | 3.9     | 4.0              | 3.9     | -      | -      | -      | -      |
| Combustion (G/minute) | 0.17      | 0.18    | 0.18             | 0.177   | -      | -      | -      | -      |

Table 3. Percentage of water content

| Treatment        | Percentage of water content (%) | Standard water content (%) |
|------------------|---------------------------------|---------------------------|
|                  |                                 | Sweden | Austria | France | German |
| First Specimen   | 9.8                             | <10    | <10    | ≤15    | <12    |
| Second Specimen  | 8.3                             |        |        |        |        |
| Third Specimen   | 6.7                             |        |        |        |        |
| Average          | 8.26                            |        |        |        |        |

Value of combustion and make the combustion and ignition process more difficult. The biopellet water content in this study has met the applicable standards in various countries as shown in Table 3.

4.3. Density

Density is the ratio between mass and volume in Biopellet [22]. Density is determined by the pressure

Table 4. Biopellet density test

| Treatment        | Density (kg/dm³) | Standard water content (%) |
|------------------|------------------|---------------------------|
|                  |                  | Sweden | Austria | France | German |
| First Specimen   | 0.55             | >0.6   | >1.2   | >1.15  | 1.0-1.14|
| Second Specimen  | 0.65             |        |        |        |        |
| Third Specimen   | 0.58             |        |        |        |        |
| Average          | 0.6              |        |        |        |        |

Table 5. Percentage of Biopellet ash levels

| Treatment        | Percentage of ash content (%) | Ash content standards (%) |
|------------------|-------------------------------|---------------------------|
|                  |                               | Sweden | Austria | France | German |
| First Specimen   | 3.9                           | <0.15 | <0.50  | ≤6    | <1.50  |
| Second Specimen  | 5                             |        |        |        |        |
| Third Specimen   | 3.3                           |        |        |        |        |
| Average          | 4.06                          |        |        |        |        |
Table 6. Test results for Biopellet heat value

| Treatment    | Heating value (m/kG) | Ash content standards (%) |
|--------------|----------------------|---------------------------|
| First Specimen | 17.52                | >19.08                    |
| Second Specimen | 17.47               | >18                       |
| Third Specimen | 17.53                | >16.9                     |
| Average       | 17.50                | 17.5-19.5                 |

used in the densification process [1]. The density calculation shows it is close to the Swedish standard shown in Table 4.

4.4. Ash rate
Ash content is a residual combustion process that has no carbon element or heat value [23]. High ash content risks the formation of mineral deposits or crust during combustion can lead to dirty furnace surfaces and corrosion, so that the quality of heat in the combustion decreases. If the ash content gets lower, the better biopellet produced [24]. In Table 5, biopellet ash averaged around 6.0% which met French standards.

4.5. Heating value
The heating value is a parameter for determining the efficiency of fuel. The heating value is influenced by water content, levels of flying matter, ash content and carbon content bound [25]. Ash content is inversely proportional to calorific value [26]. The carbon content is bound directly proportional to calorific value [22] and high lignin content increases.

Table 7. Ignition test

| Treatment    | On (Second) |
|--------------|-------------|
| First Specimen | 4.0         |
| Second Specimen | 3.9         |
| Third Specimen | 4.0         |
| Average       | 3.9         |

Table 8. Burn test

| Treatment    | Burn Rate (G/Minute) |
|--------------|----------------------|
| First Specimen | 0.17                 |
| Second Specimen | 0.18                |
| Third Specimen | 0.18                 |
| Average       | 0.177                |

calorific value [27]. In Table 6. Show about the heat of the Biopellet results from this study ranged from 17.50 and this has met the standard values in countries like Germany and France.

4.6. Ignition time and Burning speed
Tables 7 and 8 show the average value of the results of the flame test and biopellet combustion speed reaching an average of 3.9 seconds and a fuel rate of 0.177 g/minute.
5. Conclusions

In this study the characteristics of biopellets produced from raw materials for clove leaf refining waste have met various standards.

1. The quality and quality of biopellets is strongly influenced by the high heating temperature to reduce the water content in the biopellet molecules or pores.

2. Alternative biopellet fuel can be combined with coal fuel by using a Co-firing system for steam power plants (PLTU).

3. The State Electric Company has conducted intensive trials and has successfully used a Co-firing system with a mixing portion of 1%, 3%, 5% for wood pellet biomass with coal fuel. PT PLN will continue to try to approach the 30% figure.

4. Using this Co-firing scheme will have a pretty good effect on economic development by mixing around 5% in various PLTU plants located on the island of Java so that it has the potential to develop 160 pellet industries and will absorb 1600 new workers.

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