Bio-briquettes Innovation Co-FES (Coconut Fiber and Egg Shell) as the Eco-Friendly Fuel with Pressure Giving Methods for Indonesian Energy Fuels Challenge

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ABSTRACT

Problems about energy cannot be separated from human life. Therefore, alternative fuels are needed that cheap and eco-friendly for small industry and home industry. One of them is using alternative energy briquettes from biomass waste. So, the purpose of this research is to find ways of making Bio-briquette "Co-FES" from the mixture of coconut fiber and shell eggs, to determine the effect of pressure from pressing process with quality of Bio-briquette, and to determine the ratio of Bio-briquette experiments results with the Indonesian National Standardization (SNI) briquettes. There are there stages to make Bio-briquette from coconut fiber and egg shell. First step is pre-treatment stage, it is stage to prepare a raw material by drying and charing coconut fiber and eggshells. And the next stage by mixing all the raw materials of coconut fiber and egg shells plus a starch adhesive with a ratio of each of 3: 1 and 2: 1. Then, insert the material that has been mixed into the Bio-briquette mold with manual pressure, a pressure of 15 kg / cm2, 30 kg / cm2 and 45 kg / cm2. The third stage is analysis stage includes the analysis of density, analysis of water content, ash content analysis, analysis of the mass loss and calorific value analysis. From the experiments it can be concluded that higher pressure, the density value is also higher. From variable density obtained optimum pressure is at a pressure of 45 kg/cm2 on the material composition ratio of 2: 1 at 0.2654 g/cm3 according to SNI Bio-briquette No. 1/6235/2000 is ≤ 0.4507 g/cm3. The higher pressure, make water content are lower. In the variable pressure obtained the greatest water content is at manual pressure on the material composition ratio of 3: 1 equal to 5.8882% in accordance with SNI Bio-briquette No. 1/6235/2000 is ≤ 8%. The higher pressure make the ash content are lower. In the variable pressure obtained the largest ash content is at pressure of 45 kg/cm2 on material composition ratio of 3: 1 at 5.3571% in accordance with SNI Bio-briquette No. 1/6235/2000 is ≤ 8%. The higher pressure, make the mass loss is lower. In the variable pressure obtained, the mass loss is greatest at a pressure of 15 kg/cm2 on the material composition ratio of 3: 1 at 0.0055 g/s. The higher the pressure make calorific value is also higher. In variable calorific obtained pressure is greatest on manual pressure on the material composition ratio of 3: 1 amounted to 2,612,856.6 cal/g. From the analysis, it can be concluded that Bio-briquette from coconut fiber and shell eggs mixture with a composition ratio of 3: 1 and 2: 1 accordance with SNI Bio-briquette No. 1/6235/2000.

Keywords: bio-briquette, biomass, heat caloric

I. INTRODUCTION

Energy problems can not be separated from human life. Growing population, increasing human lifestyles and increasingly growing industries causing energy demand continues too, while availability of energy reserves is running low. So, it has an impact on the world fuel oil price increase, especially kerosene in indonesia. Therefore, an alternative fuel is needed that is cheap and eco-friendly as a kerosene substitute for small industries and home industry. One of these alternative energies is using briquettes from biomass waste [5]. Biological briquettes are clumps or charcoal sticks made from bioarang (soft material). Actually, bioarang is a soft material which is processed into hard charcoal with certain shapes.
Quality of this bioarang is not inferior to coal or other types of charcoal fuel. Briquettes are solid fuels that can be used as alternative energy sources that have a specific shape. Water content in the briquetting is between 10 - 20% from weight. Variation size of briquettes is from 20 - 100 grams. The selection of the briquetting process necessarily must refer to the segment market in order to achieve optimal economic, technical and environmental value [5]. Bio briquettes is often used to substitute oil fuels for small industries and large industries, the one of application bio briquette on industry that is used for boiler fuel.

II. EASE OF USE

C. Biomass

Biomass is a material that can be produced from plants, trees, grass, agricultural waste, forest waste, faeces and livestock manure. Besides of used for primary purposes such as fiber, foodstuff, animal feed, vegetable oil, building materials and so on, biomass is also used as a source of energy (fuel) but, it used economically low biomass fuel or a waste after the primary product is taken. Biomass is a material that can be produced from plants either directly or indirectly and utilized as energy or material in large quantities. Biomass is also called "Fitomassa" and often translated as bioresource or biological resources. Actually, Biomass can be used directly without going through charcoal first. However, the direct use of biomass is less efficient [3]. The main ingredients of biomass are a variety of chemicals (atoms) that mostly contain carbon atoms (C). Biomass is composed of cellulose and lignin (often called lignin-cellulose). The elementary composition of biomass is approximately 53% carbon, 6% hydrogen and 42% oxygen, and less nitrogen, phosphorus and sulfur (each typically less than 1%). Biomass can be processed into bio charcoal, which is a fuel with a high level of heat and it can be used in everyday [3].

D. Carbonization

Carbonization is a process to convert organic matter into charcoal. In the carbonization process will release combustible substances such as CO, CH2, H2, formaldehyde, methane, formic and acetil acid as well as non-combustible substances such as CO2, H2O and liquid tar [3]. Charcoal is a black residue that containing impure carbon produced by removing the water content and volatile components from animal or plant. Charcoal is generally obtained by heating wood, bones, and other objects. The charcoal, which is black, light, easy to break, and resembles coal consists of 85% to 98% carbon, and residual product is ash or other chemical elements [3]. Carbonization process occurs when there is an object heated up to its burning point so that object looks smoldering, then oxygen feed is stopped or limited by closing some of the holes so it does not burn to ash. Carbonization process was able to increase the calorific value and bounding carbon content and able to reduce water content, ash content, and levels of flying substances [3].

E. Bio-Briquette

A briquette is a solid produced by a compression process and when it burned produces little smoke. Making a Briquettes aims to obtain a quality fuel that can be used for all sectors as a replacement energy source (alternative). Briquettes are made from coal powder waste, coke, sawdust and wood charcoal with binders such as petroleum-molded or coalter [3]. Briquettes in cubic or cylindrical molds with varying sizes. By it way, then briquettes will have the characteristics: Strong enough to the handling, has a uniform shape and is resistant to air humidity. So, briquettes are only suitable for small and home industries. Calorific value of briquettes vary greatly according to the raw material [3]. Biological briquettes are clumps or charcoal sticks made of bio charcoal (soft material). Bio charcoal is actually a soft material which is processed into hard charcoal with certain shapes. The quality of bio charcoal is not inferior with coal or other types of charcoal fuel [8]. According to Setiawan (2012), factors affecting charcoal briquette characteristics are the specific gravity of the fuel or the density of the charcoal powder, the fineness of the powder, the temperature of carbonization, and the pressure of the forging. A good briquette requirement is a smooth surface briquettes and no black marks on hand. In addition, as fuel, briquettes must also fulfill the following criteria:

a. Easy to turn on
b. Without smoke
c. Combustion emission gas do not contains toxic
d. Waterproof and combustion products are not moldy when stored for a long time
e. Shows the effort of combustion rate (time, combustion rate, and combustion temperature) is good.

According to [2], briquette briquettes have several advantages compared to conventional charcoal, there are:

1. Bio charcoal produces higher combustion heat.
2. It produces smoke less.
3. Has uniform shape and size as they are made with the printer.
4. Biocharcoal can appear more attractive because the shape and size can be customized by maker.
5. The manufacturing process uses raw materials that do not cause environmental problems.

F. Coconut Fiber

Coconut (Cocos nucifera) is a type of plant from Arecaceae and is the member of the Cocos genus. This plant is used almost all its parts by humans so it is considered as a multipurpose plant, especially for coastal communities. Coconut is also the name for the fruit produced by this plant [4]. Coconut fruit is the most valuable economic part. Coir, mesokarp parts of coarse fibers, traded as fuel, seat fillers, woven ropes, doormats, and growing media for orchids. Shells, which are actually endocarp parts, are used as fuel, buckets substitutes, beverage containers, and raw materials of various handicrafts [4]. Coir (fiber) coconut or in Javanese commonly called sepet is a large part of coconut fruit, which is 35% from overall weight of the fruit. Coconut fiber consists of fiber and cork that connecting one fiber with other fibers. Fiber is a valuable part of the coir. Each coconut contains 525 grams of fiber (75% of coir), and 175 grams of cork (25% of coir). Coconut husk is usually used as a handicraft or as a planting medium, coconut husk is also used as wood fuel substitute by the villagers [4]. But its use as a fuel, in addition to oil stove and gas stove. Besides, using coconut husk as fuel is still less practical if still in the form intact. Usually, from those who use coconut husk as a fuel is a brick making industry or other ceramic craft. Whereas, if coconut husk is converted into other forms to be more practical in its use as fuel, then this will be a very good potential, because coconut husk easy to find and the price is cheap. Another form of coconut husk to be more practical in its use as a fuel is to process it further as a briquette [4].

G. Egg Shell

Egg shell is the most outer layer of eggs that serves to protect all parts of the egg. According to Utomo (2014), eggshells consist of 4 layers:

a. Cuticle layer
   The cuticle layer is a transparent protein that coats the eggshell surface. This layer coats the eggshell pores, but by its nature is still passable gas so that the release of water vapor and CO₂ gas can still occur.

b. Layers of foam
   This layer is the largest part from eggshell layer. This layer consists of protein and lime layer consisting of calcium carbonate, calcium phosphate, magnesium carbonate and magnesium phosphate.

c. Mamillary layer
   This layer is the third layer of eggshell composed from conical layer with a round or oval cross section. This layer is very thin and consists of woven proteins and minerals.

d. The membrane layer
   Is part of the deepest eggshell layer. It consists of two layers of membrane covering that entire egg. The thickness is approximately 65 microns.

According to Utomo (2014), eggshell contains almost 95.1% consisting of organic salt, 3.3% organic matter (mainly protein), and 1.6% water. The most of organic material consists of Calcium carbonate (CaCO₃) compounds about 98.5% and Magnesium carbonate (MgCO₃) compounds about 0.85%. The minerals amount in the eggshell weights is 2.25 grams which consists of 2.21 grams of calcium, 0.02 grams of magnesium, 0.02 grams of phosphorus and a little iron and sulfur. At this time, People think that egg shells are just garbage that can not be utilized and thrown away, people do not realize that egg shells contain calcium with a high percentage that can be used as a source of calcium [6].

III. EXPERIMENTAL WORK

A. Experiment Variable

Variables that used in this research are:

1. Fixed variable : Charcoal particle size using 120 mesh sieve, starch adhesive Percentage is 48% from the total weight of raw material.
2. Changes Variable : Comparison of coconut and egg shell varieties: 3: 1 and 2: 1, Pressure-pressing variables: manual, 15, 30 and 45 kg / m²

B. Materials Experiment


C. Tools used


D. Experimental Procedure

1. Pre-Treatment

   Coconut fibers Pre-treatment: Dry the coconut husk. Fabricated coconut husk that has dried. Mashing...
the finished charcoal. Filter the coated coconut husk with a 120 mesh strainer.

Eggshells Pre-treatment: Dry egg shells. Make a charcoal from dry egg shell. Mashing the finished charcoal. Filter the eggshell that has been pounded with a 120 mesh strainer.

Stage of adhesive starch: Weighing starch 3 grams. Adding water 53.4 ml and heated to be adhesive.

2. Stage of Experiment

Mix all raw materials (coconut charcoal + shell charcoal + starch adhesive). Considering the raw materials that have been mixed as much as 10 grams. Print the briquettes in the mold with the specified pressure variable and let it stand for 3 minutes. Insert briquettes into the oven with 110°C temperature. Repeats the same thing for different variables.

3. Analysis Stage

Moisture content analysis: Takes a bio briquette that be used for water content analysis. Insert into oven with 110° C temperature for 1 hour. Insert sample into the desiccator. Weight it up to constant. Calculate the water content by using this formula:

\[
\text{Water Content} = \frac{\text{Initial weight} - \text{Final Weight}}{\text{Initial weight}} \times 100\%
\]

Ash analysis: Takes a bio briquettes that be used for ash content analysis. Insert sample into the furnace with a 600ºC temperature of for 4 hours. Insert the sample into the desiccator. Weight it up to constant. Calculate the ash content by using the formula:

\[
\text{Ash content} = \frac{\text{Initial weight} - \text{furnacing weight}}{\text{Initial weight}} \times 100\%
\]

Density analysis: Determining the bio-briquette volume of tube volume calculation with \( r \) (radius) and \( h \) (height) is known by the formula \( V = \pi r^2 h \). Determine the density, which is the ratio between the mass of biobriket and the volume of briquette \( V \) by the formula:

\[
\rho = \frac{\text{bio briquette mass}}{\text{bio briquette Volume}}
\]

Heating value (HV) and combustion (LP) analysis: Insert 50 ml of water into Erlenmeyer. Measure the initial temperature of water. Picked up 1 bio-briquette to be used to calculate HV and LP. Burn the briquette and wait until the fire go out and the coals arise. Heat the water in an erlenmeyer. Calculates the time that bio-briquette takes become ash. Measures the final temperature of the water when the bio briquette has become completely ash. Weight the ashes of the bio-briquette that has been obeyed. Calculate HV and LP with this formula:

\[
\text{HV} = \frac{m_{\text{water}} \times C_{\text{water}} \times \Delta T_{\text{water}}}{\text{mass (gr)}}
\]

\[
\text{LP} = \frac{\text{Initial mass} - \text{final mass (gr)} \times \text{time (second)}}{\text{mass (gr)}}
\]

IV. RESULT AND DISCUSSION

C. Result

**Table IV.1 Analysis Result of Biobriquette Density**

<table>
<thead>
<tr>
<th>Ratio Material Biobriquette</th>
<th>Pressure Variable (kg/cm²)</th>
<th>Initial Mass (gr)</th>
<th>Final Mass (gr)</th>
<th>Dimension T (cm)</th>
<th>Dimension D (cm)</th>
<th>Volum (cm²)</th>
<th>Biobriquette Density (gr/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:1</td>
<td>Manual</td>
<td>7.8</td>
<td>6.2</td>
<td>0.6</td>
<td>3.7</td>
<td>6.44799</td>
<td>0.2481393 43</td>
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<tr>
<td></td>
<td>15</td>
<td>7.7</td>
<td>6.7</td>
<td>0.6</td>
<td>4</td>
<td>7.536</td>
<td>0.1326963 91</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>6.9</td>
<td>6.1</td>
<td>0.4</td>
<td>4</td>
<td>5.024</td>
<td>0.1592356 69</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>6.5</td>
<td>5.8</td>
<td>0.3</td>
<td>4</td>
<td>3.768</td>
<td>0.1857749 47</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:1</td>
<td>Manual</td>
<td>7.5</td>
<td>4</td>
<td>1.4</td>
<td>3.7</td>
<td>15.04531</td>
<td>0.2326306 34</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>6.9</td>
<td>5.8</td>
<td>0.4</td>
<td>4</td>
<td>5.024</td>
<td>0.2189490 45</td>
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<td></td>
<td>30</td>
<td>5.5</td>
<td>4.8</td>
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<td>4</td>
<td>5.024</td>
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<td></td>
<td>45</td>
<td>6</td>
<td>5.5</td>
<td>0.3</td>
<td>4</td>
<td>3.768</td>
<td>0.2653927 81</td>
</tr>
</tbody>
</table>

**Table IV.2 Analysis Result of Water Content Biobriquette**

<table>
<thead>
<tr>
<th>Ratio Material Biobriquette</th>
<th>Pressure Variable (kg/cm²)</th>
<th>Initial Mass (gr)</th>
<th>Final Mass (gr)</th>
<th>Water Content Biobriquette (%)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>7.8</td>
<td>6.2</td>
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<td></td>
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<td>7.7</td>
<td>6.7</td>
<td>4.47761194</td>
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<td></td>
<td>30</td>
<td>6.9</td>
<td>6.1</td>
<td>3.94736842</td>
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<td></td>
<td>45</td>
<td>6.5</td>
<td>5.8</td>
<td>2.81690141</td>
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</tr>
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<td>4</td>
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<td></td>
<td>30</td>
<td>5.5</td>
<td>4.8</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>6</td>
<td>5.5</td>
<td>3.33333333</td>
</tr>
</tbody>
</table>

**Table IV.3 Analysis Result of Dust Content Biobriquette**
### D. Discussion

The purpose of this bio briquette experiment is the way of making bio briquettes from coconut fiber and eggshell as alternative fuels that being standards, knowing the exact composition size in the batch-making mixture that meets the standards and knows what needs to be analyzed and know how to analyze the product.

On the Bio briquette production comparison from coconut husk and egg shell biobriket analysis of water content, ash content, density, rate and mass of heat on each variable bio briquette made.

#### a. Density Analysis

From Chart IV.1 showed, relationship between pressure (Kg / cm²) and density (g / cm³) of briquette with composition ratio between coco fiber and egg shell of 3:1 yield at manual pressure has a density of
0.248 gr/cm³; briquette with 15 Kg/cm² pressure has a density of 0.132 gr/cm³; briquette with 30 Kg/cm² pressure has a density of 0.1592 gr/cm³; briquette with 45 Kg/cm² pressure has a density value of 0.185 gr/cm³. ratio of the composition between coconut husk and eggshell is 2:1 yield at manual pressure has a density of 0.2326 gr/cm³; briquette with 15 Kg/cm² pressure has a density of 0.2189 gr/cm³; briquette with 30 Kg/cm² pressure has a density of 0.2388 gr/cm³; briquette with 45 Kg/cm² pressure has a density of 0.2654 gr/cm³. Results of this experiment can be concluded that briquette density for all pressures in accordance with SNI No. Biobriket. 1/6235/2000 is ≤ 0.4507 g/cm³. From the graph also obtained that the largest density at pressure 45 Kg/cm² with composition ratio between coconut husk and eggshell is 2:1, 0.2654 gr/cm³. From the graph it can be obtained that high pressure then also high density. This is accordance with the literature which that the higher pressure, it make the briquette volume are lower. When the volume is low, then the density is high. So, the higher the pressure, make the higher density. 

b. Water content analysis

From Chart IV.2 showed relationship between pressure (Kg/cm²) and water content (%). Briquette with ratio composition between coconut husk and shell is 3:1 yield at manual pressure has moisture content 5.8882%; In briquette with a 15 Kg/cm² pressure has a moisture content of 4.4776%, on a 30 Kg/cm² pressure briquette having water content of 3.9473%, on a 45 Kg/cm² pressure briquette having water content of 2.8169%. While comparison of the composition between coconut husk and egg shell is 2:1, 0.2654 gr/cm³. From the graph it can be obtained that high pressure then also high density. This is accordance with the literature which that the higher pressure, it make the briquette volume are lower. When the volume is low, then the density is high. So, the higher the pressure, make the higher density. 

From Chart IV.3 showed relation between pressure (Kg/cm²) and ash content (%). Briquette with ratio composition between coconut husk and shell is 3:1 obtained result at manual pressure having water content 4.4776%; briquette with 15 Kg/cm² pressure has water content of 2.9412%, at 30 Kg/cm² pressure briquette having water content 3.3898%, at 45 Kg/cm² pressure has moisture content of 5.3571%. While comparison of the composition between coconut husk and egg shell is 2:1, 0.2654 gr/cm³. From the graph obtained that ash content at 45 Kg/cm² pressure has a water content of 3.2257%, on biobriket with 15 Kg/cm² pressure of has a moisture content of 1.7857%, on the briquette with 30 Kg/cm² pressure has a water content of 2.8571%, on the briquette pressure 45 Kg/cm² has a water content of 4.4444%. The results of such experiments can be concluded that the briquette ash content value for all the pressures in accordance with SNI Biobriket No. 1/6235/2000 is ≤ 8%. The experimental results showed that the highest ash content at 45 Kg/cm² pressure on the composition of the 3: 1 composition was 5.3571%. From that graph obtained that ash content in the composition ratio of 3: 1 more than 2: 1 because of the composition of coconut fiber in a ratio of 3: 1 more, so ash content is generated more and from the graph obtained that the higher pressure make ash content increasingly high. This is not accordance with the literature which states that the higher pressure will give briquette ash content lower, because at the time of forging some adhesives, the ash will come out, so that eventually of briquette will be lower [1]. This incompatibility caused
by several factors such as lack of pressure when the pressing process is still a lot of water content in the briquette so that Resulting in ash content not in accordance with the literature.

d. Mass Loss Rate Analysis

From Chart IV.4 showed the relation between pressure (Kg/cm$^2$) and mass loss rate (gr/s) of briquette with composition ratio between coconut fiber and egg shell of 3:1 obtained result at manual pressure of mass decrease rate 0.0026 gr/s, on a briquette with 15 Kg/cm$^2$ pressure having mass loss rate of 0.0055 gr/s, at 30 kg/cm$^2$ pressure briquette having mass loss rate of 0.0022 g/s, at 45 Kg/cm$^2$ pressure briquette having having mass loss rate of 0.0017 gr/s. While the comparison of the composition between coconut fiber and egg shell of 2:1 obtained results at manual pressure of mass decrease rate of 0.0013 gr/s, on briquette with 15 Kg/cm$^2$ pressure having mass loss rate of 0.0048 gr/s, at Briquette with 30 Kg/cm$^2$ pressure having mass loss rate of 0.0032 gr/s, at the briquette with 45 Kg/cm$^2$ pressure having mass loss rate of 0.0007 gr/s. The results of such experiments showed that the mass loss rate at the pressure 15 Kg / cm$^2$ in the 3:1 material composition ratio is 0.0055 g / s. From the chart shows that the higher pressure so it make lower the mass decrease. This is accordance with the literature which states that the greater pressure, make smaller the burning rate. This is because the briquettes that have high pressure result in less briquette space so that oxygen can not enter and slow down the combustion process. This incompatibility caused by several factors such as lack of pressure when the pressing process is still a lot of water content in the briquettes, resulting in the calorific value is not in accordance with the literature.

e. Calorific Value Analysis

From chart IV.5 showed relationship between pressure (Kg/cm$^2$) and calorific value (cal/gr) of briquette with composition ratio between coconut fiber and egg shell of 3:1 obtained result at manual pressure of calorific value 2612856,6 cal/gr, On briquette with 15 Kg/cm$^2$ pressure, having calorific value of 2146512 cal/gr, at 30 kg/cm$^2$ briquette pressure value having calorific value of 2061129.2cal/gr, at 45 Kg/cm$^2$ pressure briquette having calorific value of 1429259.9 cal/gr. While the comparison of composition between coconut fiber and egg shell is 2:1 obtained the result at manual pressure of calorific value of 2361158,5 cal/gr, on briquette with 15 Kg/cm$^2$ pressure, having calorific value 2274951 cal/gr, at 30 kg/cm$^2$ pressure, having calorific value 1759094,8 cal/gr, on briquette with 45 Kg/cm$^2$ pressure having calorific value of 1633449 cal / gr. From the result of this experiment can be concluded that the calorific value of briquette for all pressures in accordance with SNI Biobriket No. 1/6235/2000 ie> 5000 cal / gr. The result of experiment showed that the highest heating value was at manual pressure on the composition of 3:1 composition is 2612856,6 cal / gr. From the chart is found that the higher pressure it make lower heating value. This is not in accordance with the literature which states that the higher the pressure given the higher the calorific value of briquettes, this is because at the time of forging some of the water and the binder will be wasted out, causing higher briquette calorific value [1]. This incompatibility caused by several factors such as lack of pressure when the pressing process is still a lot of water content in the briquettes, resulting in ash content is not in accordance with the literature.
CONCLUSION

From this experiment to making bio briquette from coconut fiber and egg shell charcoal can be obtained conclusion that is:

1. The higher pressure making density value is also higher. In variable Manual pressure, 15 kg/cm²; 30 kg/cm² and 45 kg/cm² obtained the optimum density value at pressure 45 kg/cm² in ratio composition 2:1 of 0.2654 gr/cm³ in accordance with SNI Biobriket No. 1/6235/2000 is ≤ 0.4507 g/cm³.

2. The higher pressure making water content is also lower. In variable Manual pressure, 15 kg/cm²; 30 kg/cm² and 45 kg/cm² obtained the highest value of water content at the manual pressure on the composition of the material 3:1 composition of 5.8882% in accordance with the SNI No. Biobriket 1/6235/2000 is ≤ 8%.

3. The higher pressure making ash content is also lower. In variable Manual pressure, 15 kg/cm²; 30 kg/cm² and 45 kg/cm² obtained the greatest value of ash content at the 45 kg/cm² pressure in the ratio of 3:1 material composition 5.3571% in accordance with SNI No. Biobriket. 1/6235/2000 is ≤ 8%.

4. The higher pressure making mass loss is also lower. In variable Manual pressure, 15 kg/cm²; 30 kg/cm² and 45 kg/cm² obtained the greatest value of mass loss rate at the 15 kg/cm² pressure in the ratio material composition of 3:1 is 0.0055 gr/s.

5. The higher pressure making calorific value is also higher. In variable pressure Manual, 15 kg/cm²; 30 kg/cm² and 45 kg/cm² obtained the largest calorific value at manual pressure on the material composition ratio of 3:1 is 2612856.6 cal/g.

6. From the analysis results can be concluded that the bio briquette of coconut and egg shell mixture with ratio of 3:1 and 2:1 composition fulfill the SNI Biobriket No. 1/6235/2000.

7. From the analysis result of density value, water content and mass loss rate according to literature while for analysis of ash content and calorific value not yet in accordance with literature.

References