The Best Biobriquette Dimension and its Particle Size

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INTRODUCTION :

- Indonesia has abundant supply of biomass. Some portions become waste after its utilization, e.g. rice husk, rice straw, coconut fiber, coconut shell, palm oil shell, palm oil fiber, bagasse, wood chip, saw dust, etc.
- These wastes can be used later on, either as natural fertilizer, or as handicrafts or building materials, or as clean and renewable fuels.
- It is briquetted to improve the energy density, to increase the heat capacity (the capability to retain heat for a longer period and maintain higher temperatures to facilitate easy ignition of fresh fuel charges), to reduce the amount of flying ash (because more ash is bound within its char), and to make handling, storage & transportation easier.

INTRODUCTION :

- Coal or char is added into biomass briquettes to improve its heating value and combustibility. In terms of energy output and pollutant emissions, the optimum blending ratio of biomass with coal is between 10% and 30%. But the mixing ratio of 1 : 3 for coal and biomass is used in this research.
- It can be used for heat generation in households and small industries, or for power generation in large industries.
- Different types of furnace are required according to heat release rates, briquette dimensions, heating values, etc. It is expected that the maximum reaction rate is maintained during combustion. Reaction rates are resulted from complex interaction of many variables.

METHODOLOGY :

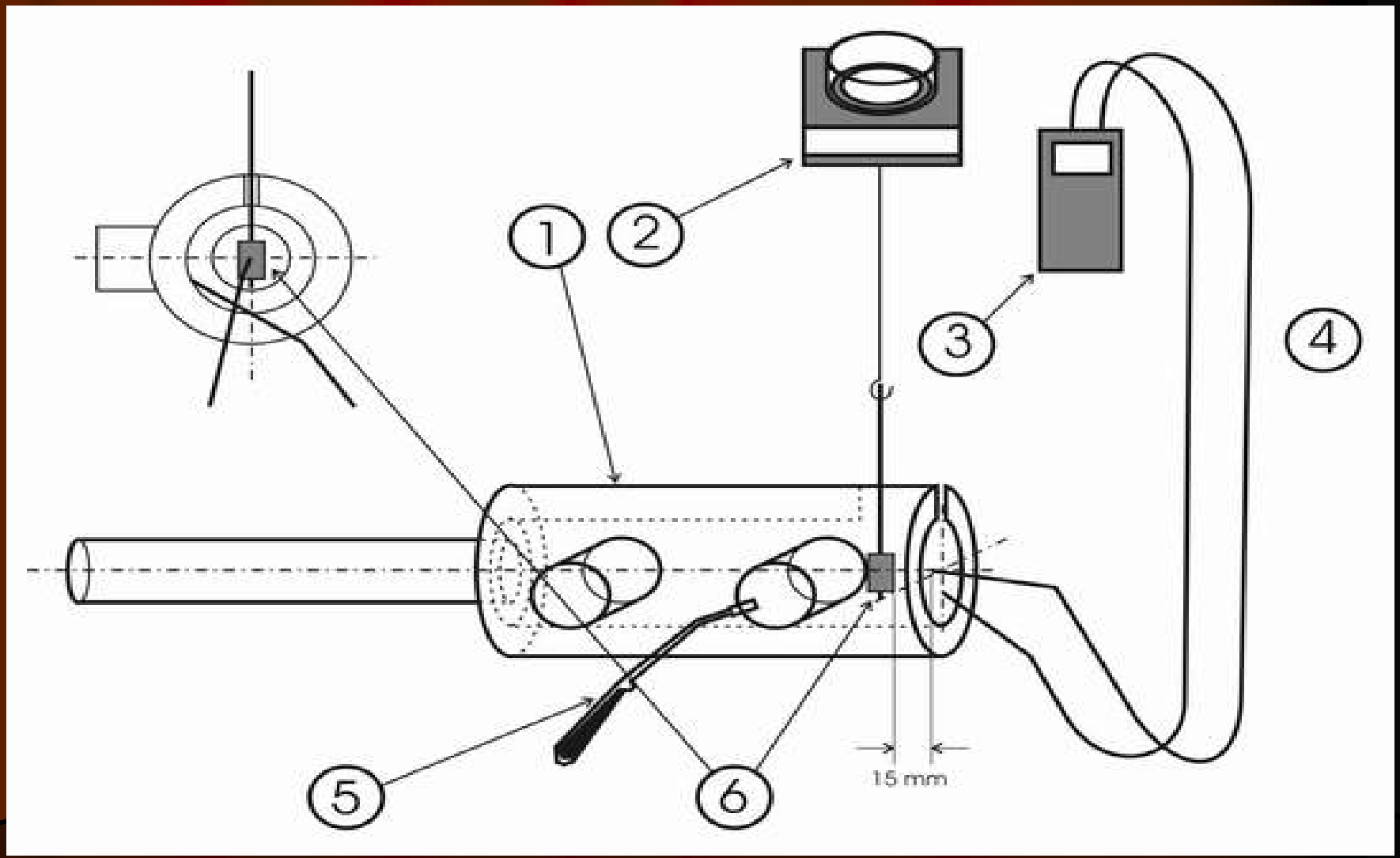
Two experiments have been carried out to investigate the influences of briquette dimension (Experiment 1) and composing particle size (Experiment 2) on the combustion characteristics.

MATERIALS :

For the first experiment : wooden saw dust, lignite and natural binder. Briquettes are cylindrical with a diameter of 13 mm, made from 75% wooden saw dust and 25% lignite. They are mixed with 40% natural binder (made from 16.6% cassava starch and 83.3% water). There are three different briquette masses, i.e. 3 g, 4g and 5 g, respectively.

For the second experiment : rice husk and natural binder (consist of 9.1% cassava starch and 90.9% water). Five different particle sizes are prepared, i.e. more than 100 mesh, 70 - 80 mesh, 60 - 70 mesh, 50 - 60 mesh, and 40 - 50 mesh. The ratio between rice husk and binder is 3 : 1, and all the wet briquettes weigh initially 4 grams in the form of 16 mm diameter cylinders.

EQUIPMENT :



LEGENDS :

1. Combustion furnace.
2. Digital scale to measure continuously the fuel mass.
3. Digital Thermometer.
4. Thermocouple to monitor the temperatures of air, hot gas and furnace wall.
5. Heating torch to heat the combustion air (first experiment) or the furnace wall (second experiment).
6. Fuel briquette.

For the 1st experiment : briquettes are placed onto a 11.7 cm diameter perforated plate which is located within the vertical combustion furnace where combustion air flows upward. A blower is provided to supply combustion air with various velocities.

PROCEDURES :

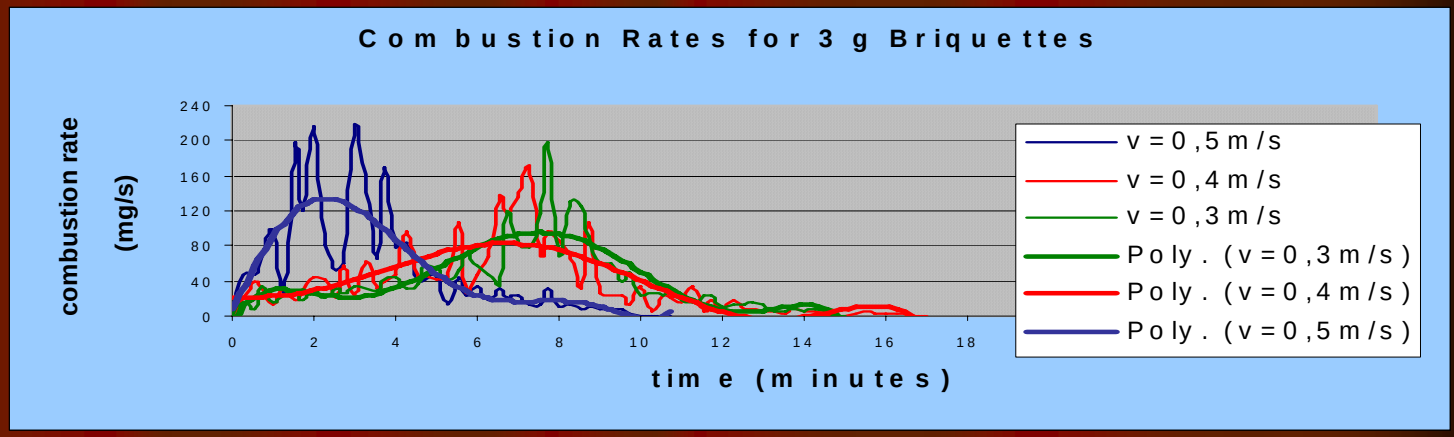
- For the 1st experiment : to obtain the same initial weight of the fuels, the followings are selected : 20 pcs of 3 g briquette, 15 pcs of 4 g briquette, and 12 pcs of 5 g briquette. Air is supplied with 3 different rates (0.3 m/s, 0.4 m/s, and 0.5 m/s), with constant temperature of 70 C with the help of a LPG air heater.
- For the 2nd experiment : The fuel is reacted one at a time. The furnace wall temperature is held constant, about 283 C. The flue gas temperature at a position behind the burning fuel is considered constant at roughly 135 C. The air at room temperature flows naturally.
- The instantaneous masses for both experiments are recorded for every 15 seconds. The measurements are terminated if there is no mass decrease anymore.

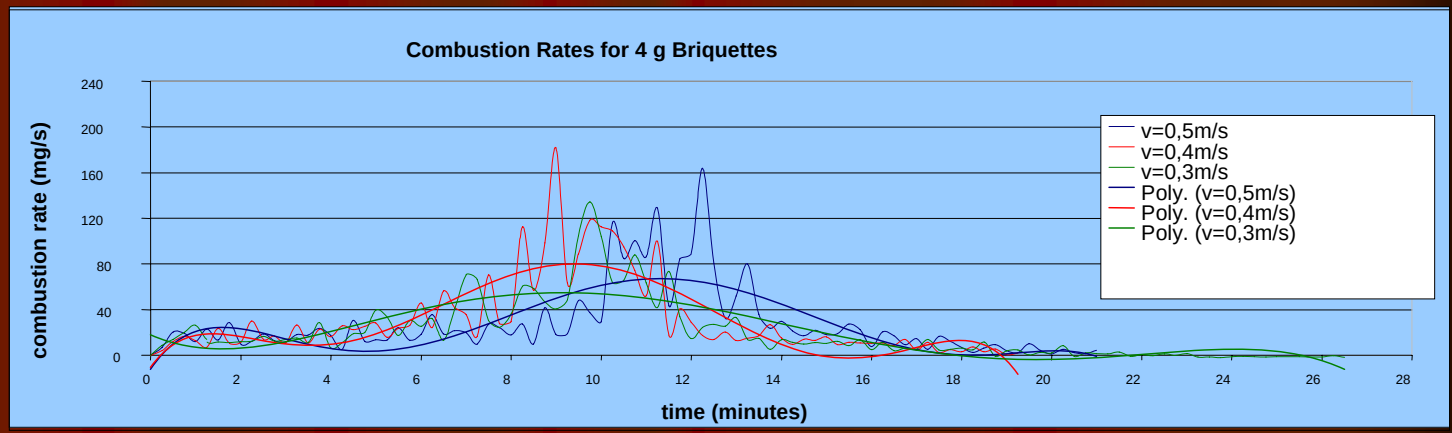
RESULTS AND DISCUSSIONS :

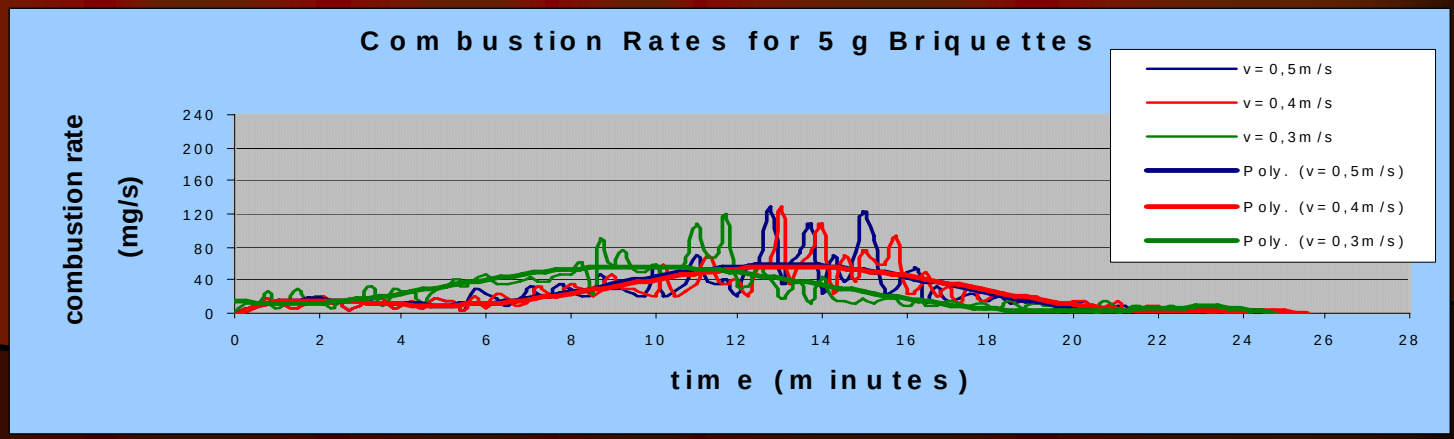
For the first experiment

The results of combustion calculations are displayed in the following figures. Since the real process is highly fluctuated and make analyses very difficult, the oscillating curves are mathematically smoothed.

By comparing those figures, particularly their smoothed curves, it can be concluded that smaller biobriquettes demonstrate better combustion characteristics (especially combustion rate) due to larger specific surface area available for reaction. More accessible surface area will obviously facilitate more O_2 to bind carbon in a certain time period. Therefore the smaller the specific surface area, the longer it will take to burn the briquettes.


Combustion Rates for 3 g Briquettes
combustion rate (mg/s)
240
200
160
120
80
40
0
0
2
4
6
8
10
12
14
16
18
time (minutes)
v = 0,5 m/s
v = 0,4 m/s
v = 0,3 m/s
Poly. (v = 0,3 m/s)
Poly. (v = 0,4 m/s)
Poly. (v = 0,5 m/s)


Combustion Rates for 4 g Briquettes
combustion rate (mg/s)
240
200
160
120
80
40
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
time (minutes)
v=0,5m/s
v=0,4m/s
v=0,3m/s
Poly. (v=0,5m/s)
Poly. (v=0,4m/s)
Poly. (v=0,3m/s)


Combustion Rates for 5 g Briquettes
combustion rate (mg/s)
240
200
160
120
80
40
0
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
time (minutes)
v = 0,5 m/s
v = 0,4 m/s
v = 0,3 m/s
Poly. (v = 0,5 m/s)
Poly. (v = 0,4 m/s)
Poly. (v = 0,3 m/s)

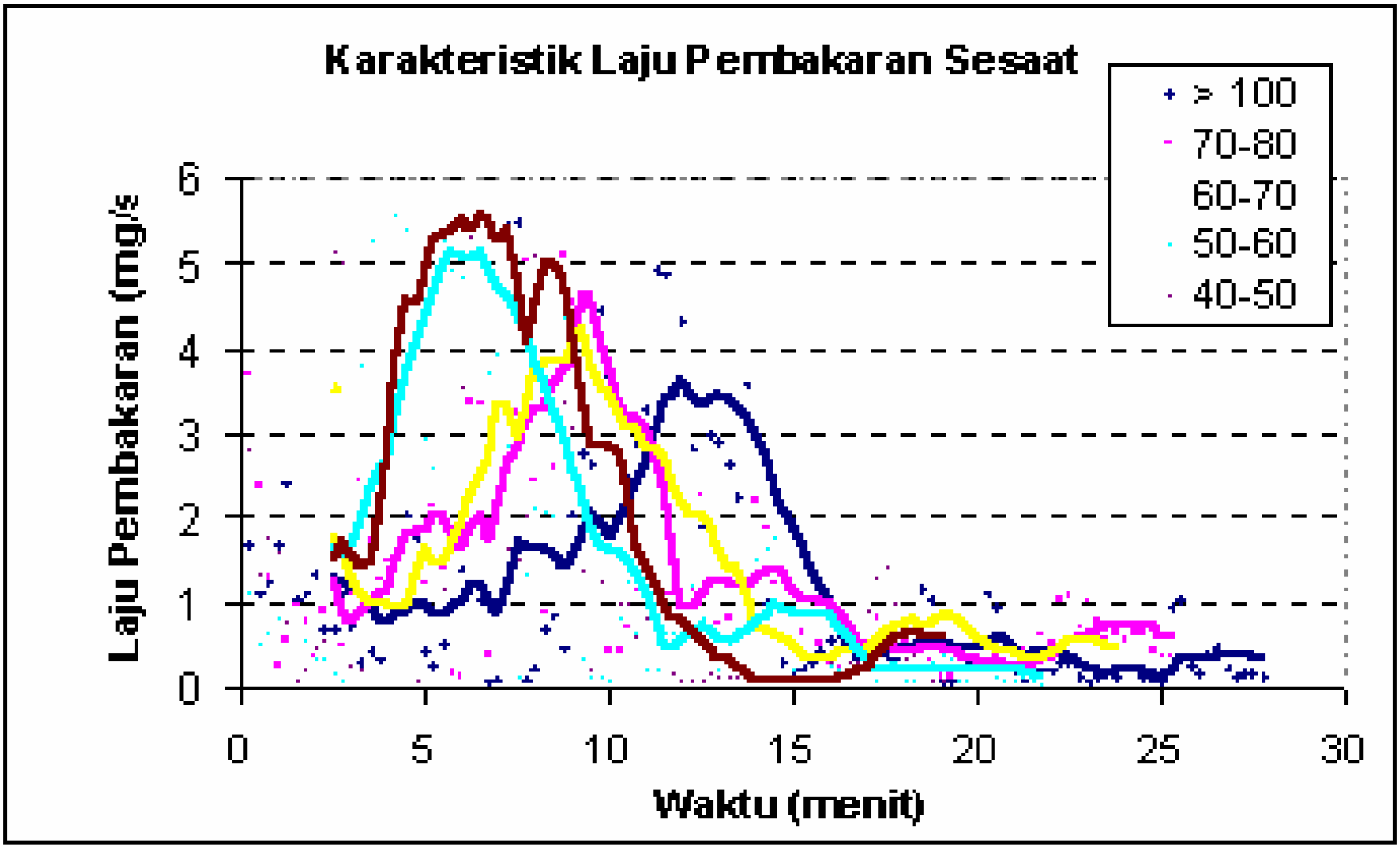
RESULTS AND DISCUSSIONS :

for the second experiment

Particle size (microns)	150	180 -212	212 - 250	250 - 300	300 - 425
Briquette mass (gram)	2.926	2.629	2.691	2.539	2.798
Briquette height (mm)	15.95	18.00	18.30	20.75	23.90
Briquette diameter (mm)	15.75	16.00	16.60	17.10	17.40
Briquette volume (mm^3)	3108.8	3620.6	3962.2	4767.3	5685.4
Briquette density (kg/m^3)	941.2	726.1	679.2	532.6	492.1
Strain (%)	32.92	38.46	40.77	48.21	70.71
Reacted mass (gram)	1.963	2.148	2.159	2.137	2.332
Unburned mass (%)	32.91	18.30	19.77	15.83	16.65
Combustion time (min)	28.0	25.5	24.0	22.0	19.25

RESULTS AND DISCUSSIONS :

for the second experiment



RESULTS AND DISCUSSIONS :

for the second experiment

Particle sizes determine porosities. The smaller the particle size, the higher the density, and the lesser the porosity. The lowest density is 492.1 kg/m3, while the highest is 941.2 kg/m3.

Briquettes of coarser rice husks expand more after released from the molding. The strain shows that the finest particles will elongate 32.9% while the largest particles can reach 70.7%.

Lower porosities hinder mass transfer, due to fewer free spaces for diffusion (H_2O, VM, and CO_2 outflows and O_2 infiltration), so its combustion rates will be lower.

Briquettes from the largest particle burn in 19.25 min leaving 16% of unburned solid, while those from the smallest particle react until 28 min but leaving 33% unburned.

RESULTS AND DISCUSSIONS :

The most appropriate furnace for the discussed biobriquettes is either suspension burning (crushed fuel) or fluidized bed, particularly CFB (circulating fluidized bed). However fluidized bed type can be better, since there is no need to provide pulverizing system because coarser briquettes are still acceptable. The resulted lower temperature within the fluidized bed combustion chamber is suitable for low ash melting characteristics typical for biomass.

A research has been conducted using a BFB (bubbling fluidized bed) which burns pellets of Empty Fruit Bunch. The biomass waste is produced from palm oil mills.

CONCLUSIONS :

It can be concluded from those two experiments that briquette dimensions should be as small as possible but their composing particles should be as coarse as possible. Combining those requirements, each briquette should be an impervious single very small unit. The most appropriate furnace type is fluidized bed, either circulating or bubbling types.

ACKNOWLEDGEMENT :

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THANK YOU

VERY MUCH

FOR YOUR ATTENTION