Rice husk gasification performance to decrease water content in liquid palm sugar

E Listijorini* and S Wiyono
Department of Mechanical Engineering, Faculty of Engineering, Universitas Sultan Ageng Tirtayasa, Jl. Jendral Soedirman KM.3 Cilegon Banten 42435, Indonesia

*E-mail: ernylisty@untirta.ac.id

Abstract. Gasification is a process of changing thermochemical solid fuel into gas. In simple terms, the gasification process can be said as a chemical reaction at high temperatures between biomass and air. The purpose of this study was to determine the effect of AFR on the performance of the TG30-1 gasification engine and compare it with the same engine performance in previous studies. This study uses blowers which are combined with an inverter to vary the frequency of rotation of the motor. From the three tests, the results of different performance analyses were obtained. In this study, experiments on corn cobs biomass for 45Hz motor frequency (90%) produced the best Fire Power and Specific Power at 23.01 kW and 3.71 kW/kg with AFR values of 1.54. Palm shell biomass with 45Hz motor frequency (90%) yields 18.32 kW and 3.24 kW/kg with an AFR value of 1.23. Wood powder biomass with 45Hz motor frequency (90%) produces 22.53 kW and 3.88 kW/kg with an AFR value of 1.36. Rice husk biomass with a 45Hz motor frequency (90%) yields 29.08 kW and 6.39 kW/kg with an AFR value of 1.15.

1. Introduction
Sugar is the flagship product of Banten province and has penetrated the international market and is known as organic sugar. In its development, liquid palm sugar is one of the prima donnas. Needing a liquid palm sugar production system needs to be improved, liquid palm sugar which is traditionally cooked in black and tastes rather bitter. A way to produce quality liquid palm sugar is to use a vaccine dryer, which can reduce the boiling temperature of liquids below 100°C. This study launched a biomass thermal generator as a heater in a vacuum drier system to drying liquid palm sugar. This research is part of the development of a wind turbine hybrid generator and a biomass thermal generator [1]. State of the art, to produce 10 kW of power it takes 28 kg/h [4], the design of a rice husk gasifier aimed at producing energy has been carried out, with many designs reviewed [5].

Research methodology
In this study, retrieval of data is taken by doing WBT (Water Boiling Test) [2] where there are two tests, namely Hot Start and Simmering. As for the flow diagram as in figure 1. The material used in this research is rice husk as fuel and palm sugar liquid as material to be distilled. Data acquisition will use temperature sensors and Arduino as a place to process data. Data will be processed using descriptive statistical methods and displayed in a graph between time and temperature.

2. Data collecting procedure
In testing the search for gasification engine performance the TG 30-1 model uses rice husk biomass with the Water Boiling Test method using a literature-based procedure on the design of a system of cooling
water biomass machines model 30-1, Water Boiling Test and manual testing standards book from TG 30-1 machine.

Figure 1. Experiment setup.

Pre testing:
- Considering the initial weight of rice husk.
- Considering the volume of water in the pot, 2/3 of the total volume of the pot.
- Measuring the blower output airflow rate.
  - Adjust the position of the sensor and settings on the computer.
  - Calculate the time of de-ashing.
  - Ensure that the water level covers the hole in the drum output of the cooling system.

Hot start testing:
- Fill the reactor with rice husk about 10 cm from the bottom of the reactor and spread it evenly.
- Open the air and gas control valve.
- Start the diesel water pump engine.
- Start the water pump and leave the valve open for flushing.
- Slowly close the gas filter valve and tar filter.
- Turn on some used paper and drop it into the reactor. Spread the burning paper evenly over the husk and let the husk burn. Until the temperature in the reactor reaches above 550°C.
- Check the fire on the exhaust air output from the engine to ensure the presence of fire gas output.
- Turn on the fire on the stove, set the valve on the drain so that the fire from the stove is stable.
- Fill the rice husk biomass up to 10 cm from the reactor lip and maintain the height of the rice husk by adding rice husk to the reactor.
- Perform step de-ashing periodically in accordance with the calculation; clean the drum cooling system from the remaining burning husk.
- Perform data retrieval using a sensor in the pot.
- If the water temperature in the pot has reached 100°C, stop taking the hot start test temperature data.

Simmering testing:
- The step is done directly after testing the hot start.
- Stop feeding the rice husk to the reactor.
c. Measure the volume of water in the pot.
d. Adjust the gas output on the stove until the fire is almost dim but stable.
e. Put the pot back on the stove.
f. Perform temperature data retrieval using sensors for 15 minutes.
g. Measure the volume of water in the pot again.
h. Perform the procedure to turn off the gasifier engine.

3. Result and discussion
From the experiments conducted 3 times, the results obtained as follows:

![Graph showing temperature over time with intervals of 5 seconds]

**Figure 2.** WBT Result.

**Table 1.** Total power rating.

| Total power rating | Unit |
|--------------------|------|
| test 1             | 1.201 kW |
| test 2             | 1.57 kW  |
| test 3             | 1.916 kW |

**Table 2.** Power per kg biomass.

| Total power rating | Unit |
|--------------------|------|
| test 1             | 0.0856 kW/kg |
| test 2             | 0.0655 kW/kg |
| test 3             | 0.0905 kW/kg |
Experiment data of vacuum drying palm sugar liquid in table 3.

| Symbol | Information                        | Value   | Unit  |
|--------|-----------------------------------|---------|-------|
| $C_w$  | Calori value of rice husk         | 13807   | Kj/Kg |
| $I$    | Boiling time                      | 1 h 57 min | Min   |
| $M_w$  | Fuel consumption                  | 15,32   | Kg    |
| $T_f$  | $x$                               | 100     | $^\circ$C |
| $T_i$  | Initial water temp.               | 25,5    | $^\circ$C |
| $W_f$  | final Water mass                  | 16,54   | Kg    |
| $W_i$  | initial Water mass                | 17,44   | Kg    |
| $V_1$  | gas velocity in nozzle 1          | 2,6     | m/s   |
| $V_{stove}$ | Gas velocity at stove         | 4,8     | m/s   |

From vacuum drying test of palm sugar liquid, the temperature versus time shown in fig 4.

---

**Figure 3. Vacuum test**

The vacuum pressure measurement in the pot is performed to ensure that the pressure in the pot is lower than the surrounding pressure, shown in table 3.

| Minute | Bar |
|--------|-----|
| 15     | 0.78 |
| 30     | 0.72 |
| 45     | 0.6  |
| 60     | 0.55 |
| 75     | 0.48 |
| 90     | 0.44 |
| 105    | 0.34 |
| 120    | 0.32 |
| 135    | 0.3  |
Many gasification designs that have been developed and concluded to burn rice husk are downdraft designs [6] in this experiment the gassifier used is the same type. Rice husk gasification has also been used to dry rice, the efficiency obtained is quite good 85%, and according to [3] this dryer can also be used for fruit dryers. Using gasification of palm fiber to power up vacuum drier [7].

Palm sugar liquid is heated to a temperature of 70 C within 30 minutes, and its temperature can be maintained at 70 C with a fluctuation of 5 C for 2 hours. And for 2 hours the water content can be reduced by up to 50%, so the sugar content can be up to 70%. But some disadvantages is sometimes vacuum pump cannot maintain vacuum condition in palm sugar fluid pot. Next experiment need to redesign of stove that used in this experiment.

4. Conclusion
From taking the three times rice husk gasification testing data using the water boiling test method, it was found that the power rating produced by the TG30-1 engine with feeding rice husks was 0.75kW, 0.76kW and 0.77kW with Specific Power of 0.0856kW / kg, 0.0655kW / kg and 0.0905kW / kg. This performance is more than enough to power up fruit dryer. For the next experiment this power must be can controlled and can be used up to 100 percent.

Acknowledgments
This research is funded by a grant research program consortium Islamic Development Bank No. 62 / UN43.9 / PT.00.03 / 2019.

References
[1] Erwin E, et al. 2018 Design Optimization of Hybrid Biomass and Wind Turbine forMinapolitan Cluster in Domas, Serang, Banten, Indonesia IOP Conference Series: Earth and Environmental Science vol. 105 p. 012010 2018/01
[2] Visser P, et al. 2005 The testing of Cookstoves: Data of Water-Boiling Tests as a basis to Calculate Fuel Consumption vol. 9.
[3] Mirani A A, Ahmad M, et al. 2013 Rice Husk Gasifier for Paddy Drying Sci. Tech. and Dev. 32(2): 120-125
[4] Lin K S, Wang H P, et al. 1998 A Process Development for Gasification of Rice Husk Fuel Processing Technology 55(3): 185-192
[5] Mohammud M M and Zikri M 2017 Rice Husk Gassifier in UITM Penang as Energy: A Design Review Malaysian Journal of Sustainable Environment 3: 139-155
[6] Mohammud Dr, M.M. and M. Zikri, RICE HUSK GASIFIER IN UITM PENANG AS ENERGY: A DESIGN REVIEW. Malaysian Journal of Sustainable Environment, 2017. 3: p. 139-155.
[7] Y.M. Yunus, H.H. Al-Kayiem and K.A.K. Albaharin, 2011. Design of a Biomass Burner/Gas-to-gas Heat Exchanger for Thermal Backup of a Solar Dryer. Journal of Applied Sciences, 11: 1929-1936.