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Combustion Characteristics Modeling of Rice Husk as Fuel for Power Plant in Indonesia

Abstract. This study was conducted to obtain a model combustion characteristic of rice husk as fuel at power plants in Indonesia. It is expected to be one of the solutions to meet the needs of electrical energy in Indonesia. Modeling characteristics performed using Ansys Fluent software.

Modeling results obtained maximum gas temperature at bed about 1600 K. Temperature and CO_2, CO, H_2O occurs fluctuation in the combustion zone to at distance of 4.66 m from the fuel inlet. Maximum combustion temperature at the base of the furnace about 1600 K and the furnace exit around 967 K. Temperature distributions in the bed and the furnace is uneven due to incomplete combustion of gas in the bed and the fuel air mixture ratio is not appropriate (stoicheometric).

Combustion gases in the furnace, ie CO_2, CO, H_2O fluctuate on the basis of the furnace, the furnace room, and the furnace exit. It was concluded that the model of the combustion characteristics of rice husk showed the feasibility of using rice husk as fuel for power plants. Keywords: Modeling, Combustion characteristic, Rice husk, Power plant.

Introduction Supplies electrical energy in Indonesia is still very limited, electrification ratio is still low, especially outside Java. Provinces with the electrification ratio was greater than 60% only 13 provinces, 12 provinces only around 41- 60%, even still there are 4 provinces still below its around 20 - 40% [1]. Rural communities are still many who do not use electrical energy for everyday purposes. In urban areas also rolling blackouts are still common.

This is due to lack of power while electricity for society and industry is increasing every year. In addition, fossil energy sources are a major source of power generation in Indonesia tends drastic and reduced environmental impacts. While the potential of rice husk (RH) in Indonesia is quite large rice producing countries every year ranked third in the world after China and India.

This potential is scattered throughout the area in each province and has not been used as a source of energy at a power plant, even still wasted as waste that pollute the environment. According to the results of previous studies, Indonesia has a huge potential of RH which is about 13.294×106 tons, 13.151 ×106 tons, 13.809×106 tons in 2010, 2011, 2013, with approximately 51,696 GWh, 51,144 GWh, 53,702 GWh of potential energy, respectively [2].

This potential can be used as fuel in power plants as well as the results of a study in Thailand [3] and in India [4]. This study was conducted to obtain a model characteristic combustion of RH as an alternative fuel in a power plant in Indonesia. Modeling results are expected to contribute to the policy makers and the competent authorities on the use of RH as a source of electrical energy in Indonesia.

Materials and Methods Modeling is done by using RH composition test results, ie calorific value, proximate and ultimate analysis. Proximate and ultimate analysis carried out in the Laboratory of Mineral and Coal Technology, Bandung, Indonesia. Proximate analysis was carried out under the standard procedure ASTM D 3172 - 3175 and ISO 565, while the ultimate analysis was performed under the standard procedure ASTM D 3176, ASTM D 4239, and ASTM D 5373. Testing the calorific value of RH was based on the standard procedure of ASTM D.5865 using bomb calorimeter.

This method is in line with previous studies [5-6]. Autodesk Mechanical Desktop software is used for the manufacture of furnace geometry, mashing done with Gambit software, and modeling the combustion characteristics of RH done using Ansys - Fluent software. Boundary condition is determined based on the results of several previous studies [7-11].

Results and Discussion Geometry Model of Furnace and Boundary Condition Geometry models of furnaces are used for small power plants ie 7.5×5.7×12 m, is presented in Fig. 1. Boundary condition, namely: fuel feed rate = 6575 kg/h at 298 K, the overall air/fuel stoichiometric ratio = 0.84, primary air = 6 kg/s at 453 K, secondary air 1 and secondary air 2 = 3.2 kg/s at T = 453 K.

Geometry of the furnace and the type of boundary condition used are: velocity inlet, mass flow inlet, wall and outflow. Meshing is made with a quad element, pave type, interval size, spacing about 0.05. Total mesh about 28,875 nodes and 28,434 elements to generate proper combustion models. Fig. 1.

Geometry of grate bed furnace Combustion Characteristics Modeling of Rice Husk. Input data used for modeling the combustion characteristics of RH that data from experiments, as presented in Table 1. Table 1. Proximate and ultimate analysis of RH.

Calori- fic value (kJ/kg) _Fixed Carbon (%) _Volatile matter (%) _Moisture content (%) _Carbon (%) _Hydro- gen (%) _Oxygen (%) _Nitro- gen (%) _Sulfur (%) _Ash (%) _ _13442 _14.81 _55.62 _10.46 _39.28 _5.08 _35.81 _0.64 _0.08 _19.11 _ _ The results of modeling the combustion characteristics of RH on the grate bed that converts solid to a gas and composition of the resulting gas flow out of the top of the bed as a function of distance along the grate, as in Fig. 2. / Fig. 2. Characteristic of gas temperature on grate bed. In Fig.

2, the maximum gas temperature about 1680 K and an average temperature in the furnace is about 1190 K. Maximum velocity of the gas is obtained around 184 cm/s, solid gasification efficiency around 99.8%, the total energy in the waste feed = 24.55 MWt, and heat recovery from the waste efficiency = 58.41%. Combustion characteristics of RH in the bed began to burn at a distance of 0.4

m and a perfect burn up at a distance of approximately 5 m from the fuel inlet. The over-bed, temperature distribution is very uneven due to the gases do not burn completely. This characteristic has similarities with the characteristics model of the previous studies [12], although there are differences in the value of each variable for different input data. (a) (b) Fig. 3. Profile combustion gases at the top bed (a) and bed height integral (b). Fig.

3 (a), shows the characteristics of the combustion gases, ie CO_2, CO, H_2O, and O_2 at the bed top fluctuating starting early of combustion at a distance of 0.7 m to 2.3 m from the fuel inlet. In these conditions the CO_2, CO, H_2O, highly fluctuates due to uneven burning. At a distance of 2.3 m, H_2O becomes zero, which means all the water content in RH turned into a gas phase.

While CO_2 and CO begins to decrease until it reaches zero point at a distance of 4.66 m. These conditions indicate that the combustion of rice husk has been completed so that the CO_2, CO, and H_2O to zero. While O_2 quickly dropped from 21% to zero% start distance of 0.8 m to 3.8 m from the fuel inlet, which means combustion of rice husk takes place in the area.

At a distance of 4.66 m, oxygen immediately increase dramatically to 21%, which means that the fuel combustion process has ended. In Fig. 3 (b), mass loss rate, volatile release, moisture evaporation, char burning rate fluctuation start at a distance of 0.4 m to 2.3 m from the fuel inlet. In these conditions, the volatile releases drastic decline until it reaches zero, while the mass loss rate reaches zero at a distance of 4.66 m from the fuel inlet.

Moisture evaporation reaches zero at a distance of 1.87 m, while the char burning rate reaches zero at a distance of 4.66 m from the fuel inlet. The process of RH combustion in the grate bed takes place at a distance of 0.4 m to 4.66 m. Where, at a point 4.66 m all combustion characteristic variables reaches zero, unless the O_2 back to normal at 21%.

These conditions indicate there is no longer the burning process and the final residual carbon in the solid reaches about 0.768% (mass). Combustion characteristics of RH models have characteristics in common with the model results of previous studies [12-14], although the value of each variable is different due to differences in input data and combustion conditions. Static Temperature CO CO_2 H_2O Fig . 4.

Contour of static temperature (K), CO (vol%), CO_2 (vol%), H_2O (vol%) In Fig 4, shows the characteristics of the gas temperature and combustion gases in the furnace bed. Gases from the combustion in the grate bed, burned again in the furnace chamber by adding secondary air to produce combustion of gases completely before exiting the furnace. Maximum combustion temperature at the base of the furnace about 1600 K and the furnace exit around 967 K, O_2 in the furnace base approximately 14.7%, and at the time of exit around 2.1%. CO maximum of about 26% on a small section at the bottom of the furnace, and the furnace came out around 1.3%.

Maximum CO_2 around 22.5% on the basis of the furnace, and the furnace came out around 5.6%, while the maximum H_2O approximately 20.2% on the basis of the furnace, and outgoing around 1.01%. Summary Combustion characteristics of RH in the bed showed that RH begins to burn after a distance of 0.4 m and the complete combustion occurs at a distance of about 0.7 m to about 5 m from the fuel inlet.

Modeling results showed a maximum gas temperature of about 1600 K at the grate bed. Tempertatur, CO_2, CO, and H_2O fluctuate during the combustion process up to a distance of 4.66 m from the fuel inlet. Maximum combustion temperature at the base of the furnace is about 1600 K and the furnace exit around 967 K.

Temperature distributions in the grate bed and the furnace is uneven due to incomplete combustion of the gas and improper overall air/fuel stoichiometric ratio. Combustion gases in the furnace, ie CO_2, CO, H_2O fluctuate on the basic of the furnace, the furnace chamber, and the furnace exit. Model of the combustion characteristics of rice husk showed the feasibility of using rice husk as fuel for power plants.

Acknowledgment The authors are grateful to the Ministry of Higher Education Malaysia for the RU Grant, Vot 05H25 and Research Management Centre, UTM for the financial and management support. References PT PLN - Persero, Power Supply Business Plan PT PLN (Persero) 2010-2019, Indonesia, 2010. Anshar, M., A.S. Kader, and Farid Nasir Ani, The Utilization Potential of Rice Husk as an Alternative Energy Source for Power Plants in Indonesia.

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