ICREASED ENERGY

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Increased Energy Content of Rice Husk through Torrefaction to Produce Quality Solid Fuel

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Abstract. Energy is the main need of humans to carry out activities with better levels of life. At present, energy for daily life is provided from the processing of crude oil. The availability of crude oil in Indonesia is increasingly limited and the price tends to be expensive. This condition requires alternative energy for fuel availability for households. One alternative energy comes from biomass because biomass is a renewable energy and Indonesia has a very large amount of biomass. Utilization of biomass as an alternative energy source has some limitation due to the non-uniform biomass quality and scattered biomass sources. Due to the lack of biomass quality, biomass needs to be pre-treatment before being used for combustion or gasification process. One of biomass pre-treatment to improve the quality of biomass is torrefaction. Torrefaction is a mild pyrolysis at a temperature between 200-300^{o}C to eliminate water content and a small amount of volatile matter from biomass. The torrefaction biomass will have high energy density and hydrophobic properties. Rice husk is one type of biomass produced from rice processing as waste. Indonesia has large amounts of rice husk waste with an energy potential equal to 7000 MW and is located in a rice mill. In this experiment, the energy content of the torrefaction rice husk was analyzed by observing the effect torrefaction temperature (200, 250 and 300^{o}C) and duration of torrefaction (30, 45 and 60 minutes). At the high temperature of torrefaction (300^{o}C), the rice husk has a darker color with high energy content (3465 kkal/kg) but almost 50 % of initial mass loss by torrefaction.

INTRODUCTION

Energy is a basic need for humans to carry out life activities. Currently, this energy mainly comes from non-renewable fossil energy such as oil, natural gas and coal. With the limited availability of fossil energy sources, it is necessary to diversify energy from other renewable sources. One source of energy that has the potential to be utilized is rice husk produced from rice processing. Indonesia has a large amount of rice husks and has not been optimally utilized so that this condition needs to be a challenge for the utilization of rice husks as environmentally friendly energy. Every 1 ton of rice will produce 23% by weight of rice husk [1].

Rice husk has a low energy content, high water content and high ash content so that direct use as energy faces obstacles. The constraints that are often encountered in the use of rice husk directly as energy is stickiness of rice husks because of the high water content. This condition causes disruption of the flow of rice husk down to be used in the combustion or gasification process. In addition, rice husks are scattered in locations of rice mills and have not been utilized optimally. Thus, it is necessary to carry out the initial processing stages of the rice husk so that the rice husk has high energy content and low water content. Optimization of rice husks will help the government in energy security because rice husks are generally located in areas that are difficult to reach by fossil fuel energy sources.

Torrefaction is pre-treatment biomass processing technology including rice husks through a thermal process -free oxygen at low temperatures of around 200-300^{o}C. The characteristics of biomass from the torrefaction process will change as water content decreases, oxygen content decreases, hemicellulose content will decrease, the nature of biomass becomes difficult to absorb water, energy content increases. Under these conditions, the biomass from the torrefaction process has properties close to coal [2]. The quality of the rice husk from the torrefaction results is greatly influenced by the temperature of the torrefaction reactor and the duration of the torrefaction process [3,4].

The principle of torrefaction was the same as pyrolysis, the difference was in the temperature range so that the torrefaction was called light pyrolysis. Biomass which has undergone a torrefaction process will have beneficial physical properties. First, the low water content, the lower the water content, the biomass raw material transportation

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process will become more economical. Second, lower smoke emissions, which can reduce air pollution. Third, the increase in heating value, which can improve the quality of fuel. Finally, biomass products from torrefaction can be used in a variety of applications such as cooking fuel, raw material for making pellet fuels, as reducing agents in the steel smelting process, making charcoal or activated carbon, gasification, and as additional fuel in boilers [5]. In addition, biomass products from torrefaction will be easier to reduce in size because hard walls of biomass have undergone hemicellulose depolymerization during the torrefaction [6].

MATERIAL AND METHODS

Materials

Rice husk was used as a raw material for biomass torrefaction. The rice husk was obtained from one of the rice mills in the Cilegon. LPG was used as fuel for the torrefaction process. Scales to weigh the mass of rice husk as raw material and torrefaction products. Thermocouple was used to measure the torrefaction temperature (200, 250 and 300oC) and the stopwatch was used to determine the duration of torrrefaction holding time (30, 40 and 60 minutes)
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Methods

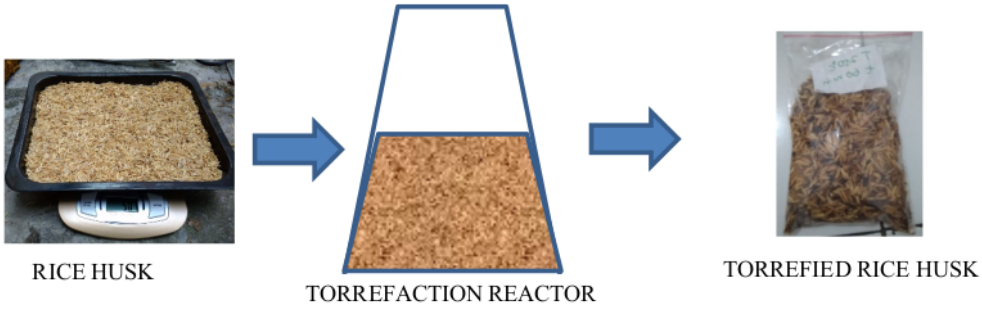

FIGURE 1. Schematic diagram of rice husk torrefaction

Rice husk was dried in the sun for 6-8 hours and the dry rice husk was checked the content by proximate analysis. Then 500 grams of dry rice husk were put into the torrefaction reactor. Furthermore, the rice husk in the torrefaction reactor was heated with a small heating rate of 30°C / minute. When the target temperature (200, 250 and 300°C) was reached then the temperature was held during 30, 45 and 60 minutes. The next process was cooling the reactor until room temperature. The decomposed rice husk product was removed from the torrefaction reactor. The torrefied rice husk was weighed to obtain the mass of rice husk for checking the mass loss of rice husk during torrefaction. The torrefied rice husks were analyzed as proximate to get the moisture content, volatile matter, fixed carbon and ash by Thermal Gravimetric Analysis (TGA). Rice husk torrefaction products in this experiment were observed visually for the color changes of rice husks based on the temperature and holding time of the torrefaction process.

RESULTS AND DISCUSSION

In the torrefaction proces, the color of material will change from light to dark because the increasing fixed carbon content with the loss of the volatile matter component biomass. At 200°C, the color of the rice husk torrefaction product was still close to the initial condition with the majority still yellowish (Fig 2) because only moisture content was removed from the rice husk at that temperature. Then, the color changed to brown during increasing the torrefaction temperature (250°C) because some of volatile matter was removed from inside of rice husk and the fixed

carbon content increase during torrefaction at this temperature. Some of rice husk product of torrefaction was change to the dark color at the 300°C because fixed carbon of rice husk torrefaction product was increase more

FIGURE 2. Color changes in the torrefaction of the torrefaction process with temperatures of 200, 250 and 300°C and 45 minutes holding time.

The proximate analysis was shown in the moisture content, volatile matter and calorific value (Fig 3-4). Moisture content of rice husk torrrefaction product was low at the high temperature and long holding time (Fig 3) because most of moisture was removed from inside of the rice husk during torrefaction at the high temperature and long holding time. The initial moisture content of rice husk was around 9.6% and drops until 5% at 300°C and a holding time of 60 minutes. The rice husk torrefaction was very effective to remove moisture content with the majority in the form of surface and inherent moisture. Moisture content of biomass will disturb the combustion process because the moisture will make rice husk sticky and difficult to burn. With a low water content, the rice husk torrefaction product was very suitable for the combustion process.

The torrefaction process also removes the volatile matter content in the pores of rice husks. At temperature 200°C, the volatile matter was relatively stable at around 55% for all torrefaction holding time 30, 45 and 60 minutes. The increasing torrefaction temperature (250°C) showed a decrease in the volatile matter below 55% (Fig 4). The loss of the volatile matter was due to the opening of the pores on the surface of the rice husk after removing the surface moisture and part of the inherent moisture. At a higher temperature (300°C), more volatile matter was lost until 35% (Fig.4). The low volatile matter at a temperature of 300°C and the holding time of 60 minutes would result low energy content of rice husk torrefaction product because some of the lost volatile matter were predicted combustible gas (CO, H_2 and CH_4).

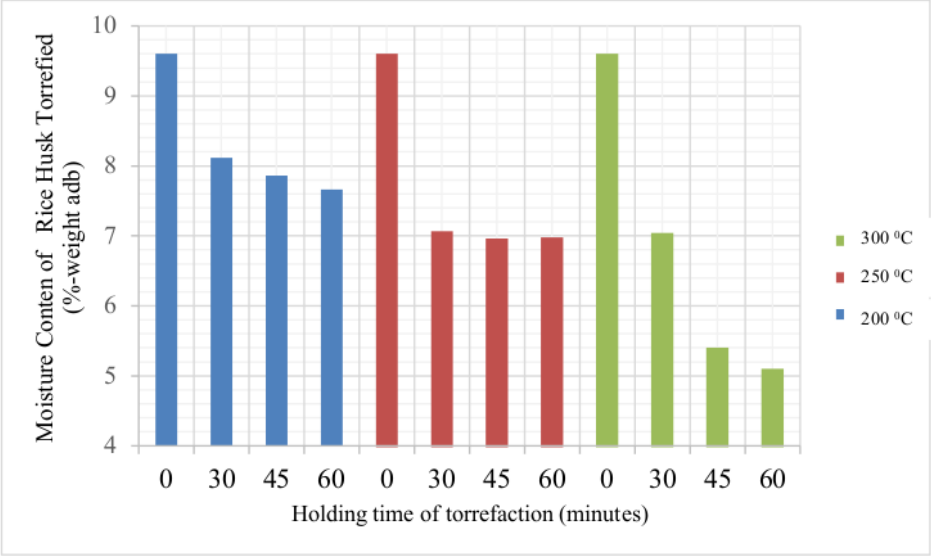

FIGURE 3. Influence of torrefaction temperature and holding time to the moisture content of the rice husk torrefied

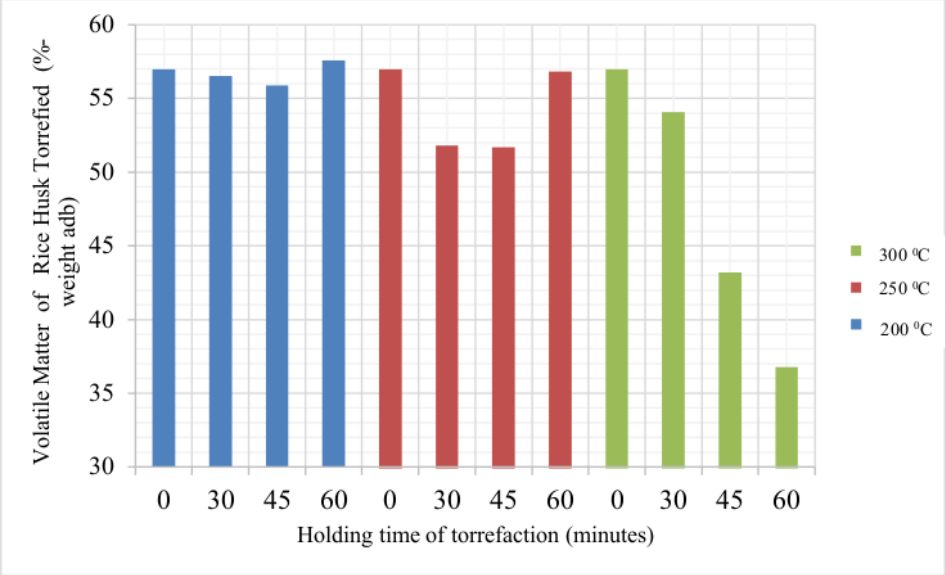

FIGURE 4. Influence of torrefaction temperature and holding time to the volatile matter of the rice husk torrefied

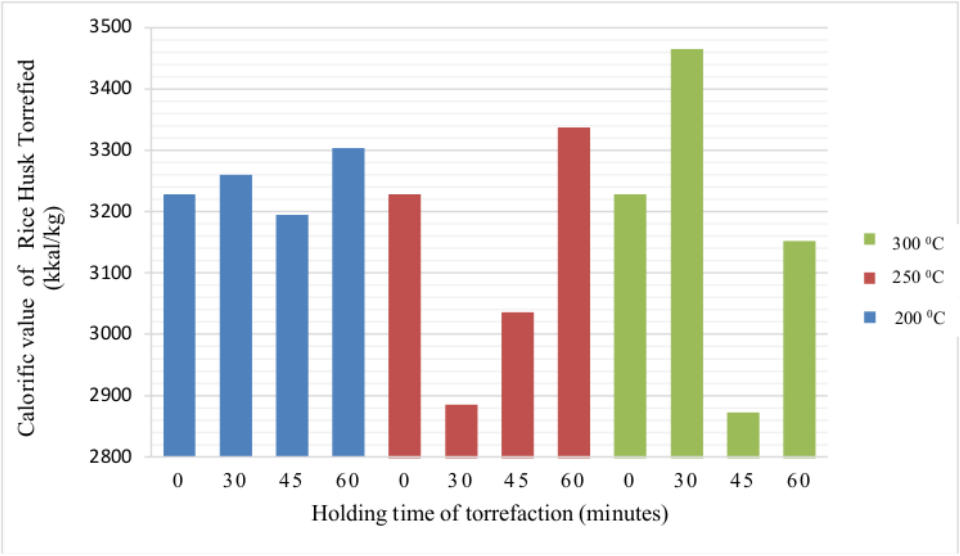

FIGURE 5. Influence of torrefaction temperature and holding time to the calorific value of the rice husk torrefied

The energy content of the torrefaction rice husk was shown in Figure 5. At temperature of 200°C with various holding time, the energy content was relatively stable because only the water content was lost. The energy content of the rice husk torrefaction product would change at temperatures of 250 and 300°C (Fig 5), because some volatile matter was lost due to more heat entering the pores of rice husks. The rice husk torrefaction product at high temperatures and longer holding times (45 and 60 minutes) has lower energy content than the 30 minutes holding time (Fig 5) because the long holding time will remove more combustible gas of volatile matter due to the structure of rice husk. The highest energy content of rice husk torrified was at 300°C and 30 minutes of holding time but the mass yield decreased until left 63 % (Table 1). From volatile matter and energy content, the rice husk torrified at 200 and 250°C was for the pyrolysis and gasification due to the high volatile matter. Then, the torrefaction rice husk products at a temperature of 300°C were used in combustion rice husks because the volatile matter began to fall and resulted in a high fixed carbon content (Table 1).

TABLE 1. Fixed carbon, calorific value and mass yield of rice husk torrefaction

Torrefaction Operation Condition		Fixed Carbon (%)	Calorific Value (kkal/kg)	Mass Yield (%)
Temperature (°C)	Holding Time (minutes)			
200	30	13,75	3260	87
	45	13,54	3195	84
	60	13,8	3304	79
250	30	11,46	2885	81
	45	13,02	3036	73
	60	14,4	3337	65
300	30	16,52	3465	63
	45	14,32	2872	49
	60	20	3152	51

CONCLUSIONS

Temperature and holding time of the torrefaction process will change the color of the torrefaction rice husk products. The loss of water content and volatile matter will affect the fixed carbon content and energy content of the rice husk torrefied. High temperature of torrefaction resulted high energy content and high mass loss of rice husk.

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