Experimental Studey on Fuel Production with the Use of Sewage Sludge

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***Abstract*- The present study is to produce the high calorific fuel using sewage sludge. Consideration is given to the effects of implication water rate of sewage sludge, temperature, and vacuum pressure on the optimum production condition and the high calorific fuel. In order to reduce the initial moisture content of sewage sludge, the vacuum drying method which is modified here is employed. It is found from the study that the lower implication water rate causes the higher caloric fuel and the maximum calorific value developed here is similar to that of woody pellet for reference. This application will accelerate the reuse and reduce of sewage sludge.**

Keywords*- *Biomass; Sewage Sludge;High Calorific Fuel; Decompression; Moisture

I. INTRODUCTION

Recently, the world faces the high cost of energy which is marked and affected by the fluctuation of world oil price. Although its price becomes stable, an upward trend will surely occur in the near future. In addition, the imbalance between supply and demand also results in the leap of price. In order to reduce the impact, several countries begin to increase the utilization of renewable energy to meet their needs for energy. One of the most important renewable energy sources in the world is biomass. During recent decades, the utilization of biomass has a sufficiently drastic increase. This is because (i) the availability of biomass is unlimited, if its regenerative process runs well, and (ii) the extraction of biomass energy can be carried out more flexibly, (iii) the biomass can be burnt directly without high technology. Biomass energy is more environment-friendly compared with the fossil fuel. Since the emission of CO_2 released by biomass into atmosphere is absorbed through a photosynthesis process, it is referred to as the carbon neutral. In other words, the excessive accumulation of carbon dioxide in atmosphere will not decrease [1].

In several countries such as Indonesia, the development of Jatropha curcas takes place as an energy plant for reducing dependence on the fossil fuel. The National Indonesian Bio-fuel Team [2] reports that Indonesia had projected the areas of 1.5 millions hectares for Jatropha curcas plant in 2010. Then, in 2015 the increase will occur two times reaching 3 million hectares. The cultivation of Jatropha curcas as a plant for energy in Indonesia is underlain by the fact that the Jatropha curcas is a plant that can grow on marginal soils. Several other countries, i.e., Mexico, Thailand [3], Nicaragua [4], and India [5] also develop Jatropha curcas. Most of researchers study a conversion from Jatropha curcas into a biodiesel [5-8], while several literatures do on Jatropha solid waste such as cake seeds (seed husk), sludge, shells like activated carbon [9], seed husk open core gasification [10], the fixed bed pyrolisis of physical nut waste [11], Jatropha curcas part for energy [12]. The cake seeds of Jatropha curcas are outcomes of waste from the processing of Crude Jatropha Oil (CJO) potential to a development as a solid fuel. As reported by Openshaw [3], Banerji et al. [7], and Sricharoenchaikul et al. [11], the content of cake seeds in the Jatropha curcas reaches 61% - 67% per unit of weight. In other words, the cake seed, i.e., waste material is not utilized.

Meanwhile, sewage sludge refers to the solids separated during the treatment of municipal wastewater. Biosolids refers to treated sewage sludge that meets the pollutant and pathogen requirements for land application and surface disposal. Present options for biosolids management mainly consist of land application, landfilling and incineration or co-combustion. Incineration as a competitive treatment option for biosolids management is reported in several recent studies [13-18]. In particular, co-combustion of sewage sludge with coal was reported by Otero et. al. [19]. When the weight percentage of sludge in the blend was less than 10%, the effects on the combustion of coal were noticeable. The similar study was carried out by Spliethoff et. al. [20] who tested sewage sludge, wood and straw cocombustion with coal. Roy et al [21] investigated the use of biosolids for co-combustion with wood pellets, because co-combustion of biosolids with coal is a cost-effective option. To the author’s knowledge, there is no information on the utilization of only waste materials for using them as a fuel, but there is a few information on co-combustion technology for using waste materials as fuel, as mentioned previously.

The aim of the present study is to produce a high calorific fuel using sewage sludge (i.e., waste material). Consideration is given the effects of implication water rate of sewage sludge, temperature, and vacuum pressure on the optimum production condition of the high calorific fuel.

II. EXPERIMENTAL APPRATUS AND EXPERIMENTAL METHOD

Figure 1 depicts a schematic of the experimental apparatus which consists of a decompression device (i.e., circulating aspirator), test flask (i.e., beaker), tank (i.e., thermostatic bath), heater, and controller. Implication water rate of sewage sludge is measured using implication water rate device. The caloric rate of the fuel, which is produced using the experimental apparatus, is estimated by the Calorie measurement device (Shimazu.co, CA-4AJ). At the same time, the corresponding moisture is measured using the moisture analyzer (A&D.co, MF50).

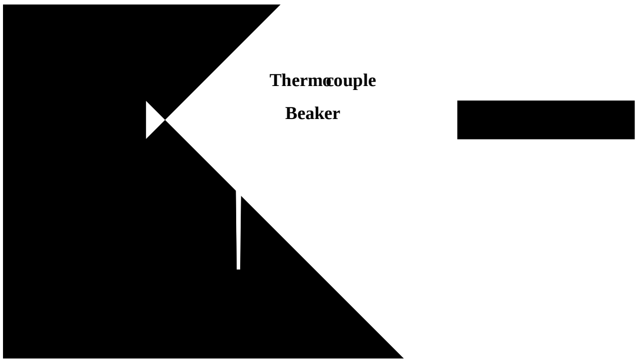

Fig. 1 Experimental apparatus

The sample material produced in this study is shown in Figure 2. The water bath temperature is maintained at 60^{o}C, 70^{o}C and 80^{o}C to obtain the optimum condition. Prior to the main process, initial mass of waste is measured before entering into a beaker. Here, the optimum condition implies that lower moisture content is obtained by low power input including water bath and decompression device.

Fig. 2 Sample of produced fuel

Thermostatic bath and circulating aspirator are operated with the use of the DC power supply (TOKYO SEIDEN CVS1-5K) and its voltage is adjustable with the aid of the voltmeter (YOKOGAWA 2011). The thermostatic bath is surrounded by a thick thermal insulation material to suppress heat loss from the bath.

III. RESULT AND DISCUSSION

The fuel produced here is illustrated in Figure 3 in the form of the calorific value versus the implication water rate, i.e., moisture content. Here, initial moisture content of waste material is 85%. One observes that the calorific value is increased with a decrease with the implication water rate, as expected. In other words, low calorific value of initial waste material is caused by larger water content in waste material. Note that (i) since the initial implication rate of the sewage sludge is 85%, a reduction of the implication water is achieved by the electric energy supplied and (ii) the maximum calorific value produced here is similar to that of woody pellet.

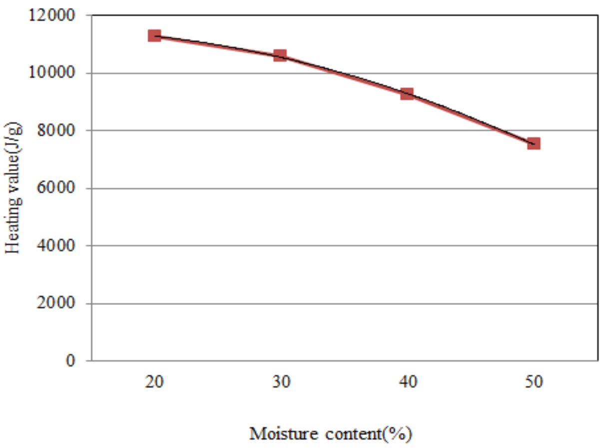

Fig. 3 Relationship of calorific value versus moisture content for each fuel produced

As mentioned previously, lower implication water rate, i.e., high caloric fuel is produced by the electric energy supplied. In order to effectively make higher caloric fuel by lower input power, the optimum operating condition is needed. Figure 4 depicts the relationship between energy efficiency and moisture content. Here energy efficiency is defined as the calorie of the production fuel divided by both the total electric power supplied and the initial mass of waste material. One observes that as the moisture content is decreased, the energy efficiency increases and achieves the maximum at 40% and its value is gradually attenuated. This is because in higher moisture content region of the waste material, lower electric energy supply is needed to reduce moisture content, but lower caloric fuel is produced. In the lower moisture content region of the waste material, higher caloric fuel is produced and at the same time, larger electric power energy supply is substantially consumed, resulting in the lower energy efficiency. Here, larger electric power energy supply implies that water bath and decompression device operate in rating for a long time.

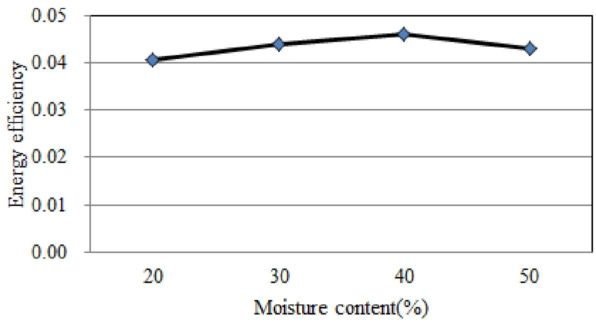

Fig. 4 Energy efficiency for each moisture content of waste material

In general, the moisture content of the fuel produced here is affected by the bath temperature and the decompression of the beaker including sewage sludge. Figure 5 illustrates the effect of bath temperature on the energy efficiency under the decompression condition of 0.1 MPa in test flask. One observes that as the bath temperature is increased, the energy efficiency is amplified. In other words, the higher calorific fuel is produced by the lower supply electric power with an increase in bath temperature. This is because at the lower temperature bath, the consumption electric power energy supply becomes larger due to the long operating time to attenuate the moisture content of sewage sludge.

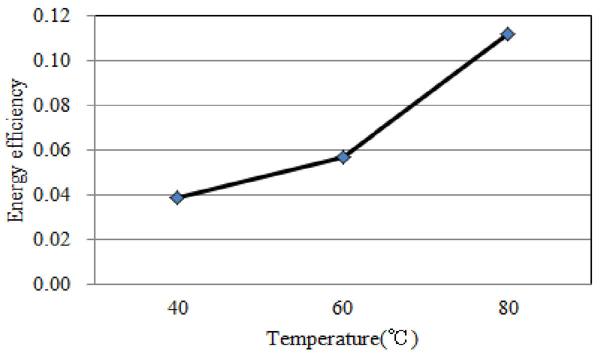

Fig. 5 Effect of bath temperature on energy efficiency

The effect of decompression in the beaker on the energy efficiency is shown in Figure 6 in the form of the dimensionless energy versus decompression. Note that a value of decompression means reduction level from the atmospheric pressure that is 0.1 MPa of decompression is almost 0 Pa for the absolute pressure. In the figure, the result is obtained at the bath temperatures of 80^{o}C. It is observed that the energy efficiency is increased with an increase in the decompression. This is because at higher decompression value, the evaporation of moisture in sewage sladge is induced, resulting in short operating time.

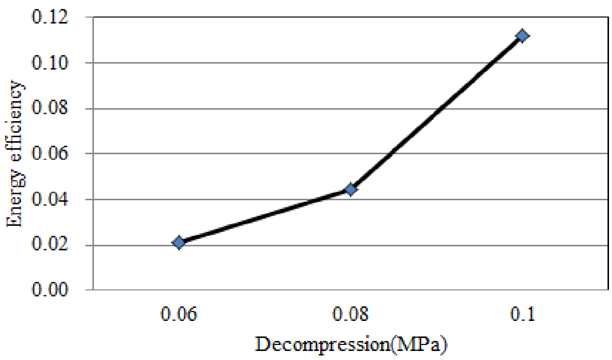

Fig. 6 Effect of decompression of beaker on energy efficiency

IV. SUMMARY

Experimental study has been performed to produce the high calorific fuel using sewage sludge. Consideration is given the effects of implication water rate of sewage sludge, temperature, and vacuum pressure implication water rate of sewage sludge, temperature, and vacuum pressure on the optimum production condition and the high calorific fuel. The results are summarized as follows:

(i) The lower implication water rate causes the higher caloric fuel.

(ii) The ratio of the combustion energy of the produced fuel to the consumption energy is intensified with an increase in the bath temperature.

(iii) If the bath temperature is fixed, the energy efficiency is increased with an increase in the decompression.

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