Experimental Study on High Caloric Fuel Production with the Use of Sewage Sludge and Discarded Oil

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***Abstract*-The present study is to produce the high calorific fuel using sewage sludge and discarded oil. Consideration was given to the effects of volume fraction of sewage sludge and discarded oil 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 was modified and employed. It was found from the study that lower implication water rate causes higher caloric fuel. The maximum calorific value developed is similar to that of coal for reference. This application will accelerate the reuse and reduce of sewage sludge and discarded oil.**

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 oil price. Although the oil price becomes stable, an upward trend will surely occur in the near future. In addition, the imbalance between supply and demand is intensified, resulting in the leap of price. In order to reduce the impact, several countries began to increase the utilization of renewable energy to meet their need for energy. One of the most important renewable energy sources in the world is biomass. During recent decades, the utilization of biomass had a sufficiently drastic increase. This is because (i) the availability of biomass is unlimited, if biomass can effectively replace the huge quantity of fossil fuel burned every day, (ii) the extraction of biomass energy can be carried out more flexibly, and (iii) biomass can be directly burned without high technology. Biomass energy is more environment-friendly compared with fossil fuel. Since the emission of CO2 released by biomass into atmosphere is absorbed through a photosynthesis process, it is referred to as carbon neutral. In other worlds, the excessive accumulation of carbon dioxide in atmosphere will not decrease [1]. Notice that new biomass should be produced, when the clearing of the jungle is contributing very much to the CO2 emission as the forest is being burned and less productive plant are grown.

In several countries such as Indonesia, the development of Jatropha curcas as an energy plant is taking place for reducing dependence on the fossil fuel. The National Indonesian Bio-fuel Team [2] reported that Indonesia will project the areas of 1.5 millions hectare for Jatropha curcas plant in 2010. Then, in 2015 the increase will increase by two times, reaching 3 million hectares. The cultivation of Jatropha curcas as a plant for energy in Indonesia is underlain by the fact that Jatropha curcas is a plant that can be grown on marginal soils. Several other countries such as Mexico, Thailand [3], Nicaragua [4], and India [5] also develop Jatropha curcas. Most researchers study the 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], and Jatropha curcas part [12]. The cake seeds of Jatropha curcas are waste from the processing of Jatropha curcas plant to produce Crude Jatropha Oil (CJO) and have the potential as a solid fuel. As reported by Openshaw [3], Banerji et al. [7], and Sricharoenchaikul et al. [11], the content of cake seeds in Jatropha curcas reaches 61% - 67% per unit of weight. In other words, the cake seed, i.e., waste material, are not utilized. To the authors' knowledge, there is no information on the utilization of waste materials as a fuel.

Meanwhile, waste oil includes used crankcase oils from automobiles and trucks, used industrial lubricating oils (such as metal working oils), and other used industrial oils (such as heat transfer fluids). When discarded, these oils become waste oils due to a breakdown of physical properties and contamination. Different types of waste oils may be burned as mixtures or as single fuels where supplies allow. Waste, or used, oil can be burned in a variety of combustion systems, but containing over certain levels of metals, it cannot be recycled in some countries.

The aim of the present study is to produce high calorific fuel using sewage sludge (i.e., waste material) and discarded oil. Consideration was given to the effects of volume fraction of sewage sludge and discarded oil on the optimum production condition and the high calorific fuel.

II. EXPERIMENTAL APPRATUS AND EXPERIMENTAL METHOD

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

The sample material produced in this study is shown in Fig. 2. Due to the fact that after a mechanic pressure process in oil conversion, the traces of oil in cake seeds will agglutinate the particles of cake seeds, the produced material was agglutinated in a randomized manner. Initial stage conditions of fuels to be produced here are summarized in Table 1. The temperature of pyrolysis was maintained at 60 ^oC, 70 ^oC and 80 ^oC to obtain the optimum condition. Prior to the process, initial mass of waste was made the same before being put into a reactor, i.e. beaker.

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

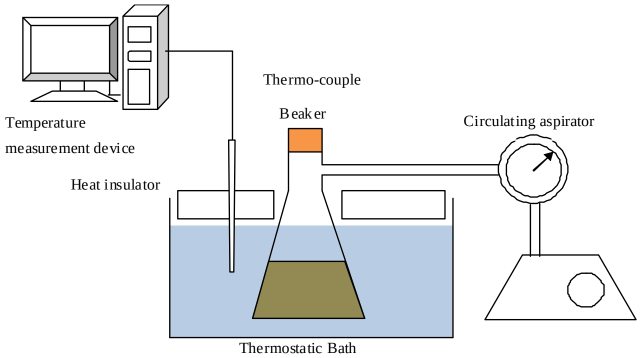

Figure 1 Experimental Apparatus

Figure 2 Sample of produced fuel

TABLE 1 CHARACTERISTICS OF PRODUCED FUELS

Type	Mixing ratio (Sewage sludge : Heavy oil)	Water content (Mixture)
A	3.0 : 1.0	50.6%
B	3.1 : 1.0	50.7%

III. RESULT AND DISCUSSION

The fuel produced here is illustrated in Fig. 3 in the form of the calorific value versus the implication water rate, i.e., moisture content. Here, symbols of Type A and Type B, for initial water content of 85%, correspond to 3.0:1 and 3.1:1, respectively, based on the ratio of sewage sludge and discarded oil. It was observed that the calorific value is increased with a decrease with the increase in water percentage, as expected. Note that (i) since the initial water content of the sewage sludge was 85%, lower water content was achieved by electric energy supply and (ii) the slightly high calorific value yields for Type A was because that the corresponding oil ratio was slightly higher. In other words, the low water content caused the higher caloric fuel. The maximum calorific value developed here was similar to that of coal for reference.

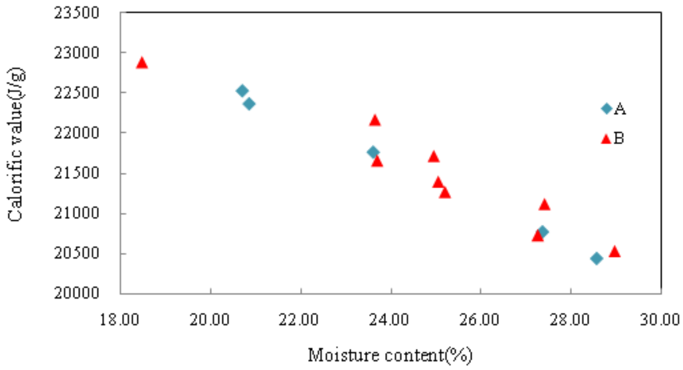

Figure 3 Relationship of calorific value versus moisture content

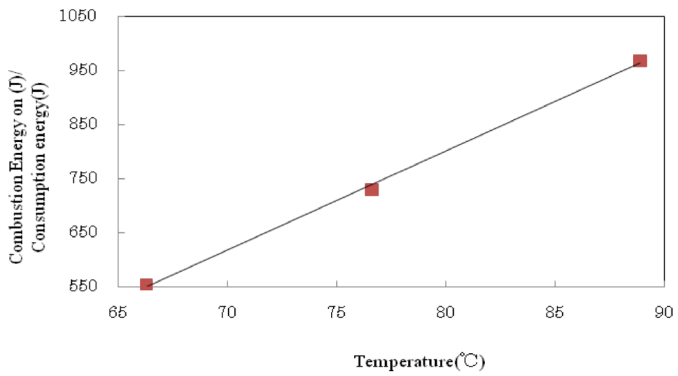

Figure 4 Effect of bath temperature on energy efficiency

In general, the moisture content of the fuel produced here was affected by the bath temperature and the decompression of the beaker, which contains sewage sludge and discarded oil. Fig. 4 illustrates the effect of bath temperature on the energy efficiency. Here, the energy efficiency implies the ratio of the combustion energy of the produced fuel to the consumption energy, i.e. the supplied electric power for operating thermostatic bath and circulating aspirator. It was observed that as the bath temperature increased, the energy efficiency was amplified. In other words, the higher calorific fuel was produced by the lower supply of electric power with an increase in bath temperature. This is because at lower temperature bath, the consumption energy becomes higher due to the long operating time to attenuate the water content of sewage sludge, as seen in Table 2. Here the corresponding final water content is fixed and about 50% (Table 1). Table 2 depicts the summary of operating time, consumption energy, and combustion energy at each bath temperature. It can be concluded that since the water content of the produced fuel is almost the same value as seen in Table 1, the combustion energy is the same under different temperature conditions, as seen in Table 2.

TABLE 2 OPERATING CONDITION AT EACH BATH TEMPERATURE

Temperature (°C)	**65.5**	**74.5**	**85.0**
Power consumption (W)	**287**	**303**	**330**
Operating time (s)	**19000**	**13800**	**9610**
Consumption energy (J)	**1510**	**1160**	**880**
Combustion energy (J)	**839000**	**847000**	**852000**

The effect of decompression in the beaker on the energy efficiency is shown in Fig. 5 in the form of the dimensionless energy versus decompression with the bath temperature as the parameter. In the figure, red and blue symbols depict bath temperatures of

80°C and 70°C, respectively. It was observed that the energy efficiency increased with an increase in the decompression and this trend became larger at higher bath temperature. This is because at higher bath temperature and higher decompression value, the evaporation of moisture in sewage sludge is induced, resulting in shorter operating time.

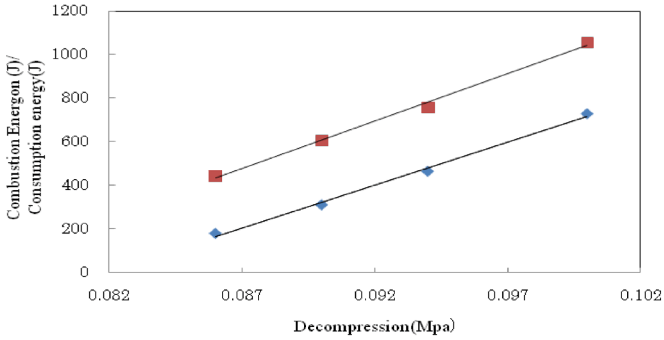

Figure 5 Effect of decompression of beaker on energy efficiency

IV. SUMMARY

Experimental study was performed to produce high calorific fuel using sewage sludge and discarded oil. Consideration was given to the effects of operation condition on the optimum production condition and the high calorific fuel. The results are summarized as follows:

(a) The lower water content caused the higher caloric fuel.

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

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

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