

Municipal Solid Waste Densification as an Alternative Energy

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Abstract

The number of Municipal Solid Waste (MSW) increases as the growth of population enlarges. The MSW collected from communal district and dumped into open area creates problems. On the same time people face equally serious problem on their fuel consumption caused by the policy of government on conversion of kerosene into gas fuel. To solve these problems, an experimental study on MSW conversion into solid fuel or briquette has been conducted. Pressing method is carried out by using a modified piston presser consists of 15 moveable molds. Processes of drying, carbonizing, grinding, binding, and mixing have been done prior to the pressing process. The final step was sun drying process on MSW briquettes for a couple days before utilizing them as energy. Some analysis works have been done, and satisfying results were obtained.

Keywords: Municipal Solid Waste, Densification, Biomass, Briquette

1. Introduction

Wood burning for household fuel in some developing countries is a common sight, as the impact of scarcity and expensive price of kerosene. However it should be banned. Otherwise, deforestation will dramatically increase and removes the submersion of carbon dioxide, makes the global warming worse. Even though gas fuel has being introduced to replace kerosene in Indonesia, there are some hesitation about the safety of gas cylinder and gas pipe.

MSW is generated by activities such as household, traditional market, hospital, office, etc. Conversion of MSW into biogas and fertilizer has been carried on in order to minimize the extent of MSW. But in some developing countries it is still possesses a defect as it commonly left uncollected beside the roads, usually on large scale, therefore, causing health and environmental problems. As published in Suara Pembaruan (2010), in 2000 every people created 1 kg of waste, this weight of waste will increase in 2020 by 2.1 kg. If currently the number of Indonesians is 220 million, this massive waste will be a threat to the environment as well as endangering public health. Moreover, 50 kg methane gas that generated by 1 ton of MSW will deepen the global warming effect.

Based on those realities, Indonesian government encourages people to use alternative energy made from bio-mass or agriculture residue. Generally, all materials consist of carbon can be converted into fuel, this carbon can be found as well in MSW. Raw material of MSW is available everywhere for free, therefore the easiest way to propose an alternative energy is by converting it into briquettes. MSW briquette is one of the important renewable bio-energies based on non-fossil resource.

Many papers of study on densification or briquetting process from residue, biomass, coal, and other samples have been published. According to Grover (1996), rubbish briquetting is a technology to change idle rubbish into useful and valuable energy. The technology is an agglomeration process that can be categorized as densification technology which makes the bulk density of rubbish to be compact and dense. Physical and chemical behavior of raw material has a significant influence of the briquette quality as a fuel. Physical properties such as water content, density, porosity, and thermal characteristics are very important during binding process. And the impacts of chemical properties on briquette are proximate analysis, ultimate analysis and heating value.

Densification of corn cobs has been carried out in order to produce biomass briquette by using a uniaxial piston-cylinder. The effect of particle size, concentration of water, and preheating temperature on briquette's density was observed (Kaliyan, 2010). The similar work also conducted by Singh (2006) who developed eco-fuel briquettes from the mixture of coal and plastic. He claims that eco-fuel is clean, strong and easy to handle, moreover compared to raw coal, eco-fuel is resistant to water and water vapor.

To have more compact and solid briquette and to make it to burn longer, the bounding force should be really strong and this condition can be achieved by mixing process between MSW with binders such as wood ash, fish waste, molasses, corn starch or wheat starch, cement, silicate, tar, and resin (Dahlman, 2001). As viscous binders, tar and other organic liquids create a mixture with a similar bound as solid matter. Adhesive force at interface of solid-liquid and cohesive force between solids will occur during binding process. While Delana (2004) says that briquette quality usually depends on the type of raw material and binder. Siritheeranas (2000) states that not as coal, MSW does not have much volatile matter and sulfur, therefore the addition of CaO on MSW as an absorbent of SO_2 and form calcium sulfate is not necessary. On the other hand, according to Febijanto (2001) the addition of CaO is needed due to avoid micro-organism growth. Young (2003) noted that densification of agriculture residue and bio-mass waste in pellet and cylinder shape most utilize in Europe and North America, and Sweden is a country that produces the biggest briquette and consume approximately 1 million ton of briquette per year. Recently, Poespowati (2007, 2008a, 2008b, 2009) conducted experiments on densification of MSW. She designed and developed a new pressing system. First, she used a very simple single tube manual presser (2007) made from wood and PVC tube. Later in 2008 she improved the presser by using piston system but still consisted of a single tube, and in 2009 she designed and constructed a piston presser with 15 tubes. In 2007, some analysis has been done on the briquette, they were: heating value, ash content, fixed carbon, moisture content, volatile matter, and porosity. While in 2008, the analysis expanded on gas emission from burnt briquette that consists of carbon dioxide oxygen, carbon monoxide, and nitrogen analysis. Later on the drop test analysis has been done on briquette resulted by the latest presser and compared the result with briquettes produced by the former presser.

The benefits of using MSW briquette include it's cleanliness, easy to stock and carry, cheap, does not need any high technology to produce, and efficient for household fuel. In order to reduce the negative environmental impacts of MSW and to support the Indonesian Government encouragement to develop alternative energy, this paper presents a study on densification of MSW.

2. Experimental Methods

MSW material used in this study constitutes of waste from traditional marked that consists of the heterogeneous materials such as waste of fruit, vegetable, paper, plastic, glass, metal, wood, leaf, and other materials. Cassava starch, molasses, and clay were used as binders.

Different with the method developed by Kaliyan (2010) that used a uniaxial piston-cylinder densification apparatus, with a maximum compression pressure of 150 MPa, the method of this paper utilized a 15 tubes piston pressure which the maximum pressure of 500 kg/cm^2 or same as 4 ton if multiplied by the surface area of piston.

The sequences of the experimental method is as follow, first of all, before sun drying, in-organic materials such as plastic, metal, rubber, glass were sorted from MSW. Secondly, dry material was carbonized followed by grinding and screening process. Carbon was mixed well with binder, and the mixture was pressed with the compression pressure was 250 kg/cm^2. Finally briquettes were dried prior drop test analysis which referred to US Patent Number 6013116 (Major, 1998). In this drop test analysis, briquette was dropped from the height of 1 meter onto a rubber mat and measured the weight of briquette both before and after drop test. The number of mass loss must be less than 10%.

As conditions obtained from the former experiment, the particle size of carbon was 60 Mesh, while the ratio of binder and carbon were 1:2, 1:3, and 1:4; and the binders were cassava starch, molasses, and clay. History of temperature profile on time was recorded for every second by using temperature controller (TC-08) with K-type thermocouple that able to record temperature up to 1300^{o}C. Photograph of the presser can be seen in Figure 1 bellows, the number of hole or mold are 15 with 4 cm of diameter, therefore it can be obtained 15 pieces of briquettes in one pressing process, and the pressure force can be set up with a manometer.

3. Results and discussions

In order to have a better method to produce alternative energy, experiments have been conducted on converting MSW into briquettes. The specification of MSW briquettes is tabulated in Table 1, while the figures of MSW briquettes, MSW briquette fire, weight loss characteristics, and history of temperature performance are figured out in Figure 1 to Figure 5. Parameters 1 to 12 in Table 1 were obtained from the former experiments (Poespowati 2007, 2008a, 2008b).

As can be seen from Table 1, all percentage of emission components is acceptable as fuel. Even though heating value of MSW briquette below than heating value of coal briquette and kerosene which are 9000 kcal/liter and 5400 kcal/kg respectively, MSW briquette still appropriate for domestic fuel. Moreover burning life and the burning temperature are suitable for daily household energy.

The presser shown in Figure 1 consists of 15 molds and modified by a moveable lid and mold base. Piston system is applied during pressing process; therefore pressing process does not need much power to produce briquettes.

The uniform shape, color and dimension of MSW briquettes with the fine surface of their edges were figured out in Figure 2. The dimension of briquettes was 3.5 cm of height and 4 cm of diameter. Visually, binder of molasses gave well black color.

It can be seen from Figure 3 the great fire after a while of starting up of ignition process. The flaming of fire can be adjusted by using a small fan. Smokeless fire will obtained when drying process of briquette is perfect, because smoke is generated caused by water content in briquette. Extinguishment process of fire is simply by isolating it from air. Ash as a result of ignition process can be used for other purposes such as fertilizer or absorbent.

Figure 4 indicates the mass loss character after dropping the MSW briquette. All mass loss is much bellow than 10%, in general compared with molasses and clay, starch gives the best result and the lowest mass loss was shown at ratio of binder and carbon by 1:4. It is understandable because cassava starch comprises of adhesive component which able to make mixture as a glue.

As can be seen from Figure 5, temperature profile at the center of fire gives the highest value, followed by the temperature at the distance of 15 and 40 cm from the center of fire. The peak temperature of 1000^{o}C was occurred at around 3000 – 4000 second, and after that temperature gradually decreased and reached at about 300^{o}C at time of nearly 10000 second. The dramatic drop of temperature at fire center between 1000 – 2500 second happened when the probe of thermocouple was removed from the fire center. The duration of burning life depends on the treatment of fire, if forced convection is introduced on it, the burning life will shorter than without forced convection.

4. Conclusions

Conversion of Municipal Solid Waste into alternative solid fuel can be considered as household energy, especially for low income people. Indeed, environmental impact caused by MSW can be minimized, and contribute the effort of forest safety program. Economically, compares with kerosene and coal briquette, MSW briquette able to save about 29 % and 2.56% respectively. Compared with the experiment conducted by Singh (2006) that used mixture of coal and plastic as raw material of briquette, MSW briquette much more reasonable to consider for alternative solid fuel because the raw material consists of renewable organic matter and sulfur free that healthy for human and environment.

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Table 1. Analysis result of MSW briquettes

Parameter	Result
Moisture content	9.84 %
Ash content	5.13 %
Volatile Matter	17 %
Fixed Carbon	63.99 %
Density	1.2 g/cm^3
Heating Value	4954.62 kcal/kg
CO emission	0.06 – 2 %
CO_2 emission	1.63 – 5.75 %
O_2 emission	2.5 – 5.88 %
N_2 emission	78.38 – 84.06 %
Burning life	3 hours (approximately) per 1 kg of briquette
Burning temperature	900 – 1000^{o}C (at the center of fire) 600^{o}C (average temperature)
Texture	Generally fine and smooth, there was no crack at the edge of briquettes
Compactness	Compact
Drop Test	Less than 10% mass losses (strong enough for handling and delivery process)

Figure 1. Photograph of presser

Figure 2. Photograph of MSW briquettes

Figure 3. Photograph of MSW briquette fire

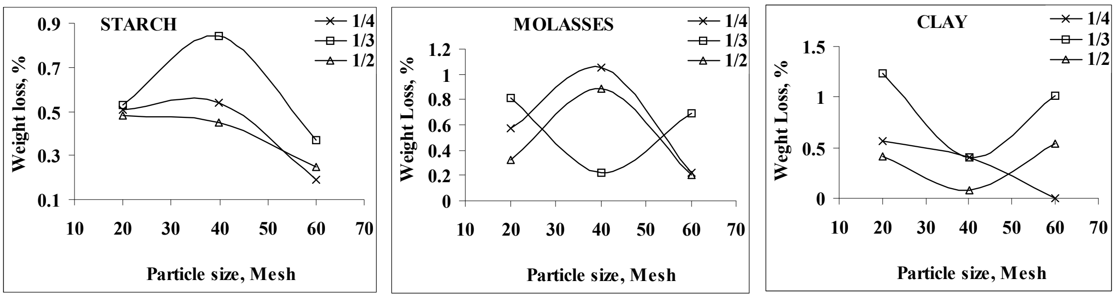

Figure 4. Weight Loss Profiles

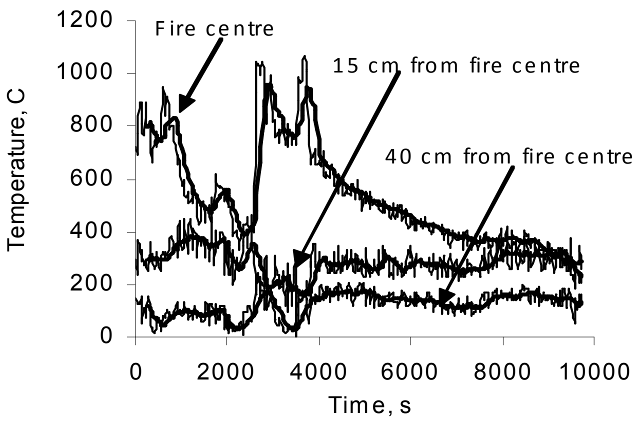

Figure 5. Temperature profiles of MSW fire