The Effect

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Submission date: 15-Jun-2021 11:55AM (UTC+0700)
Submission ID: 1606733932
File name: The_Effect_of_Temperature_on_Characteristics.pdf (9.44M)
Word count: 3125
Character count: 16047

The Effect of Temperature on Characteristics of Wood Pellet

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ABSTRACT

One way to minimize negative impact of wood waste and increase its value, is processing it and convert it into something with higher economic value. One of such products is called wood pellet. This study aims to determine the characteristics of wood pellet made from acacia *(Acacia mangium* Wild*)* and pine (*Pinus merkusii)* woods, namely moisture content, calorie, density, ash content, ignition time and burning time. Firstly the wood waste milled by Hammer Mill machine and screened to 22 and 40 mesh size. The wood mill is then molded in a mould and hot pressed under three different temperatures; 90°C, 110°C and 130°C for 25 minutes and triplicate samples were taken for each temperatures. The results indicate that the temperatures affected the characteristics of wood pellet at different levels to depending on the species of wood samples. Density of acacia wood pellets are 0.83, 0.85 and 0.85 g/cm^3, ash contents are 0.73, 0.73 and 0.74%, moisture contents are 2.97, 2.48, 2.26%, calorie are 18.99, 19.43, and 19.87 MJ/kg, ignition time are 8.14, 7.12 and 4.96 seconds, and burning time are 7.97, 6.43, and 6.38 minutes, respectively. Density of pine wood pellets are 0.83, 0.84 and 0.84 g/cm3, ash contents are 0.76, 0.79, 0.84%, moisture contents are 7.91, 2.05 and 1.47%, calorie values are 17.71, 18.07 and 18.96 MJ/kg, ignition time are 4.19, 3.51 and 2.98 seconds, and burning time are 7.91, 2.05 and 1.47 minutes for each temperature. Wood pellet made from both of acacia and pine woods did not meet wood pellet standard provided by Austria, Sweden and New Zealand.

Keywords : wood pellet, density, ash content, temperature, moisture content

INTRODUCTION

Increasing daily consumption of energy while supply of fossil energy is decrease has causing energy problems that must be faced by all countries, both developed and developing countries. Household sector is the largest consumer of conventional fuels such as fuel, firewood, charcoal and gas (Sartikasari (1995) in Masturin (2002). The source of energy from unrenewable materials very limited in number and a time will run out, so it is necessary to discover of alternative energy sources from renewable materials by diversifying fuel and energy conservation.

One source of energy that has been used by Indonesian society is wood, but in present wood supply decrease, thus the use of wood as fuel has begun to be replaced by other energy sources. Nevertheless wood waste resulted by forest exploitation and wood processing industry is still great potential use as an energy source. It is known that wood waste is organic material formed from carbon compounds such as holocellulose, lignin and carbohydrate compounds, so it could potentially be used as an energy source.

Wood waste resulted by forest exploitation activities is estimated to reach 30% of the total amount of wood harvested. In addition it also has the potential to produce industrial sawmill waste by 50.2% of the raw materials are processed, while the plywood industry has the potential to resulting waste by 60% (Dephut, 1990). Data from the Ministry of Forestry and Plantations for the year 1999/2000 show that Indonesia's plywood production reached 4.61 million m3, while sawn wood reached 2.6 million m3 per year. Assuming that the amount of waste wood that resulted reached 61%, then the wood waste resulted is estimated to reach more than 4 million m^3. Based on the data resulted waste from wood processing industry, if not used properly, it is may leading pollute to the environment. Waste resulted during this generally just stacked on the ground and mostly discharged into the river so it could potentially lead to a narrowing of the flow and siltation of rivers and pollutes the water, and some even burned directly so it would increase emissions of carbon gases in the atmosphere (Pari, 2002).

Thus the utilization of wood waste into a product that has added value should continue to be pursued, in addition to reducing the negative effects of the existence of such waste, as well as to create new revenue sources for the community. One form of wood waste utilization potential to be developed is the wood pellets that can be used as an alternative energy source. The fuel is more easily ignited when compared with conventional wood. The burning of the fuel pellets produce 2000 kg of heat energy equal when compared with 3200 kg of wood burning, 957 m3 of gas, 1,000 liters of diesel, and 1370 liters of fuel oil (Gardner, 2009). In this regard it is necessary to study the characteristics of wood pellets from various types of wood, especially pine and acacia wood pellets according to standard being used in Sweden, New Zealand and Austria.

MATERIALS AND METHODS

Materials used in this study are pine and acacia wood waste. The samples are made of mill by using a hammer mill, then screening and drying until air dry moisture content. The mill screened using a sieve into 22 and 40 mesh size. The mill were used as the sample is a pass 22 mesh sieve and retained on 40 mesh sieve. Samples were weighed to ± 1.5 gram weight and then inserted into each hole of the mould which consists of 9 holes with a diameter of each hole is 0.8 cm and height of the mould is 6 cm. The mould is heated before inserted into the hot press with three different temperatures (90°C, 110°C and 130°C). The temperature measured by a thermometer and then the mould is inserted into the hot press. A buffer of 2 cm height placed between press plates and mould as buffer to the hot press during pressing. Besides that, the buffer also was done to get a pellet length of 2.5 cm. Once the sample is pressed, the sample was allowed to stand for about 20 minutes so that the mill can be bound and then mould removed from the hot press. After that the samples are removed from the mould and triplicate samples were taken for each temperature. Observed variables are the moisture content, density, ash content, ignition time and burning time, and calorific value.

RESULT AND DISCUSSION

Moisture Content

Increasing temperature above 90°C causes moisture content of pellets are decreasing, but temperature above 110°C tend not to reduce moisture content significantly. Increasing of the temperature causes removing the water bounded to the hydroxyl groups of cellulose. Therefore, the higher temperature will cause more water regardless of the hydroxyl groups of cellulose.

This is consistent with the statement of Hill (2006), that wood heating causes decrease of wood hygroscopicity. The amount of reduction in hygroscopicity of wood is dependent on heating time and temperature. In addition, thermal modification of wood causing the wettability of wood also decreases caused by reduced hydroxyl groups. This is influenced by the increasing degree of crystallinity so that the amorphous part of the wood which has a free hydroxyl group decreased. This decline led to decreased ability to absorb moisture content of the wood.

The results of moisture content of acacia and pine wood pellets as can be seen in Figure 1 below:

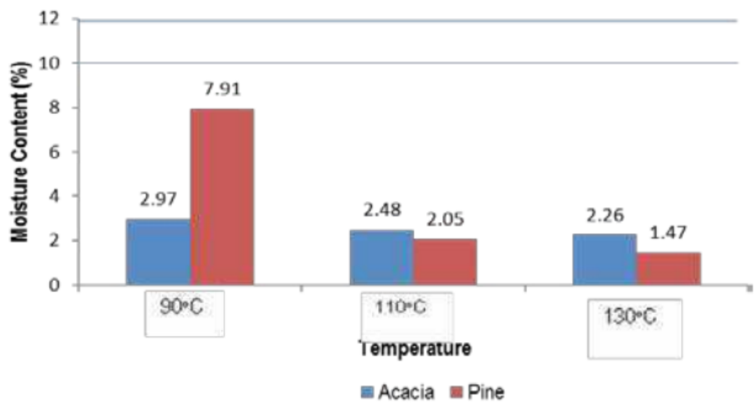

Fig. 1. Mositure Content of Acacia and Pine Wood Pellets

The moisture content of wood pellets greatly affect to the calorific value. The high moisture content will cause a decrease in calorific value. This is caused by the heat stored in the pellet is first used to remove water that existed prior to then resulting heat that can be used as the heat of combustion (Cornburning, 2010). Austria, New Zealand, and Sweden Standard each require a maximum moisture content of 12%, 8%, and 10%. Thus, the moisture content of acacia and pine wood pellets produced from the three different temperatures of 90°C, 110°C and 130°C have met the established standards.

Density of Wood Pellet

Data on the density of acacia and pine wood pellets can be seen in Figure 2 below:

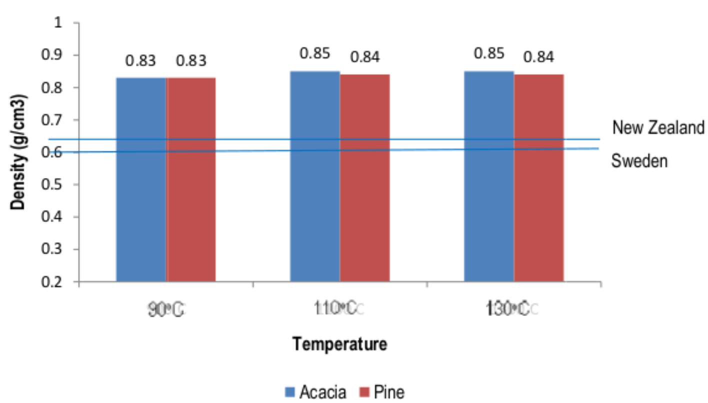

Fig. 2. Density of Acacia and Pine Wood Pellets

Increasing of the temperature resulted moisture content decrease by reduces the hygroscopic properties of wood so that water absorption is decrease. This fact causes the cavities between mill particles more tightly so there is no gap/space between the particles. This is consistent with the statement of Hill (2006), that heating with high temperature will cause broken of the carbon bonds in the lignin structure. Where, when more and more carbon C decomposes, it will cause a high crystallinity so the bonding between lignin structure that would otherwise be tighter and tighter. This proves that the modification of thermal or temperature will increase the density of a compacted mill pellets because it would be able to cover the cavities of the cells compared with solid wood. In addition, the compaction of mills to form a pellet can also remove water and form a stronger bond between the OH group (hydroxyl group) of cellulose and other chemical components.

Materials contained in the wood to form a pellet, consisting of a polymer material (lignin). This material has a function as an adhesive in the process of pressing. Lignin is then extracted and spread to every particle of mill which can bind a single particle with other particles. The fact causes wood mill was became more solid.

Minimum density requirements of New Zealand and Sweden Standards are 641 kg/m^3 (0.641 g/cm^3) and 600 kg/m^3 (0.600 g/cm^3), respectively. The pellets produced in this study on the temperatures of 90°C, 110°C and 130°C are 0.83 g/cm^3 (830 kg/m^3), 0.84 g/cm^3 (840 kg/m^3) and 0.84 g/cm^3 (840 kg/m^3), respectively. Thus, the density of pellets that was produced in this study have met the standards established by the state of New Zealand and Sweden.

Ash Content of Wood Pellets

Study of the percentage ash content of pellets showed as seen in Figure 3 below:

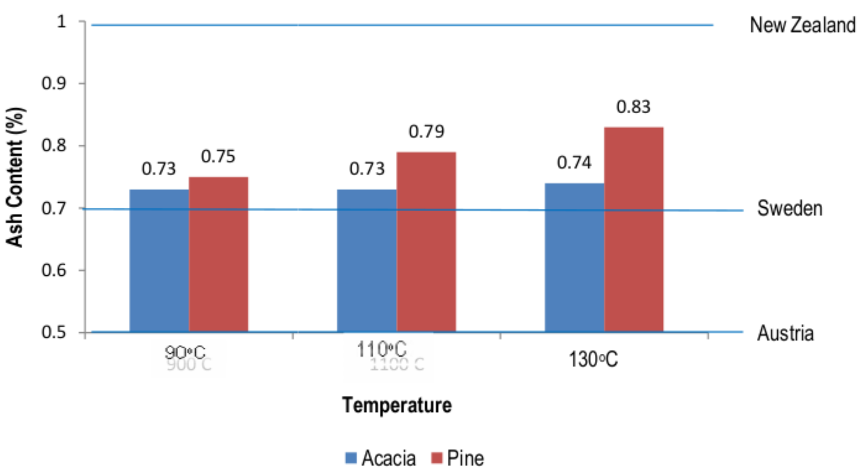

Fig. 3. Ash Content of Acacia and Pine Wood Pellets

According Martawijaya, et al. (1981), ash content indicates the amount of minerals, particularly metal elements in the material. Ash as a part of the combustion process that is no longer has the carbon element. The main element of ash are silica and its effect is less well against the heat generated. The lower the ash content of the higher quality pellets.

In addition, according to the statement of Smook (1994) that the process of changing dimensions of the logs into chips and mill causes minerals content of wood are decrease. The silica content greatly influence of ash content. Pine wood contains silica by 0.2%. The ash content of wood pellets resulted in this study has met quality standard by New Zealand which is maximum of 1%, but did not meet the standards of Austria and Sweden with the maximum 0.5% and 0.7% ash content.

Calorific Value of Acacia and Pine Wood Pellets

Calorific value of acacia and pine wood pellets can be seen in Figure 4 as follows:

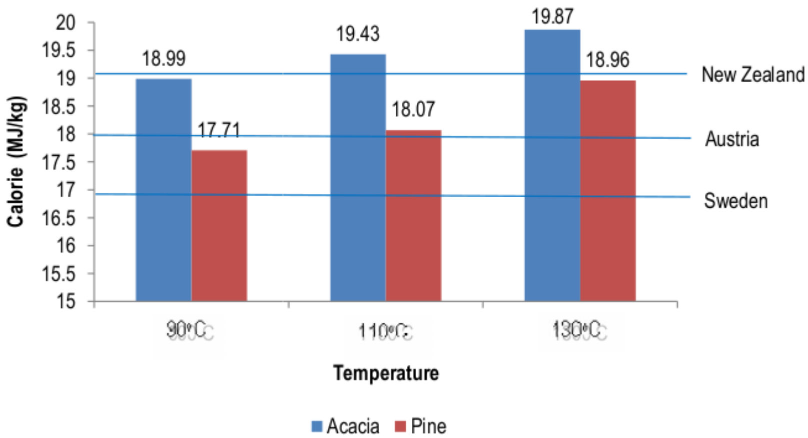

Fig. 4. Calorific Value of Acacia and Pine Wood Pellets

Temperature increase in each treatment affect to reduce moisture content of the pellets, thus causing density of pellet is increasing. The higher density the higher calorific value. Increased density caused by the compaction process, which the carbon content increases and need energy to burn perfectly the material with oxygen that known as calorific value.

The calorific value will determine quality of wood pellets. The higher calorific value the better quality of the pellets. According to Nurhayati (1974) in Triono (2006), the calorific value is affected by moisture content and ash content of pellets. The higher moisture content and ash content the lower calorific value of pellets. The calorific value of wood pellets according to Austrian, New Zealand, and Sweden Standards are at least 18 MJ / kg, 19.1 MJ / kg, and 16.9 MJ / kg respectively. Based on the standards, the calorific value of pellets resulted in this study have met the standards set by these countries.

Ignition Time of Acacia and Pine Wood Pellets

Test results of ignition time of acacia and pine wood pellets showed that the higher temperatures, the faster ignition time of the pellets. This fact occured estimated because of particle surface area difference that influence the difference ignition time. Pratoto, et al. (2010) states that this is caused by the high surface density of small particles which increases contact area between particles with biomass gasification agent, so the higher density the slower ignition time (Widiarti et al. 2010). Besides that, differences of ignition time are also caused by moisture contentof pellets that resulted in each temperature. This is consistent with the statement of Hill (2006), that the higher moisture content, it will be reduce the flame ability of a material.

Results of ignition time of acacia and pine wood pellets is presented in Fig. 5.

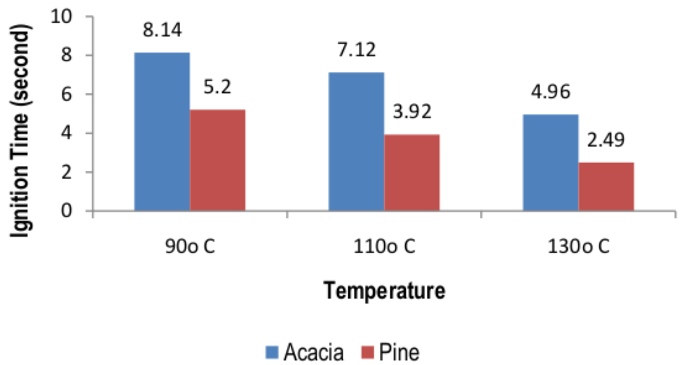

Fig. 5. Ignition Time of Acacia and Pine Wood Pellets

Burning Time

Burning time of acacia and pine wood pellet, as shown in Figure 6 below:

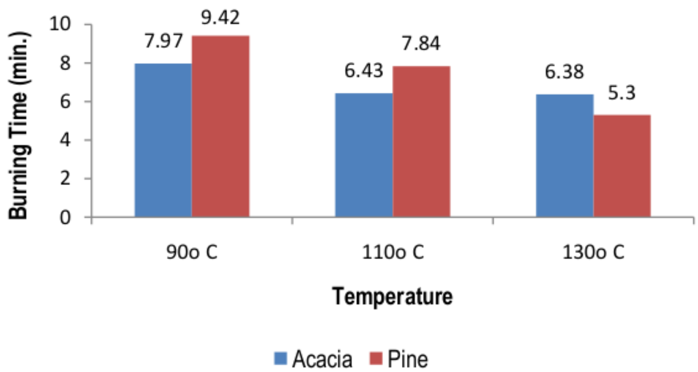

Fig. 6. Burning Time of Acacia and Pine Wood Pellets

The results of burning time test showing that the burning rate of acacia and pine wood pellets tend to similar trend where the higher temperature, the shorter of burning time. This is assuming that evaporation of volatile compounds of extractive that causing reduced contents of extractives, while presence of extractive can cause burning time is shorter. As a statement of Sudrajat (1983), that the lower contents of extractive the shorter burning time.

In addition, differences in burning time are also thought due to other factors. Saptoadi and Himawanto (2011) suggest that there are some factors influence the burning time of solid fuels such as particle size, air velocity, temperature, fuel type, pressure, oxygen concentration and the nature of the elementary reactions that occur. Moreover, the burning time is also influenced by differences in the weight pellet that resulted in each temperature. The higher ratio between weight and surface area, it will produce shorter burning time, whereas in this study the surface area tends to similar in pellets that produced.

CONCLUSIONS

1. In general, temperature affect the characteristics of the wood pellets, where the higher temperature provided the better characteristics of pellets produced
2. Wood pellets produced by the temperature of 110°C has better characteristics compared to the temperature of 90°C and 130°C
3. The pine pellets only meet the standards of Sweden and New Zealand, unless the water levels that meet the standards of Austria, New Zealand and Sweden, while the acacia pellets for moisture content and calorific value at temperature of 110°C meet the standards of the third State.

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