RESEARCH ON BIOMASS BRIQUETTE AS AN ALTERNATIVE ENERGY FROM PTEROCARPUS INDICUS LEAVES AND TWIGS WASTE

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ABSTRACT

Indonesia has a variety of plant species which are very useful for life. Plants that have a lot of benefits that include Pterocarpus indicus. This plant is commonly used as greening because of the characteristics that have dense leaves and rapid growth. During the rainy season, the leaves and twigs of this plant will often fall fallen because with the wind and rain. In the summer, the leaves will fall due to dry. The actual leaves and twigs can be used as an alternative fuel in a way that is good and correct processing. Alternative fuels is that biomass briquettes. This research was conducted with the aim of knowing the potential of the plant Pterocarpus indicus for biomass briquettes made with raw materials leaves and twigs Pterocarpus indicus and tapioca starch adhesive material. This research will be tested to determine whether the calorific value of the leaves and twigs Pterocarpus indicus can be used as biomass briquettes. The composition ratio of raw materials and adhesives as follows: 100%, 90%, 80%, 70%, 60%, 50%. Tests using a bomb calorimeter calorific value. From the experimental results show that the best composition is 90% raw materials and 10% adhesives

Keywords: Pterocarpus indicus. Alternative Energy, Briquette, Biomass, Article, Journal Mechnova, Mechanical Engineering

1. Introduction

The longer the energy needs of more and more. However this is not comparable with the energy resources diminishing. These deficiencies are caused from the exploitation of natural resources redundant by the industry. Diminishing energy sources can result in fuel prices have also increased due to the needs of a huge market but little resources. Therefore, the renewable energy needed to meet the energy needs are less [1-6].

Biomass is a renewable form of energy that is often used in the world. The types of biomass, among others, biodiesel, biogas, solid biomass, etc. Biomass can be produced from wild plants, forest plants, plant waste, garbage, grass, etc. Biomass itself is much in demand by many people all over the world. It has been observed that the biomass is an alternative energy that can replace fossil fuels in the future. Consumer demand for the use of biomass is also increasing with the reduction in fossil fuels [7-10].

. Plants in Indonesia has the potential to be used as biomass. Plant is like a tree that serves as the greening of the city. Particularly tree Pterocarpus indicus is one plant that is common throughout Indonesia as a plant roadside grow tall and large as shown at figure 1. But when the rain and heat, the leaves and twigs of this plant often fall to the ground and the highway. This is very detrimental to the urban community [11-13]. In Surabaya own plants Pterocarpus indicus very numerous necessitating a waste disposal plant Pterocarpus indicus quite a lot as well as shown at figure 2.

Figure 1. Pterocarpus indicus Tree, Surabaya, Indonesia

Figure 2. Waste leaves and twigs of Pterocarpus indicus

Pterocarpus indicus plant is grown in tropical areas, particularly in parts of Southeast Asia. Indonesia is one country with a tropical climate, therefore Pterocarpus indicus trees can grow in the area of Indonesia. This tree has the characteristic of high trees can grow up to a height of 15 meters, has leaves that much. Pterocarpus indicus trees can actually be used as biomass briquettes [13-15]. If it can be processed properly, the waste will be overcome Pterocarpus indicus and alternative fuel can also be fulfilled because of the abundant amount of Pterocarpus indicus are easy to find. As for some of the characteristics of the tree Pterocarpus indicus as follows.

Classification Pterocarpus indicus.[16]

Scientific name	Pterocarpus indicus
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Fabales
Family	Fabaceae
Upafamili	Faboideae
Nation	Dalbergieae
Genus	Pterocarpus
Species	P. indicus

The highest calorific value is achieved if the wood is dry kiln, which is about 4500 kcal / kg (Haygreen et al., 2003). In practical use, the wood drying kiln to dry conditions are not economical in terms of cost. To obtain optimum calorific value, the wood used in air-dry conditions (moisture 12%) with a calorific value ranging from 4000 kcal / kg. Comparison of wood with a calorific value of coal used in the industry are presented in Table 1.

Table 1. comparison of the calorific value of trees Pterocarpus indicus with other substances [17]

Jenis Kayu	Parameter		
	Kadar air (%)	Nilai kalor (kkal/kg)	Kadar abu (%)
Lamtoro (*Leuchaena leucocephala*)	10.13	4.197	5.78
Trembesi (*Samanea saman*)	10.36	3.926	1.92
Turi (*Sesbandia grandiflora*)	6.83	3.965	0.62
Gamal (*Glirisidia maculate*)	23.97	4.168	2.97
Angsana (*Pterocarpus indica*)	7.53	4.060	9.08
Sengon Buto (*Enterolobium cylocarpum*)	14.21	3.948	1.08
Waru (*Hibiscus tiliaceus*)	10.33	4.266	1.48
Gmelina (*Gmelina arborea*)	9.24	4.282	1.47
Batu bara muda (*lignite*)	2.8	5.600	19.2
Batu bara	2.1	6.300	18.1

From the table it appears that the water content 9:24 Gmelina% has the highest calorific value compared to other crops, while tamarind wood with a moisture content of 10:36% have low calorific value, ie 3,926 kcal / kg. Pterocarpus indicus has the highest ash content, which is 9:08%, but this value is still much smaller than the brown coal ash content of 19.2%. Coal with better quality have calorific value of 6,300 kcal / kg at 2.1% moisture content and ash content of the smaller, ie 18.1%.

2. Experiment Method

This study used Pterocarpus indicus leaves waste that they have already fallen from the plant. After collected, the leaves must be sun dried for three days. Biomass briquettes were made by crushing dried Pterocarpus indicus leaves waste into the desired particle size (60 Mesh) as shown in Figure 3, mixing them with tapioca flour as a binder material, and compacting the mixture under pressure. The Pterocarpus indicus leaves waste (60 Mesh particle size) mixed with tapioca as an adhesive material. The composition of Pterocarpus indicus leaves waste with tapioca flour is 100% Pterocarpus indicus leaves waste : 0% tapioca to 50% Pterocarpus indicus leaves waste : 50% tapioca. After that it will be tested heat values by using a bomb calorimeter. Can be seen in Figure 3 how the bomb calorimeter suite of tools that will be used. A mixture of all the above will be examined one by one to determine the value of each heat. The calorific value biomass briquettes from the Pterocarpus indicus leaves waste were performed using a oxygen bomb calorimeter as shown in Figure 4 at various composition of Pterocarpus indicus leaves waste from 50% to 90% rising by 10% for each experiment.

Figure 3. Mesh 60 particle size of Pterocarpus indicus

Figure 4. *Parr oxygen bomb calorimeter*

Before the combustion test is conducted. The briquette should be shaped first according to the existing mold as shown in Figure 5. The pressing process uses 1 MPa and 2 MPa pressure.

Figure 5. Briquette Mold

For burning test using furnace as shown in figure 6. The tested briquettes are 90% raw material with 10% tapioca starch. Variations of particle size used were 20 mesh, 40 mesh, and 60 mesh.

Figure 6. Combustion Furnace

3. Result and Discusion

From the results of calorimeter bomb test as shown in figure 7. It can be seen that the highest calorific value of leaves briquettes with 90% leaf composition and 10% tapioca flour is 4648 Kcal / Kg. While the calorific value of twister briquettes is only 3777 Kcal / Kg. From this graph shows that the less the composition of tapioca starch, the resulting heating value will be better.

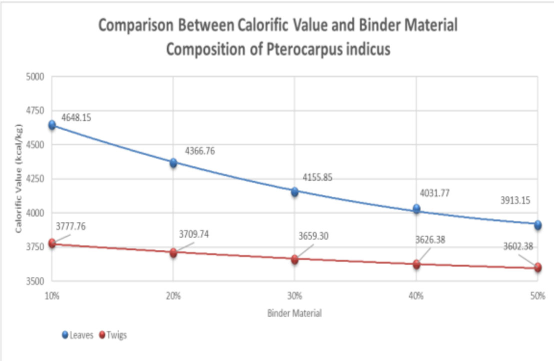

Figure 7. Graph of calorific value of briquette adhesive substance.

In addition to the above calorific value experiments, this study also examines discussion materials such as ultimate analysis and proximate analysis. This test is performed in a laboratory that has standards in performing the test. The sample tested in this laboratory has a mixture of tapioca starchy glue by 90% of leaf waste and twigs of angsana tree and 10% tapioca flour. In the Table 2 shows the results of testing proximate analysis.

Proximate analysis is a test based on the physical properties of the fuel. The physical properties are Total moisture, ash content, volatile matter, fixed carbon, total sulfur and gross calorific value (HHV). Total moisture is the moisture content of the fuel, in the wastewater lab test results of leaves and branches of angsana trees total moisture obtained by 5.2 and 9.8% of the mass percentage. Ash content or ash content contained in leaf waste and twigs of angsana trees has levels of 6.2 and 10.1% of the percentage of mass. Volatile matter or volatile substances in leaf waste materials and branches of angsana trees have levels of 73.3 and 67.9% of the mass percentage. Fixed carbon or carbon bound between 15.3 and 12.2% of the mass percentage. The total content of sulfur present in leaf waste material and branch of angsana tree is 0,25 and 0,17% from mass percentage.

Table 2 Proximate Analysis

Parameters	*unit*	*Twigs*	*Leaves*	*Test Method*
Total Moisture	%wt	9.8	5.2	ASTM D 2961-11
Ash Content	%wt	10.1	6.2	ASTM D 3174-12
Volatile Matter	%wt	67.9	73.3	ASTM D 3175-11
Fixed Carbon	%wt	12.2	15.3	ASTM D 3172-13
Total Sulfur	%wt	0.17	0.25	ASTM D 4239-14E1

Ultimate analysis is a fuel analysis in terms of chemical content of the chemical composition. Levels of chemical composition obtained from the ultimate analysis of Carbon, Hydrogen, Oxygen, Nitrogen and Sulfur. Table 3 shows the ultimate analysis of angsana tree waste.

Table 3. Ultimate Analysis

Parameters	*unit*	*Twigs*	*Leaves*	*Test Method*
Carbon	%wt	41.55	49.12	ASTM D 5373-14
Hydrogen	%wt	4.76	5.67	ASTM D 5373-14
Nitrogen	%wt	0.28	0.19	ASTM D 5373-14
Sulfur	%wt	0.17	0.25	ASTM D 5373-14e1
Oxygen	%wt	33.37	33.40	ASTM D 5373-15

Table 3 shows the ultimate analysis of leaf waste and twigs of angsana trees. The largest chemical content is carbon element with mass percentage of 49.12 and 41.55%. The next largest percentage is the oxygen element with a mass percentage of 33.40 and 33.37%. Subsequent elements are Hydrogen (5.67 and 4.76%), Nitrogen (0.19 and 0.28%), and sulfur (0.25 and 0.17%) of the mass percentage.

Briquettes that have been formed using a press machine, then in the combustion test to obtain data on the speed of ignition, duration of combustion, and combustion temperature. The following tables 4 and 5 show burning test results. Based on tables 4 and 5, briquettes with the longest combustion duration are briquettes with pressures of 20 bar and 60 mesh, while the fastest combustion duration is a briquette with a 10 bar pressure with a particle size of 20 mesh.

Table 4. The result of burning test of angsana twigs

Particle Size (*mesh*)	Pressure (Mpa)	Flame Temperature (C)	Ignition Time (s)	Burning Time (s)	Burning Velocity (gram/s)
20	1	402	101	5465	0.00366
40	1	410	124	5576	0.00359
60	1	425	158	6398	0.00313
20	2	463	198	5552	0.00360
40	2	498	225	5763	0.00347
60	2	515	251	6590	0.00303

Table 5. The result of burning test of angsana leaves

Particle Size (*mesh*)	Pressure (Mpa)	Flame Temperature (C)	Ignition Time (s)	Burning Time (s)	Burning Velocity (gram/s)
20	1	437	172	6371	0.00314
40	1	455	193	6792	0.00294
60	1	501	214	7721	0.00259
20	2	543	267	6431	0.00311
40	2	579	281	6813	0.00294
60	2	613	306	7923	0.00252

Figure 8 shows that the smaller the particle size the higher the combustion temperature. Similarly, press briquette pressure, the higher the pressure of briquette press then the burning temperature will increase. In data with particle size of 60 mesh with 2 MPa pressure showed the highest burning temperature.

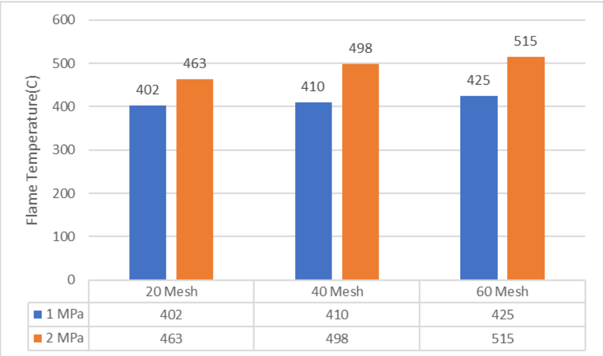

Figure 8 Influence of partique size to fire temperature (twigs)

Figure 9 shows the effect of particle size on the ignition time. Based on the graph, the greater the particle size of the fuel will facilitate the process of fuel ignition. Briquette pressure also affects the duration of briquette ignition. The higher the briquette pressure then the briquette ignition time will be longer. In the graph can be seen on briquettes with 60 mesh particle size with a power of press of 2 MPa has the longest ignition time, which is 251 seconds.

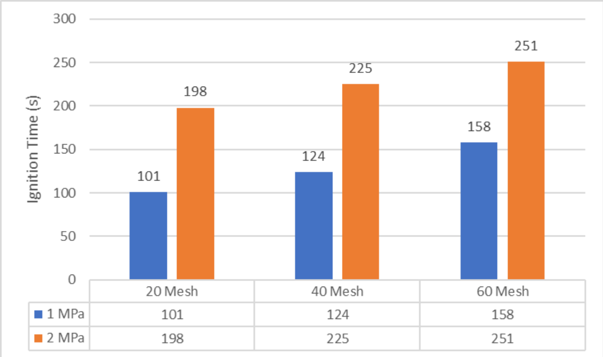

Figure 9 Effect of particle size on ignition time (twigs)

Figure 10 shows the effect of particle size on the duration of combustion. Based on the graph the duration of the combustion is affected by the particle size and pressure of the briquette press. The smaller the particle size the longer the combustion duration. Similarly, at the pressure, the greater the pressure of briquette press the duration of burning will be longer. In the briquette graph that has the longest burning duration is a briquette with 60 mesh particle size with press pressure of 2 MPa..

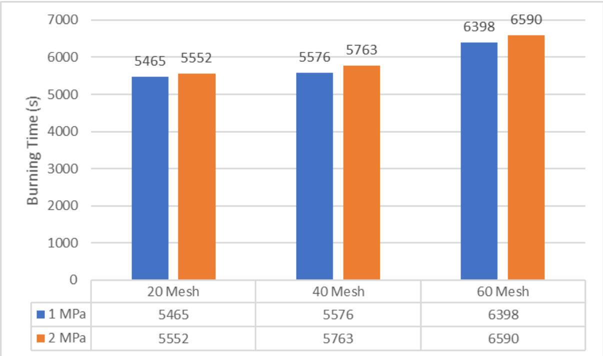

Figure 10 The effect of particle size on the duration of combustion (twigs)

Figure 11 shows the effect of particle size on the rate of combustion. Based on the graph can be concluded the burning rate will be higher if the particle size is greater and press briquette pressure is lower. At the lowest burning rate graph is briquettes with 60 mesh particle size with press pressure of 2 MPa.

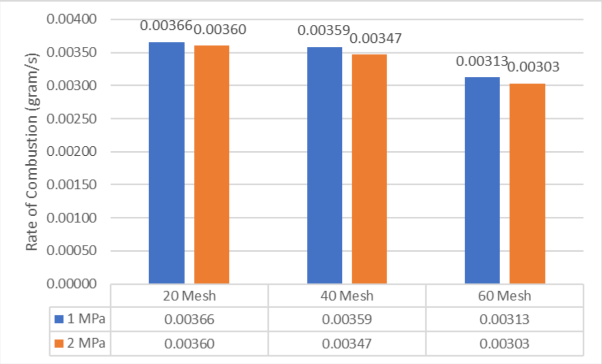

Figure 11 The effect of particle size on the rate of combustion (twigs)

Figure 12 shows that the smaller the particle size the higher the combustion temperature. Similarly, press briquette pressure, the higher the pressure of briquette press then the burning temperature will increase. In data with particle size of 60 mesh with 2 MPa pressure showed the highest burning temperature.

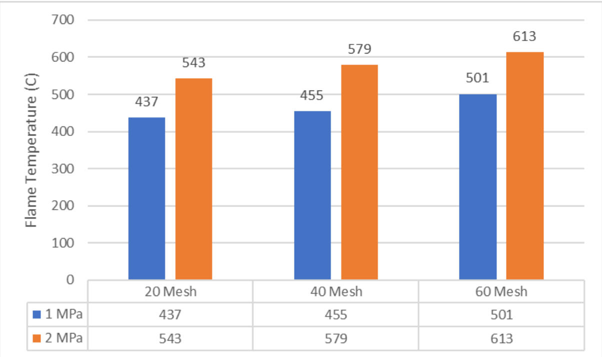

Figure 12 Influence of partique size to fire temperature (leaves)

Figure 13 shows the effect of particle size on the ignition time. Based on the graph, the greater the particle size of the fuel will facilitate the process of fuel ignition. Briquette pressure also affects the duration of briquette ignition. The higher the briquette pressure then the briquette ignition time will be longer. In the graph can be seen on briquettes with 60 mesh particle size with a power of press of 2 MPa has the longest ignition time, which is 306 seconds.

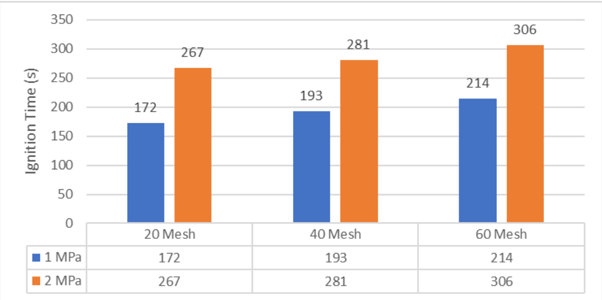

Figure 13 Effect of particle size on ignition time (leaves)

Figure 14 shows the effect of particle size on the duration of combustion. Based on the graph the duration of the combustion is affected by the particle size and pressure of the briquette press. The smaller the particle size the longer the combustion duration. Similarly, at the pressure, the greater the pressure of briquette press the duration of burning will be longer. In the briquette graph that has the longest burning duration is a briquette with 60 mesh particle size with press pressure of 2 MPa..

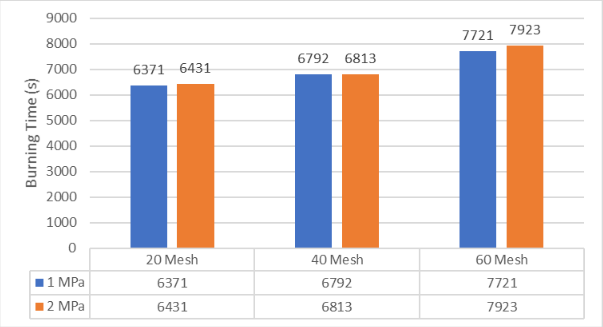

Figure 14 The effect of particle size on the duration of combustion (leaves)

Figure 15 shows the effect of particle size on the rate of combustion. Based on the graph can be concluded the burning rate will be higher if the particle size is greater and press briquette pressure is lower. At the lowest burning rate graph is briquettes with 60 mesh particle size with press pressure of 2 MPa.

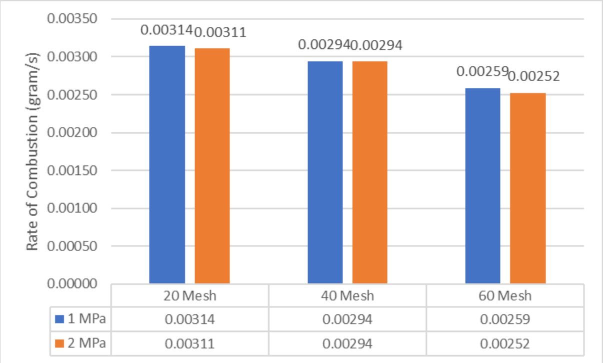

Figure 15 The effect of particle size on the rate of combustion (leaves)

Pterocarpus indicus leaves briquette has the highest calorific value is 4648 kcal/kg compared to sawdust briquette, sugarcane briquette, rice straw briquette and coconut coir briquette can see Fig. 16. But calorific value of Pterocarpus indicus twigs briquette is the lowest with 3777 kcal/kg. The calorific values of sawdust briquette, rice straw briquette, sugarcane briquette, coconut coir briquette 90% carbera manghas briquette are 4161 kcal/kg, 3927 kcal/kg, 3903 kcal/kg, 4146 kcal/kg and 4164 kcal/kg respectively [18-21].

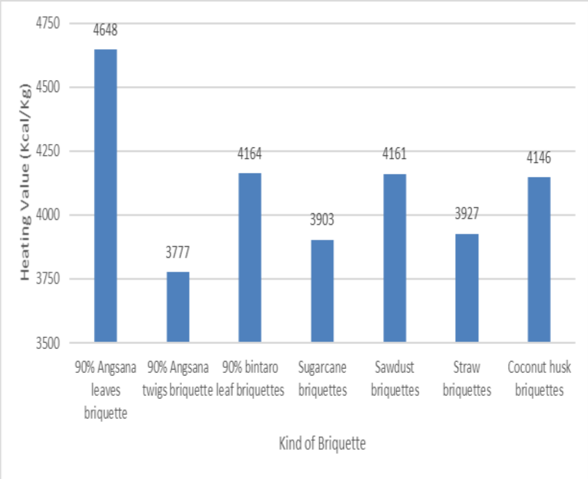

Figure 16 Comparison Heating Value of Pterocarpus indicus briquette with other briquette

4. Conclusion

The best mixture of briquette and adhesive raw materials (tapioca flour) is 90:10. The calorific value of angsana briquettes with composition of 90:10 is 4648 Kcal / Kg while Angsana branch briquette with 90:10 composition of 3777 Kcal / Kg. In terms of environmentally friendly / pollution then briquettes are classified as environmentally friendly because the content of sulfur (S) and nitrogen (N) under 1% of the total mass of briquettes. In terms of size, it is known that particles of smaller size will produce better results that are evident from the comparison between mesh 20, 40, and 60. The best results are mesh 60 for all the above research categories.

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