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Biomass Briquette Investigation from Pterocarpus Indicus Leaves Waste as an Alternative Renewable Energy Willyanto Anggono1, Sutrisno2, Fandi D. Suprianto3, Jovian Evander4 1,2,3,4Mechanical Engineering Department, Petra Christian University, Surabaya, Indonesia 1,2,3,4Centre for Sustainable Energy Studies, Petra Christian University, Surabaya, Indonesia E-mail: willy@petra.ac.id Keywords: Pterocarpus indicus, leave waste, biomass briquette, alternative renewable energy. Abstract. Indonesia is a tropical country located in Southeast Asia. Indonesia has a lot of variety of plant species which are very

useful for life. Pterocarpus indicus are commonly used as greening and easily found everywhere in Surabaya city because of its characteristics that they have dense leaves and rapid growth. Pterocarpus indicus leaves waste would be a problem for residents of Surabaya and disturbing the cleanliness of the Surabaya city. Therefore, the Pterocarpus indicus leaves waste can be used as biomass briquettes. This research investigated the calorific value of biomass briquettes from the Pterocarpus indicus leaves waste, the effect of tapioca as an adhesive material to the calorific value of biomass briquettes from the Pterocarpus indicus leaves waste, the optimum composition for Pterocarpus indicus leaves waste biomass briquettes as an alternative renewable fuel and the property of the optimum resulted briquettes using ultimate analysis and proximate analysis based on the ASTM standard. The calorific value biomass briquettes from the Pterocarpus indicus leaves waste were performed using an oxygen bomb calorimeter at various composition of Pterocarpus indicus from 50% to 90% rising by 10% for each experiment. The experimental results showed that the 90% raw materials (Pterocarpus indicus leaves waste)- 10% adhesive materials (tapioca) mixtures is the optimum composition for biomass briquettes Pterocarpus indicus leaves waste. The lower the percentage of the mass of tapioca in the briquettes, the higher calorific value generated. 1. Introduction Energy crisis is a concern because of the diminishing natural resources. Diminishing energy sources influence to the fuel prices. The fuel price will be increased due to the needs of a huge market but limited resources. Therefore, the renewable energy needed to meet the energy needs.

Biomass is a renewable energy that **is** often used **in** 8

the world. Biomass can be produced from wild plants, forest plants, plant waste, garbage, grass, etc. [1]. 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 [2]. Indonesia is a tropical country with various types of plants. The plants in Indonesia have the potential to be used as biomass briquettes. Pterocarpus indicus is a plant road side which grow tall and large in Indonesia as shown at figure 1. The leaves of this plant often fall to the ground and the highway when the rain and heat as shown in figure 2 [3-5]. Figure 1. Pterocarpus indicus tree in Surabaya Figure 2. Pterocarpus indicus leaves waste in Surabaya Pterocarpus indicus plant is grown in tropical areas, particularly in parts of Southeast Asia. Surabaya is one city in Southeast Asia with a tropical climate, therefore Pterocarpus indicus trees can grow in the area of Surabaya, Indonesia. These tree has the characteristic of high trees can grow up to a height of 15 meters and the trees can actually be used as biomass briquettes [6-9]. The Pterocarpus indicus leaves waste can be used as an alternative energy through the right process. Table 1. Calorific values comparison of various wood [10] Wood Type Moisture Content (%) Calorific Value (kcal/kg) Leuchaena leucocephala 10.13 4197 Samanea saman 10.36 3926 Sesbandia grandiflora 6.83 3965 Glirisidia maculate 23.97 4168 Enterolobium cyclocarpum 14.21 3948 Hibiscus arborea 10.33 4266 Gmelina arborea 9.24 4282 From the table, it appears that Gmelina arborea (9.24 % moisture contents) has the highest calorific value of wood (4282 kcal/ kg), while Samanea saman (10.36% moisture contents) has lowest calorific value of wood (3926 kcal/ kg). The coal with better quality has the highest calorific value (6300 kcal/ kg at 2.1% moisture content) compare to all various wood [10]. 2. Experimental 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), mixing them with tapioca flour as a binder material, and compacting the mixtures under pressure (2 MPa). The calorific value biomass briquettes from the Pterocarpus indicus leaves waste were performed using a

1341 Plain Jacket oxygen bomb calorimeter Parr Instrument 7

at various composition of Pterocarpus indicus leaves waste. The experiments in this paper were performed at various compositions of Pterocarpus indicus leaves waste biomass briquettes from 50% Pterocarpus indicus leaves waste (using 50% tapioca as a binder material) to 90% Pterocarpus indicus leaves waste (using 10% tapioca as a binder material) rising by 10% for each experiment. After that it will be tested heat values by using a bomb calorimeter. 3. Result and Discussion Based on the experimental investigation using an oxygen bomb calorimeter, the calorific value of 100% Pterocarpus indicus leaves waste was 4909.89 kcal/ kg and the calorific value of 100% tapioca as a binder material was 3574.47 kcal/kg. The calorific value of biomass briquette from waste leaves Pterocarpus indicus at various composition mixtures are shown in Table 2 and the summary of the results from calorific value or heating value of Pterocarpus indicusâ€“tapioca mixtures at various composition are shown Figure 3. The greater amount of tapioca the lower the heating value

of the biomass briquette Pterocarpus indicus leaves. **The** highest **heating value of the** biomass **briquette** 2

Pterocarpus indicus leaves was the biomass briquette using 90% Pterocarpus indicus leaves waste-10% tapioca mixtures as shown in figure 3. The 90% Pterocarpus indicus leaves waste-10% tapioca mixtures successfully creates a briquette model as shown in figure 4. The composition of 90% Pterocarpus indicus leaves waste-10% tapioca mixtures using 60 mesh particle size was used as the best biomass briquette model. Table 2. Pterocarpus indicus leaves waste biomass briquette calorific value of at various composition Biomas Briquette Composition Calorific Value (kcal/kg) 50% Pterocarpus indicus-50% tapioca mixtures 60% Pterocarpus indicus-40% tapioca mixtures 70% Pterocarpus indicus-30% tapioca mixtures 80% Pterocarpus indicus-20% tapioca mixtures 90% Pterocarpus indicus-10% tapioca mixtures 3913.16 4031.77 4155.85 4366.76 4648.15 Figure 3. Effect of binder material to the calorific value Pterocarpus indicus leaves waste briquette Figure 4. Pterocarpus indicus leave briquette Tapioca as a binder material reduces the

heating value of the biomass briquette 2

from waste leaves Pterocarpus indicus. The greater amount of tapioca, the lower the

heating value of the biomass briquette 2

from Pterocarpus indicus leaves. In term of cost, the effective composition also 90%:10% because Pterocarpus indicus leave is cost free. The higher the precentage of tapioca in the biomass briquette from waste leaves Pterocarpus indicus the higher the cost of the briquettes. The proximate analysis and ultimate analysis also have been examined through a laboratory test. The test uses some ASTM standardization. The moisture content using ASTM D 2961-11 which is covers a single-stage procedure for the determination of total moisture less than 15 % in product reduced to 2.36 mm 1

top size.

This test method is for determination of total moisture only. Materials subjected to this test shall not be used in the determination of other test parameters. It is recognized that the conditions of the test can increase the potential for significant oxidation effects on the 1

product. The ash content was examined using ASTM D 3174-12.

Ash, as determined by this test method, is the residue remaining after burning the products. Ash obtained differs in composition from the inorganic constituents present in the original 3

product. The volatile matter was examined using ASTM D 3175- 11. Fixed carbon calculation was examined using ASTM D 3172-13. The proximate analysis result of Pterocarpus indicus leaves briquettes (90% Pterocarpus indicus leaves and 10% tapioca) shows

total moisture, ash content, volatile matter, fixed carbon. total sulfur 5

and gross galorific value as shown in Table 3. Table 3. Proximate analysis result of Pterocarpus indicus leaves briquette Test Method Parameters Unit Value ASTM D 2961-11 ASTM D 3174-12 ASTM D 3175-11 ASTM D 3172-13 ASTM D 4239-14E1 ASTM D 5865-13

Gross Calorific Value kcal/kg Total Moisture Ash Content Volatile Matter Fixed Carbon Total 4

Sulfur %wt %wt %wt %wt %wt 5.2 6.2 73.3 15.3 0.25 4648.15 Table 4. Ultimate analysis result of Pterocarpus indicus leaves briquette Test Method Parameters Unit Value ASTM D 2961-11 Total Moisture %wt 5.2 ASTM D 3174-11 Ash %wt 6.2 ASTM D 5373-14 Carbon %wt 49.12 ASTM D 5373-14 Hydrogen %wt 6.67 ASTM D 5373-14 Nitrogen %wt 0.19 ASTM D 4239-14E1 Sulfur %wt 0.25 ASTM D 5373-15 Oxygen %wt 33.40 The ultimate analysis result of Pterocarpus indicus leaves briquettes (90% Pterocarpus indicus leaves and 10% tapioca) used to investigate the Carbon, Hydrogen, Oxygen, Nitrogen and Sulfur concentration on Pterocarpus indicus leaves briquettes. The examination of the proximate analysis using ASTM D 5373-14, ASTM D 5373-14e1 and ASTM D 5373-15. The result of ultimate analysis of Pterocarpus indicus leaves briquettes shown in Table 4. Pterocarpus indicus briquette has the highest calorific value compared to waste leaf Cerbera manghas briquette (4164.00 kcal/kg), sawdust briquette (4161.08 kcal/kg), sugarcane briquette (3902.96 kcal/kg), rice straw briquette (3926.86 kcal/kg) and coconut coir briquette (4146 kcal/kg) [1,2,11]. 4. Conclusion Biomass briquette from Pterocarpus indicus leaves waste is an alternative renewable and sustainable energy and tapioca as a binder material play a role to the calorific value on the biomass briquette from Pterocarpus indicus leaves waste. The lower the amount of tapioca as a binder material, the greater

the heating value of the briquette and **the** cheaper the cost **of the** 2

biomass briquette from Pterocarpus indicus leaves waste. The biomass briquettes have been developed as energy source from Pterocarpus indicus leaves waste using 90% Pterocaraus indicus leaves waste and 10% tapioca as the optimum composition. 5. References [1]. Sutrisno, Anggono W, Suprianto F D, Kasrun A W and Siahaan I H 2017 ARPN Journal of Engineering and Applied Sciences 12 931 [2]. Anggono W, Suprianto F D, Sutrisno and Kasrun A W 2016 International Journal of Industrial Research and Applied Engineering 1 1 [3]. Sellin N, Bianca G, Marangoni C, Souza O, Pedro N and Novais T M 2013 Chemical Engineering Transactions 32 349 [4]. Rosua J M and Pasadas M 2012 Renewable and Sustainable Energy Reviews 16 4190 [5]. Raju C A I, Jyothi K R, Satya M and Praveena U 2014 International Journal of Research in Engineering and Technology 3 54 [6]. Prasityousila J and Muenjinab A 2013 Procedia Environmental Sciences 17 603 [7]. Yank A, Ngadi M and Kok R 2016 Biomass and Bioenergy 84 22 [8]. Jittabut P 2015 Energy Procedia 79 2 [9]. Po Z X, Hu P Y, Sheng L M, Li K S and Qing Z J 2010 Asian Pacific Journal of Tropical Medicine 109 [10]. Cahyono T D, Coto Z, dan Febrianto F 2008 Forum Pasca Sarjana 31 105 [11]. Lela B, Barisic M, and Nizetic S 2016 Waste Management 47 236 Acknowledgments Thanks to Petra Christian University Indonesia and Direktorat Jendral

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(Hibah Penelitian Produk Terapan 2016- 2017) for their support during this research. Authorsâ€™ background Your Name Title* Research Field Personal Email Willyanto Anggono Associate Professor Renewable Energy willy@petra.ac.id Sutrisno Dr. Energy Conversion tengsutrisno@petra.ac.id Fandi D. Suprianto Lecturer Energy Conversion fandi@petra.ac.id Jovian Evander Assistant Lecturer Energy Conversion jovianevander95@gmail.com