Biomass Pellets from Oil Palm Empty Fruit Bunches (OP-EFB)

Rahmat Farhan Aditya

[a]*Swiss German University, Indonesia*

rahmatfar.aditya@gmail.com

Abstract: Oil Palm growths in Indonesia are getting higher every year. Oil palm plantation produced various waste, including oil palm empty fruit bunches (OP-EFB). 95 % Indonesia energy demand still provided by the fossil fuel and only 5 % provided by renewable energy, which provide opportunity of OP-EFB biomass pellets to be utilized as alternative resource. The research of biomass still low, especially research of OP-EFB biomass pellets. Therefore, the research objectives were to determine the production process of OP-EFB and to define the most effective binder and binder ratio for the biomass pellets. This research experiments consist of shredding, chopping, drying, grinding, and sieving as raw material pretreatment. Also, varying the binder and binder concentration of the mixture between raw materials was the part of this thesis research. The binders used in this thesis research are PVAC paste and tapioca based paste with 4 variations of concentration. The analyses of the biomass pellets characteristic are density, compressive strength, proximate analysis (moisture, ash, volatile matter, and fixed carbon), calorific value, combustion rate, and gas chromatographic & mass spectroscopy (GCMS). The result shows that OP-EFB biomass pellets are qualified to be considered as biomass pellets. The most effective OP-EFB biomass pellets is biomass pellets with 10% tapioca binder concentration.

Keywords: Oil Palm Empty Fruit Bunches, Biomass, Biomass Pellets, PVAC, Tapioca.

1. Introduction

Growth of oil palm plantations in Indonesia are increasing due to the high demand of oil palm mainly as cooking oil, with annual production around 6,645,876 ton in 2016 (Direktorat Jenderal Perkebunan, 2016). Oil palm plantation produces various of waste (solid waste & process waste) and oil palm empty fruit bunches (OP-EFB) is one of the waste alongside palm shell, palm fibre, and palm oil mill effluent (Abdullah & Sulaiman, 2013). Oil palm empty fruit bunches (OPEFB) shows great potential as solid biomass fuel (SBF) for thermochemical energy applications based on the calorific value as consideration (Nyakuma, Ahmad, & Johari, 2015).

Currently, almost 95% of Indonesia energy demand still provided by fossil energy (oil, coal, and natural gas) and 5% renewable energy (Permasalahan, 2014). However, the research and development of oil palm empty fruit bunches (OP-EFB) as biomass pellets in Indonesia are still low, which make this as the main background of this thesis research.

The objectives of this thesis research are to define the appropriate pretreatment process for oil palm empty fruit bunches as biomass pellets, to define the most effective process of pellet productions, to determine the chemical and physical characteristic of the biomass pellets, and to define the most effective type of binder and binder concentrations in biomass pellets, which in this thesis research, 2 types of binder were utilized (PVAC & Tapioca) with 4 various binder concentrations (3%, 5%, 7%, 10%).

2. Research Method

This thesis research was divided into three steps. First step is the pretreatment method. The pretreatment methods consist of several process, start from chopping, shredding, drying, grinding, and sieving with

20-40 mesh of raw materials particle size. Second step is the manufacturing method. Manufacturing method is mixing the pretreated OPEFB with the binder. Before mixing, the binder should be prepared.

The preparation of PVAC binder is to mix 5 gram of PVAC paste with 3 gram of water and mix it until become homogenized, while the preparation of tapioca binder is to mix 1 gram of tapioca starch with 5 gram of water and mix it with addition of heat until it become homogenized. After the binder prepared, each of the binder will be mixed with the pretreated OPEFB with 4 various binder concentrations (3%, 5%, 7%, and 10%). The mixture of OP-EFB and binder will be proceed into the pelletizing process with the pelletizing condition are 150°C, 2500kg/cm^2 pressure and 10 minutes of process time. The expected output is biomass pellet with various binder concentrations and binder type. Last step is the analytical method, with the purpose the determining the characteristic of the biomass pellets. There were 6 characteristics of the biomass pellets to be analyzed, which are density, compressive strength, proximate analysis (moisture content, ash content, volatile matter, and fixed carbon), calorific value, combustion rate, GCMS (Gas Chromatography and Mass Spectrophotometer) analysis. All of the analyses were done using ANOVA test.

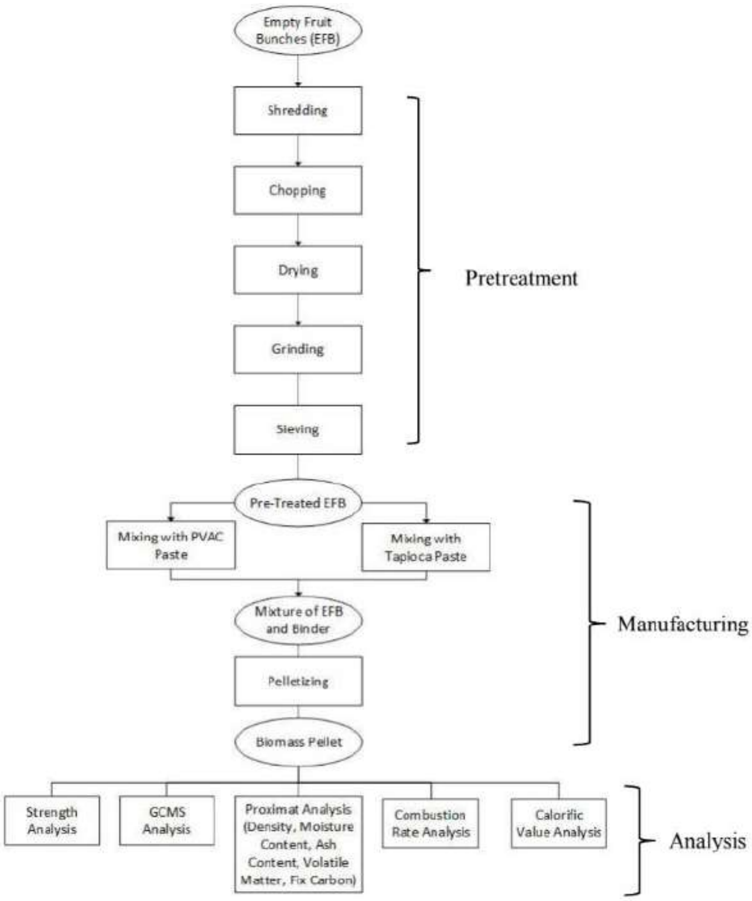

Figure.1. Process Flow Diagram of the Research

3. Results and Discussions

The results of 6 analyses were a comparison of biomass pellet with PVAC binder with 3%, 5%, 7% and 10% binder concentration and comparison of biomass pellet with tapioca binder with 3%, 5%, 7%, and 10%. The mesh selected for this thesis research was 20-40 mesh, which were different than the common mesh selected for biomass pellets raw materials, which is minimum 40 mesh. The reason that mesh selected is because the binding power of minimum 40 mesh raw materials was not strong enough to bind as biomass pellet.

The sample codes in this thesis research were P-3, P-5, P-7, P-10 and T-3, T-5, T-7, T-10. Letter T and P define the type of binder (Tapioca and PVAC), while the number (3, 5, 7, and 10) define the binder concentrations

Table 1 Proximate Analysis of Biomass Pellet

	Moisture Content (%)	Ash Content (%)	Volatile Matter (%)	Fixed Carbon (%)
P-3	0.06	7.3	72.75	19.89
P-5	1.2	7.52	71.12	20.17
P-7	1.32	7.59	70.62	20.28
P-10	1.87	8.21	69.66	20.26
T-3	0.16	7.72	73.12	19.005
T-5	0.46	7.61	72.82	19.11
T-7	0.5	7.56	72.65	19.82
T-10	0.9	7.36	72.24	20.4

The average moisture content of PVAC is higher than tapioca because the preparation of PVAC binder did not involve heat so there is no moisture loss, different than tapioca. The ash content of PVAC was increasing alongside the binder concentration while tapioca was decreasing. The reason that ash content of PVAC was increasing is because PVAC contain vinyl acetate. Acetate is determined as organic salt and it is incombustible compound, which make it ash. The ash content of tapioca was decreasing because the ash content of tapioca is lower than the ash content of the raw material. From volatile matter aspect, PVAC still have bigger role in biomass pellet with PVAC binder because PVAC is a polymer and it will break down into monomer when contacted with heat so it will easier to vaporized. Also, PVAC mainly consist of vinyl alcohol and vinyl acetate, which both of the content have low boiling point. Fixed carbon determines the residual combustible solid inside the biomass pellets after the moisture was taken and volatile matter was vaporized. The fixed carbon of PVAC already reach the peak point (P-7), while tapioca still not reach the peak point of fixed carbon.

Table 2 Analysis of Biomass Pellet

	Density (g/cm3)	Compressive Strength (kg/cm2)	Calorific Value (kcal/kg)
P-3	1.329	1.184	4046
P-5	1.363	1.216	4098
P-7	1.48	1.68	4119
P-10	1.57	1.714	4221
T-3	0.95	0.45	4118
T-5	1.13	0.86	4128
T-7	1.23	0.95	4134
T-10	1.32	1.2	4206

The average density and compressive strength of biomass pellet with PVAC binder is higher than tapioca because as a binder, PVAC has higher density and stronger than tapioca. The average calorific value of tapioca binder is higher than PVAC because tapioca has higher calorie than PVAC.

After all of the analyses were done, the best binder concentration was selected from each type of binder. For PVAC, the best binder concentration was P-7 (PVAC 7% concentration) because P-7 have significantly lower ash content and moisture content than P-10, while the difference of the other analysis of P-7 and P-10 are not significant. For tapioca, the best binder concentration was T-10

(Tapioca 10% concentration) because T-10 has 4 out of 7 advantages in analysis than T-7. Between the best binder from each type of binder (P-7 and T-10), the best binder concentration is T-10 because T-10 has 4 out of 7 advantages in analysis than P-7. Also, from the GCMS analysis, T-10 does not produce harmful material (TRIDEUTEROACETONITRILE) when it combusted.

Both of the best binder (P-7 and T-10) already met requirement or the standard of biomass pellets from Germany (DIN 51731) and Indonesia (SNI8021-2014), except the ash content. The maximum ash content from both of the standard is 1.5%, while the ash content from P-7 is 7.59% and T-10 is 7.36%. The high ash content indicates that the raw material (oil palm empty fruit bunches) has high ash content.

4. Conclusion

Oil palm empty fruit bunches (OP-EFB) can be utilized as the raw materials of biomass pellets. OP-EFB biomass pellets with certain binder concentrations met the requirement of the pellet standard (DIN 51731 & SNI8021-2014), except the ash content. The production process of OPEFB biomass pellets are shredding, chopping, drying, grinding, sieving (20-40 mesh), and pelletizing. In terms of compressive strength and volatile matter, biomass pellet PVAC binder is favored. In terms of density, moisture content, ash content, fixed carbon, calorific value, combustion rate, and GCMS, biomass pellet with tapioca binder is favored. Biomass pellet with 10 % tapioca concentration is the best binder concentration in this thesis research.

References

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