Biomass pyrolysis briquette molding machine design and analysis

Agus Noviar Putra1,2*, M. Sabri1, and Taufiq Bin Nur1

1Dept. of Mechanical Eng., Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia
2Medan State University, Medan 20221, Indonesia

*Corresponding email: praptomeunimed@gmail.com

Abstract. The increasing population and industry in the world have increased the energy demand. Fossil fuel still dominates the current energy consumption in Indonesia, although renewable energy sources are widely available in the country. One of the sources that can be used as a renewable energy source is a solid waste as biomass from palm oil processing. The biomass can be converted to solid fuel by using the pyrolysis technique prior molded into a briquette. This study aims to analyze the biomass briquette molding machine in the simulation environment. The solid work simulation is used to analyze the machine regarding the material strength, static test, displacement, strain, and safety factor. The strength test of von mises stresses achieves a maximum value of 3.713 x 10^5 psi with node 43.485. It is known that the frame is still safe to use because the Yield Strange value is below the Von miss Stress value. Meanwhile, with a maximum displacement of 0.748 cm at node 62816, a maximum strain of 0.00104 at element 43485, and a safety factor of 3.278 x 10^8, it shows this briquette's design molding machine is safe to use.

1. Introduction
Increasing population growth and industry globally then increasing energy demand by 80% leads to an increase in the use of energy in fuels, resulting in depletion of petroleum reserves. The phenomenon makes people put effort into increasing alternative renewable energy sources. Biomass energy can be considered a renewable energy source [1-4]. The Oil Palm Empty Fruit Bunches (EFB) comes from palm oil mill activity is currently served as solid biomass [4-7].

The oil palm mill produces 60% crude palm oil, 20% fiber, and 20-23% EFB. The EFB is a solid waste that can be used as alternative energy besides shells and fiber [8-9]. Indonesia has abundant availability of EFB [10-11]. The fibers and shells have been used extensively for fuel boilers to generate steam for processing palm oil and generate electricity for other parts activities during processing. Meanwhile, the EFBs are usually used as fertilizer for oil palm plantations [12].

The EFBs can be converted into renewable energy solid fuel as charcoal by a thermochemical process [13]. Charcoal from EFB can be processed using a pyrolysis process at a temperature of 350 – 500°C [14-15]. The pyrolysis process produces syngas, bio-oil, and solid [16-17]. The percentage yield of pyrolysis products depends on several conditions working during the process [18-19].

The charcoal produced from pyrolysis has a high calorific value. It can be served as fuel and processed into solid fuels in the form of briquettes [20]. The briquettes compose charcoal powder and
Retraction

Retraction: Biomass pyrolysis briquette molding machine design and analysis (J. Phys.: Conf. Ser. 2193 012073)

Published 08 June 2022

This article has been retracted by IOP Publishing following an allegation that this article bears similarities to an unreferenced previous publication [1] by the authors. Furthermore, that the article was submitted to the conference, and to the journal for publication by the submitting author without their two co-authors consent.

IOP Publishing has investigated in line with the COPE guidelines, and has found the article bears significant similarities to the author’s previous publication. Based on the information to hand, it appears the consent of the submitting author’s co-authors, M. Sabri and Taufiq Bin Nur, was not sought to publish the work in the journal.

IOP Publishing wishes to credit the anonymous whistle-blower for bringing the issue to our attention. The authors agree to this retraction.

[1] Agus Noviar Putra, M. Sabri and Taufiq Bin Nur, (2021), ‘Design and analysis of biomass pyrolysis briquette molding machine’, E3S Web Conf. Volume 306, (The First International Conference on Assessment and Development of Agricultural Innovation (1st ICADAI 2021), https://www.e3s-conferences.org/articles/e3sconf/abs/2021/82/e3sconf_icadai21_04024/e3sconf_icadai21_04024.html.

Retraction published: 08 June 2022
adhesive mixed before entering the pressing process to get the desired solids [21-22]. Making solid briquettes requires a compaction process of about 25 – 125 N cm⁻¹ according to the Indonesian National Standard (SNI) number 01-6235-2000 [23-24]. Therefore, it is necessary to design a suitable machine for briquette molding. The machine design process needs to be carried out with material selection and strength analysis, especially the machine frame. It is essential to hold every burden in the work process of making briquette.

This study analyzes the design of the briquette molding machine, especially the machine frame, in terms of the strength of the material using ASTM A 36. This briquette molding machine's design and analysis process use SolidWorks software to analyze the material characteristics, stress, strain, displacement, safety factors, and finding the durability of the material on the briquette molding machine frame.

2. Methodology

Briquette production requires charcoal machines, adhesives, and molding machines. The charcoal as a pyrolysis product is used as raw material for the briquette. EFB is treated as raw material with a working temperature of 400 °C – 500 °C for 180 minutes in the pyrolysis processes. Charcoal from the pyrolysis process is then mashed into 40 mesh to get a uniform size, mix with the tapioca glue adhesive of 10% of the weight of the charcoal. The mixture is then brought to the molding process before entering the drying process at the oven with a temperature of 100 °C for 60 minutes to reduce water content.

Figure 1 is a briquette molding machine designed to produce 16 briquettes in 1 time of production. The briquettes are rectangular in size with a size of 40 mm x 40 mm. There is a middle cavity of 5 mm. For 1-time molding, production takes 10 minutes due to the molding process has several stages: the entry of molding materials, the compaction process, and removing the briquettes to the dryer. The selection of a square briquette shape facilitates the packaging and is expected to enhance the briquette's complete burning process.

Things to be considered first in the machine's design are the specifications of pressure and material used. The briquette machine frame design is shown in Figure 2. In contrast, the material specification used for the molding machine is shown in Table 1. This briquette machine frame has 500 mm x 400 mm x 1100 mm in size.

The machine frame will be analyzed to get the information on structural strength using SolidWorks software when pressurized by 8 bar (116.03 psi). The analysis also will be carried out to get information on the stress, displacement, strain, and safety factor of the proposed design.
Figure 2. Briquette Machine Frame Design.

Table 1. Specification for the molding machine.

| No | Name             | Size                                                                 |
|----|------------------|----------------------------------------------------------------------|
| 1  | Frame            | UNP                                                                  |
| 2  | Pressure         | ASTM A36                                                             |
| 3  | Tube molding     | (thick = 0.5 mm, Long = 40 mm, Wide = 40 mm, Hige = 60 mm)            |
| 4  | Molding          | ASTM A36 (size 400mm x 500mm x 3mm)                                 |
| 5  | Drawer           | Stainless steel                                                     |
| 6  | Compressor       | Maximum pressure = 8 bars                                            |
| 7  | Pneumatic        | Bore = 50 mm; Stroke = 70 mm                                         |

3. Results and Discussion

The value of ASTM A36 material characteristics in yield strength, tensile strength, modulus of elasticity, Poisson's ratio, shear modulus, nodes, elements, and aspect ratio are shown in Table 2.

Table 2. Value of material characteristics.

| Name     | Property     | Unit          |
|----------|--------------|---------------|
| material | Yield Power  | $6.20422 \times 10^8$ N m$^{-2}$ |
|          | Attractiveness| $7.23826 \times 10^8$ N m$^{-2}$ |
|          | Elastic Modulus| $2.1 \times 10^{11}$ N m$^{-2}$ |
|          | Poisson's Ratio| 0.28          |
|          | Shear Modulus | $7.9 \times 10^{10}$ N m$^{-2}$ |
|          | Element Size  | 1.84521 cm    |
|          | Total Nodes   | 64621         |
|          | Total Element | 30950         |
|          | % elements with an aspect ratio < 3 | 38.4% of elements with Aspect Ratio > 10 | 52

From the analysis, the yield strength of ASTM A36 material is $6.20422 \times 10^8$, tensile strength is $7.23826 \times 10^8$, and elastic modulus is $2.1 \times 10^{11}$. The values obtained are the highest point of the material in receiving static loading. Based on the simulation, the maximum yield strength material is $6.20422 \times 10^8$ N m$^{-2}$. The minimum stress value at a compressive load of 8 bar (116.03 Psi) for the briquette molding process should not be above the value of the yield strength of the material due to the yield point is the limit point for the strength of the material.

The stress analysis simulation obtained a maximum value of $3.713 \times 10^5$ Psi on the node of 43.485, showing by a red bar chart. In comparison, the minimum value is $2.745 \times 10^4$ Psi on the node of 53.500 (blue bar charts).
Figure 3. Stress Analysis (Von Mises Stress)

Figure 3 shows the lowest and highest value of stress based on simulation analysis with the indicated yield strength of 8.998 x 10^4. This value is the point where the occurrence of strains and displacement on the machine frame. It can be stated that the machine frame is still safe to use, where the yield strength is still above the minimum value of stress analysis. The highest stress point occurs at the connection, marked with a red circle and a red dot, as shown in Figure 4.

Figure 4. Highest Stress Point

Displacement occurs on the mold base around 0.748 mm, with the maximum transfer analysis of 2.391 x 10 mm, as shown in Figure 5. In addition to the simulation, the strain value obtained indicates that the machine can handle the working pressure up to 8 bar. The strain of 0.00142 occurs at the molding plate base, as shown in Figure 6.

Figure 5. Displacement Analysis.
The safety factor analysis on the molding frame obtained a maximum value of $3.278 \times 10^8$ at node 53,500 and a minimum point of $2.424 \times 10^{-1}$ at node 43485. The simulation analysis results in Figure 7 show that the lowest security value is on the red graph, and the highest security value is on the blue graph. The minimum value of the safety factor obtained at a pressure of 8 bar (116.03 Psi) with a value of $2.424 \times 10^{-1}$ where the value of the safety factor is still below the yield strength of the molding frame with a value of $8.998 \times 10^4$. Therefore, the value of the safety factor obtained is still below the value of yield strength, thus the molding machine designed can be declared safe to use in the production process using a pressure of 8 bar (116.03 Psi).

4. Conclusion

This study focuses on design, simulate, and analyzing the briquette molding machine utilizing biochar from EFB. Based on the results and discussion, the design proposed of a briquette molding machine using ASTM A36 with a working pressure of 8 bar shows that frame stress simulation results, including stress, strain, and displacement, are safely used. The fabrication of the machine is in progress at this time based on the proposed design. After the machine available, the authors will conduct experiments to produce briquette, which can be acceptable as a renewable fuel for household appliances economically.

References

[1] S. Duangwang, and C. Sangwichien, Energy Procedia, 79 (2015)
[2] A. Harjanne and J. M. Korhonen, Energy Policy 127 (2019)
[3] Seetharaman, K. Moorthy, N. Patwa, Saravanan and Y. Gupta, Heliyon, 5 (2019)
[4] BPPT, Journal of Chemical Information and Modeling, 53 (2018)
[5] D.S. Bajwa, T. Peterson, N. Sharma, J. Shojaeiari and S. G. Bajwa, Renew. Sustain. Energy Rev, 96 (2018)
[6] W.G. February, (The Economic Benefit of Palm Oil to Indonesia. 2011)
[7] V. Strelov, and T.J. Evans, Biomass Processing Technologies (2014)
[8] Laporan Pelaksanaan Kegiatan dan Anggaran Tahun 2015, (Kantor Wrrim / Lppmr Institut Teknologi Bandung, 2015)
[9] S. Ependi, and T.B. Nur, Design and process integration of organie Rankine cycle utilizing biomass for power generation. IOP Conf. Ser. Mater. Sci. Eng. 309, 2018
[10] E.A. Afriani and T. Kardiansyah, J. Selulosa 5 (2015)
[11] R. Alamsyah, and D. Supriatna, Technical and Economical Analysis of Biomass Waste of Empty Fruit Bunches (EFB) Pellet as Renewa, 35 (2018)
[12] N. Abdullah, and F. Sulaiman, J. Phys. Sci. 24 (2013)
[13] G. Zhang, Y. Sun, and Y. Xu, Renew. Sustain. Energy Rev, 82 (2018)
[14] Z. Liu et al., Fuel Process. Technol. 177 (2018)
[15] R.C. Uluisik et al., J. Inorg. Biochem, 167 (2017)
[16] S. Gupta, P. Mondal, V.B. Borugadda, and A.K. Dalai, Environ. Technol. Innov, 21 (2021)
[17] A. Ferdiyanto, F. Munfaridi, and A. Hidayat, Khizanah J. Mhs, 8, 12 (2020).
[18] F. Febrioni, N. Fadila, A.S. Sanjaya, Y. Bindar, and A. Irawan, J. Chemurg, 3, 12 (2019)
[19] S.S. Harsono, P. Grundmann, and D. Siahaan, Energy Procedia, 65 (2015)
[20] Z. Liu et al., Fuel Process. Technol. 177, 228–236 (2018).
[21] J. Prasityousil, and A. Muenjina, Procedia Environ. Sci, 17 (2013)
[22] E.I. Rhofita, P.L. Hutardo, F. Miraux, The Characterization of Rice Straw Briquette as an Alternative Fuel in Indonesia. In Proceedings of the Built Environment, Science and Technology International Conference, (2018)
[23] Z. Liu et al., Bioresour. Technol, 249 (2018)
[24] I.S. Aisyah, A. Saifullah, T. Satya, U.M. Malang, Proses Desain Dan Pengujian Mesin Press Hidrolik. Semin. Nas. Teknol. dan Rekayasa, (2017).