2nd Proceeding of International Conference on Science and Technology UISU (ICST)
"Engineering for Suistanable Future: Innovation in Renewable Energy, Green Technology, and Circular Economy"
ISSN: 3063-7929 (Online)
DOI: https://doi.org/10.30743/icst

Utilization of Wood Powder Waste for Briquette Production Using the Taguchi Experimental Approach

Taufik Hidayat[1], Chitara Utami P.A.[2], Nukhe Andri Silviana*[3], Haniza[4]
[1,2,3]Department of Industrial Engineering, Faculty of Engineering, Universitas Medan Area, Indonesia
*nukheandri@staff.uma.ac.id

Abstract− UD. X is a home industry engaged in the production of stone mortars. The production capacity is approximately 30 pieces per day or 780 pieces per month, resulting in waste of about 60 kg per month. The goal of this research is to recycle waste from production into a commercially viable product, namely briquettes.There search method usedwas the Taguchi experimental design to determinethe optimal composition by varying supporting factor parameters in the briquette production from wood sawdust, including the amount of sawdust waste used and the raw material composition of the briquettes.The results indicated that the factorsaffecting the quality characteristics of briquettes from wood sawdust include the ratio of sawdust waste, tapioca flour, water, and drying time. ANOVA showed that the factor significantly affecting the quality characteristics of briquettes was the amount oftapioca flour at 35.00%, while the amount ofsawdust waste, water, and drying time do not significantly influence the briquette quality characteristics. It can beconcluded that briquettes can be produced using wood sawdust waste with a formulation based on SNR Smaller The Better, namely A1B1C1D1.

Keywords: Quality Engineering; Taguchi Experiment; Orthogonal Array; Briquette Quality

1. INTRODUCTION

Indonesia is oneof the tropical countries, and North Sumatra Province is one of them. There are numerous types of trees that can thrive in Indonesian soil, particularly in North Sumatra Province.Many large industries or home industries (Home Industry) attempt to utilize and process the woodavailable in their regions into marketable products.

UD. X is a home industry operating in the production of Lumpang. Woodis the primary raw material used at UD. LumpangIrwansyah. In October,approximately 30 pieces of Lumpang can be produced per day or 780 pieces per monthof Lumpang products. The waste generated by UD. LumpangIrwansyah consists of wood sawdustobtained from the lumpang production process. This wood sawdust waste can beconverted into an alternative energy source in the form of charcoal briquettes,which can be used by the community as an environmentally friendly alternativefuel.

From the results of observations conducted, it was found that wood sawdust waste can be recycled into products with commercial value, specifically charcoal briquettes. In every product manufacturing process, we must pay attention to the quality and quantity of the product. According to SNI 01-6235-2000, high-quality briquettes are those with a maximum ash and moisture content of 8% (Ardiansyah et al., 2022). The quality of these briquettes is also significantly influenced by their base materials, which include wood sawdust waste, cassava flour, water, and the duration of drying time. Therefore, in order to create optimal charcoal briquette quality, research is needed on the aspects that can affect the quality of wood sawdust charcoal briquettes, to identify control factors in the form of basic briquette materials that affect the ash and moisture content using Taguchi experimental design to obtain the best results for wood sawdust waste briquettes.

2. RESEARCH METHOD

This type of research is classified as experimental design. The purpose of this research is to determine the factors that can affect the quality of charcoal briquettes in accordance with SNI standards. The factors that can affect the quality of charcoal briquettes are measurements of moisture content, ash content, and the composition of raw materials so that sawdust charcoal briquettes can be produced with a quality that meets SNI standards. The data obtained from data collection was processed using the Taguchi Experimental Method, following three stages:

1) Planning Stage

The planning stage is important, as it allows researchers to learn various things from several experiments. Sometimes, the information obtained from an experiment can be both positive and negative. Positive information obtained includes indications of factors that do not affect the improvement of a product or process performance, but the factors that do affect it cannot be found. The planning stage includes determining the dependent variables, separating control factors and disturbance factors, determining the number of levels and factor levels, calculating the degrees of freedom, and selecting the orthogonal matrix.

2) Experimental Stage (Implementation)

The Experimental Stage (Implementation) is the stage when the results of the testing are collected. When the experiment is well-planned and executed, the analysis can be carried out much more easily and will yield positive

ISSN: 3063-7929 (Online)
DOI: https://doi.org/10.30743/icst

information about factors and levels. The experimental stage (implementation) involves determining the number of replications and the number of randomizations.

3) Analysis Stage

The Analysis Stage is the stage where the level of importance is relatively low in terms of whether an experiment will yield positive results. However, this stage is a statistical phase. The analysis stage includes Analysis of Variance, Factor Polling, F-Test, and S/N Ratio.

3. RESULT AND DISCUSSION

1. Briquette Production Process

The process of making charcoal briquettes from wood sawdust waste begins with charring and grinding. Whole wood sawdust is turned into charcoal through manual charring (burning). Once the charring process is complete, the charcoal from the wood sawdust is ground until smooth. After undergoing the carbonization and grinding processes, to obtain soft and fine charcoal, the charcoal is sieved using a 50-mesh sieve. The sieved wood sawdust charcoal is then mixed with a ratio of 90% wood sawdust charcoal and 10% tapioca flour adhesive, and thoroughly mixed to form a dough. After the ingredients are thoroughly mixed, the next step is to place them into a briquette machine mold or briquette-making tool. The next step is to dry the molded briquettes by sun-drying them under direct sunlight for 2–7 days. After completing all processing steps, the briquettes can be packaged.

2. Planning Stage

The level of factors used in the experiment is based on observations of sample tests conducted in the laboratory. The data for determining this level can be seen in Table 1.

Table 1. Determining the Number of Levels and Level Values of Factors

Code	Control Variable	Level1	Level2
A	Jumlah Limbah Serbuk Kayu	90gr	150 gr
B	Jumlah Tepung Tapioka	10gr	20gr
C	Jumlah Air	90ml	100 ml
D	Drying Time	7hari	10 hari

3. **Experimental Stage (Implementation)**

The quality testing of charcoal briquettes made from sawdust was conducted in a standardized laboratory. The experimental data from the orthogonal array experiments with each factor can be seen in Table 2.

Table 2. Experimental Results on the Quality of Wood Sawdust Briquette Products

Experiment	Orthogonal Matrix $L8(2^7)$							Briquette Product Quality		Average
	1	2	3	4	5	6	7			
	A	B	C	D	e	E	e	I	II	
1	1	1	1	1	1	1	1	10,2	7,22	8,71
2	1	1	1	2	2	2	2	10,4	8,26	9,33
3	1	2	2	1	1	2	2	10,6	7,40	9,00
4	1	2	2	2	2	1	1	10,7	7,93	9,31
5	2	1	2	1	2	1	2	9,7	8,15	8,95
6	2	1	2	2	1	2	1	9,5	8,25	8,87
7	2	2	1	1	2	2	1	9,6	7,46	8,53
8	2	2	1	2	1	1	2	8,2	7,16	7,68

2nd Proceeding of International Conference on Science and Technology UISU (ICST)
"Engineering for Sustainable Future: Innovation in Renewable Energy, Green Technology, and Circular Economy"
ISSN: 3063-7929 (Online)
DOI: https://doi.org/10.30743/icst

Table 3. Average Response to Product Factors

	A	B	C	D
First Level	9,08	8,96	8,79	8,85
Second Level	8,50	8,63	8,80	8,73
Selisih	0,58	0,33	0,01	0,12
Rating	1	2	4	3

Based on Table 3 above, it can be seen that factor A ranks first, which means that this factor has the greatest contribution to improving briquette quality based on the variance in moisture content and ash content values and is the most influential factor on briquette product quality and average briquette quality.

4. Analysis Stage

a. Calculation of the Effect of the S/N

Ratio Factor S/N (Signal-to-Noise) ratio analysis is used in selecting factors or levels that contribute to reducing the variation of a response.

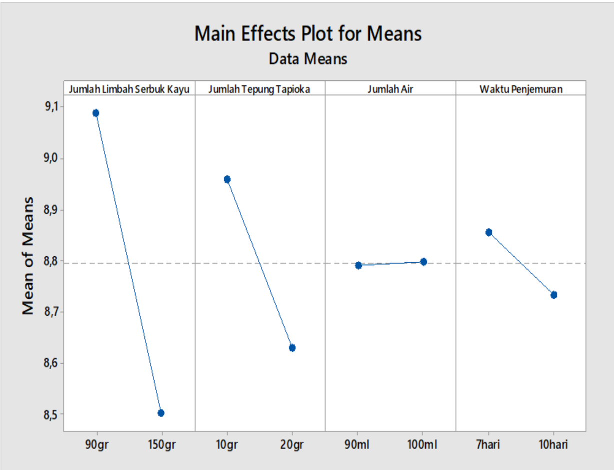

Figure 1. The Effect of Level on the Average Quality of Wood Powder Briquettes

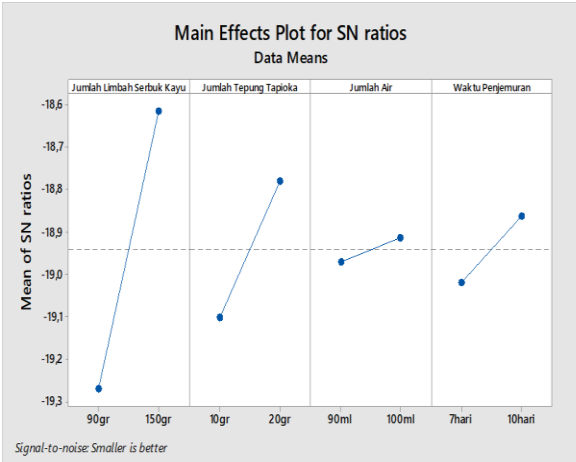

Figure 2. The Effect of Level on the Average SNR Quality of Wood Powder Briquettes

Based on the average results and Signal To Noise Ratio (SNR) for the quality of sawdust charcoal briquettes to assess moisture content and ash content, which can be interpreted in the form of a graph obtained from processing using Minitab 17 software, it can be seen that based on the effect of the average Signal To Noise Ratio (SNR) factor, i.e., Smaller The Better (the smaller, the better). If one wishes to obtain optimal charcoal briquette quality, the required composition ratio is as follows: 90 grams of wood sawdust waste at level 1 (A1), 10 grams of tapioca flour at level 1 (B1), 90 ml of water at level 1 (C1), and 7 days of drying time at level 1 (D1). The rankings and differences of each factor based on Signal to Noise calculations can be seen in Table 4.

Table 4. Signal to Noise Factor and Interaction Rankings and Differences

	A	B	C	D
First level	-19,26	-19,09	-18,96	-19,05
Second Level	-18,60	-18,77	-18,90	-18,75
Difference	0,66	0,32	0,06	0,30
Rating	1	2	4	3

ISSN: 3063-7929 (Online)
DOI: https://doi.org/10.30743/icst

b. Analysis of Variance

Table 5. Percentage Contribution Results

Source	Dof	SS	MS	F-Ratio	SS'	P(%)
A	1	0,6728	0,6728	0,80	0,1650	34,61%
B	1	0,2245	0,2245	0,26	0,6133	11,54%
C	1	0,1775	0,1775	0,21	0,6603	9,13%
D	1	0,0312	0,0312	0,03	0,8066	1,60%
Error	3	0,8690	0,2897	-	-	-
Amount	7	1,9750	1,3957	-	-	-

Factor A contributes the most to the quality of sawdust charcoal briquettes, at 34.61%. From Table 5. Hypothesis testing and conclusions with a 95% confidence level were conducted for factor A. The table value used was F(0.05;2;3) = 10.13. If the F test value is smaller than the F table value, then H0 is accepted, meaning there is no effect of the treatment. However, if the F value is greater than the F table value, then H0 is rejected, meaning there is an effect of the treatment.

c. Results of S/N Ratio Calculations for Confirmation Experiments

From the results of the confidence interval calculation at a 95% confidence level for the Taguchi experiment, which was then compared with the confidence interval for the confirmation experiment, it was found that the average in the experiment was within the Taguchi experiment confidence interval. The confidence interval can be seen in Table 6 below.

Table 6. Interpretation of the Results of Briquette Product Quality Calculations Based on SNI

Response	(Quality of sawdust briquettes)	Prediction	Optimization
Experimental Taguchi	Average **μ**	9,29	9,29± 0,74
	Variability(SNR)	-19,60	-19,60±0,81
Experimental Confirmation	Average **μ**	9,85	9,85± 0,44
	Variability(SNR)	-27,69	-27,69±0,36

The results of the Taguchi experiment to the confirmation experiment showed an increase in the average and variability. This means that the quality of briquette products based on SNI is better using the combination of factors and optimal levels of the Taguchi experiment results. The table also shows that the confidence interval of the confirmation experiment is within the confidence interval of the Taguchi experiment results, so the combination of factors and factor levels of the Taguchi experiment design is valid and acceptable.

4. CONCLUSION

After conducting research and experiments on the utilization of sawdust waste as biomass charcoal briquettes with briquette quality testing based on SNI, several conclusions can be drawn, namely:

1. Based on the factor analysis, the factors influencing the moisture content and ash content of wood sawdust charcoal briquettes are wood sawdust waste (A1), tapioca flour (B1), water (C1), and drying time (D1). Based on the comparison between the F-ratio and F-table in the pooling strategy, the factors significantly influencing the moisture content and ash content of charcoal briquettes are factor A (amount of wood sawdust waste) at 21.70% and factor B (amount of tapioca flour) at 35.00%.
2. Based on the response to the influence of factors and the Signal-to-Noise Ratio, the optimal composition of wood sawdust charcoal briquettes was obtained from the comparison of factors A (amount of wood sawdust waste): factor B (amount of tapioca flour): factor C (amount of water): factor D (drying time) in the following order: level 1 (90 g): level 1 (10 g): level 1 (90 ml): level 1 (7 days).

ISSN: 3063-7929 (Online)
DOI: https://doi.org/10.30743/icst

REFERENCES

[1]. Aprilyanti, S., & Suryani, F. (2020). Penerapan Desain Eksperimen Taguchi Untuk Meningkatkan Kualitas Produksi Batu Bata Dari Sekam Padi. *J@ Ti Undip: Jurnal Teknik Industri*, *15*(2), 102–108.
[2]. Ardiansyah, I., Putra, A. Y., & Sari, Y. (2022). Analisis Nilai KalorBerbagai Jenis Briket Biomassa Secara Kalorimeter. *Journal of Research and Education Chemistry*,*4*(2), 120.
[3]. Aziz, M. R., Siregar, A. L., Rantawi, A. B., & Rahardja, I. B. (2019). Pengaruh Jenis Perekat Pada Briket Cangkang Kelapa Sawit Terhadap Waktu Bakar. *Prosiding Semnastek*, 1– 10.
[4]. Erita, E. (2021). Analisis Kandungan pH, Ca dan Mg, Dengan Persentasi Penggunaan Perekat Tepung Kanji Untuk Pembuatan Pupuk Organik. *Biram Samtani Sains*, *5*(1), 1–20.
[5]. Polewangi, Y. D., Siregar, N. A., Silviana, N. A., & Delvika, Y. (2021). *Pengantar Teknik Industri*. Universitas Medan Area Press.
[6]. Halimah, P., &Ekawati, Y. (2020). Penerapan Metode Taguchi untukMeningkatkanKualitas Bata Ringan pada UD. XY Malang. *JIEMS (Journal of Industrial Engineering and Management Systems)*, *13*(1), 1–14.
[7]. Indrawati,D.,Sutoni,A.,&Putro,B.E.(2021).*PenerapanDesainEksperimenTaguchiUntukOptimasiKuatTekanBatako(StudiKasusTB.Intan Jaya)*.