Technologies of Sustainable Development

Selected peer-reviewed full text papers from the 3rd Borneo International Conference on Applied Mathematics and Engineering (3rd BICAME)

Edited by
Andromeda Dwi Laksono

TRANS TECH PUBLICATIONS

Technologies of Sustainable Development

Selected peer-reviewed full text papers from the
3rd Borneo International Conference on
Applied Mathematics and Engineering
(3rd BICAME)

Selected, peer-reviewed papers from the
3rd Borneo International Conference on
Applied Mathematics and Engineering 2020
(3rd BICAME 2020),
September 9-10, 2020, Balikpapan, Indonesia

Edited by

Andromeda Dwi Laksono

Scientific.Net

Trans Tech Publications Ltd
Kapellweg 8
CH-8806 Baech
Switzerland
http://www.scientific.net

Volume 104 of
Advances in Science and Technology
ISSN print 1662-8969
ISSN cd 1661-819X
ISSN web 1662-0356

Full text available online at *http://www.scientific.net*

***Distributed** worldwide by*

Trans Tech Publications Ltd
Kapellweg 8
CH-8806 Baech
Switzerland

Phone: +41 (44) 922 10 22
Fax: +41 (44) 922 10 33
e-mail: sales@scientific.net

List of Committee

General Chairman

Elin Diyah Syafitri, ST., M.T

Steering Committee

Prof. Ir. Budi Santosa, Ph.D
Nurul Widiastuti, S.Si., M.Si., Ph.D
Dr. Muhammad Mashuri, M.T.
Dr. Moch Purwanto, S.Si., M.Si

Secretary

Bima Catur Apriadi

Treasurer

Kamilina Rhodiyah, S.E.I

Technical Committee

Dr. Eng. Lusi Ernawati, S.T., M.Sc.
Nadia Almira Jordan, S.T., M.T
Winarni, S.Si., M.Si.
Intan Dwi Setyo Rini, S.T., M.T.
Muchammad Chandra Cahyo Utomo, M.Kom.
Nur Fajri Azhar, S.Kom., M.Kom.
Syalam Ali Wira Dinata .S., S.Si., M.Si.
Syamsul Mujahidin, S.Kom., M.Eng.
Ainun Zulfikar, S.T., M.T
Diniar Mungil Kurniawati, S.T., M.T.
Andromeda Dwi Laksono, S.T.,M.Sc
Annisa Rahmita Soemarsono, S.Si, M.Si
M. Gilvy Langgawan Putra, S.Kom., M.MT
Trisnadi Bagus Arifianto, S.Kom.

Scientific Committee

Luh Putri Adnyani, S.T.,M.T.
Ardiansyah Fauzi, S.T.,M.Eng.
Riki Herliansyah, S.Si.,M.Sc.
Yunita Triana, S.Si, M.Si
Happy Aprillia, S.T., M.T., M.Eng.
Cut Keumala Banaget, S.T, M.T.
Thorikul Huda, S.T., M.T.
Riyan Benny Sukmara, S.T., M.T.

Adi Mahmud Jaya Marindra , S.T.,M.Eng.
Teodoro Astorga Amatosa, Jr., D.Eng.
Handriyanti Diah Puspitarini, ST, MT, MSc, PhD
Ima Mufidah S.T., M.T., M.B.A., Ph.D.
Julian Supardi, M.T.
Dr. Ir. Isna Yuniar Wardhani, MP.
Subchan, Ph.D.
Dr. Suhartono
Bima Prihasto, S.Si., M.Si.
Rahmat Aris Pratomo, S.T., M.T., M.Sc.
Fandisya Rahman, S.Kom., M.Kom.
Dr. Dra. Mardlijah, MT.
Dr.-Ing. Victor Yuardi Risonarta, ST M.Sc.

Table of Contents

Advances in Science and Technology
ISSN: 1662-0356, Vol. 104, pp 89-94
doi:10.4028/www.scientific.net/AST.104.89

Submitted: 2020-08-03
Revised: 2020-10-26
Accepted: 2020-10-26
Online: 2021-02-09

The Influence of Energy Released and Machine Performance on the Yield of Biochar from Jengkok Tobacco Processed Using Pyrolysis

Taufik Iskandar[1,a], Ayu Chandra Kartika Fitri[2,b]*, SP. Abrina Anggraini[3,c]

[1,2,3]Department of Chemical Engineering, Faculty of Engineering, Tribhuwana Tunggadewi University, Malang, 65144, East Java, Indonesia

[a]email: taufik.iskandar@unitri.ac.id
[b]*Corresponding author: ayu.chandra@unitri.ac.id HP. +6285797094724
[c]email: abrina@unitri.ac.id

Keywords : jengkok tobacco, biochar, yield percentage, lost energy, machine performance

Abstract. The pyrolysis process of jengkok tobacco is influenced by the quality of the raw material, production machine, process parameters and production yield standards. Optimal process requires efficiency and effectiveness of the usage of energy and machine, because all of those affect the quantity and quality of the end products. The purpose of this study was to determine the effect of energy released and machine performance on the percentage of Jengkok Biochar Yield produced through the pyrolysis process. The primary data was obtained directly from the production process. Variables used were temperature (510°C, 515°C, 520°C) and processing time (30 minutes, 35 minutes, 40 minutes). This study found that the most efficient energy required was at the temperature of 520°C and 35 minutes time period, so that the energy released decreased while the machine performance increased and the % yield was higher.

Introduction

Production process involves an interaction between raw materials, production machines, processing parameters and production results standards. The efficiency and effectiveness of the factors must be considered to achieve the most optimum process. High temperature in the pyrolysis process causes oxidation which can break down the chemical compounds into carbon. According to James G. Speight (1994) pyrolysis is a complex process, in which organic compounds in biomass are decomposed through heating in the absence of oxygen [1]. Thus, only the volatile matter is released, while the carbon remains in it. In other words, the Pyrolysis process produces solids, liquids and gases [2]. The percentage of the product is influenced by the factors related to the operational process such as the temperature and duration the material stays in the reactor. In addition, the number of carbon atoms in biomass chemical compounds can affect the number of carbon in the charcoal, so that the increase of carbon is linier with the increase in the carbonization temperature. According to M. Tirono & Ali Sabit (2011), carbon is formed well at temperatures between 300^0C and 500^0C and will cause smoke due to the release of volatile elements [3].

Heat can flow from an object that has a high temperature to other that has a low temperature. The amount of heat absorbed or released by an object is directly related to the mass of the object, the heating value, and changes in temperature. The heat of a system's chemical reaction can be released (exotherm) or absorbed (endotherm). The quality of heat added to an object is positive and the quantity leaving an object is negative. So the heat energy generated from the combustion process of hydrocarbon compounds is the most important. Appropriate and efficient energy management is an important step in the effort to save production costs as a whole. The use of equipment or machinery in a production activity contributes greatly to the amount of output produced.

Effectiveness is also required in a process that measures the percentage of the output of a production system. This can be done by comparing the ratio of actual output with the planned output. Efficiency is a measure of actual (actually produced) output in effective capacity [4]. Thus, efficiency is a measure that shows how well resources are used in the process of producing output. In addition to making efficiency on the factors of production, maintenance of the machine will provide many benefits for the smooth production process. According to Setiawan (2008:9), a decrease in engine performance is caused by overload, fatigue, corrosion which reduce surface area, or changes of shape [5].

It is important to know the effect of lost energy and engine performance on the percentage of Jengkok Biochar yield produced through Pyrolysis process. This research is aimed to understand (1) the effectiveness of heat used by calculating lost energy (Q loss), (2). the optimum machine performance. The results of this study is important to achieve optimum production process with efficient energy requirements and engine performance as well as the effective use of temperature and processing time, therefore can produce standardised products.

Research Methods

This research was conducted for five months at PT. Gudang Garam Tbk Kediri by using a case study method. Analysis on the existing problems was conducted by observing the production process and investigating its efficiency and effectiveness. The results were reported and discussed using descriptive methods by providing systematic, factual, and accurate description of the object under study. The primary data was the data obtained directly from the production process. The variables include the temperature of the pyrolysis process (510^0C, 515^0C, 520^0C) and processing time (30 minutes, 35 minutes, 40 minutes).

Materials and Machines

The material used is Jengkok Tobacco, with a moisture content of 10% -15% and weight per batch was 200 kg. The equipment used was pyrolysis machines.

Research Procedure

The use of Jengkok directly is considered inefficient and needs to be converted into biochar using pyrolysis process [6]. The pyrolysis process was preceded by the collection of Jengkok tobacco raw materials from cigarette production waste and then measuring the moisture content, noting it must notexceed 10% by weight of the material. The carbonization process was then carried out using a pyrolysis machine at the temperature and processing time according to the predetermined variables. Observations were made during the production process which include: initial weight of jengkok tobacco waste, biochar weight produced, temperature of jengkok raw material and biochar temperature produced. After the required data was complete, the percentage of yield was calculated using certain formula :

$$\% \, Yield \, Biochar = \frac{\text{Biochar Weight}}{\text{Jengkok material weight}} \times 100\,\% \qquad (1)$$

$$\text{The Percentage of the missing components} = 100\% \text{ Weight of Biochar} - \%\text{ Yield Biochar} \qquad (2)$$

Furthermore, the other existing data is used to calculate the released energy (Q loss) and machine Performance. The data was analysed using correlation test, using Spearman rank, because based on the results of the normality test, the data distribution was not normal.

Results and Discussions

The results of the calculation of % Yield and % components of the missing can be presented in the following table 1.

Table 1. The Percentage of Yield and Components of Missing

Temp. (°C)	Time (menit)	Weight of Material (kg)	Weight of Biochar (kg)	Yield (%)	Component loss (%)
510	30	200	59,7	29,85%	70,15%
510	35	200	59,9	29,95%	70,05%
510	40	200	56,4	28,20%	71,80%
515	30	200	56,8	28,40%	71,60%
515	35	200	49,7	24,85%	75,15%
515	40	200	52,4	26,20%	73,80%
520	30	200	59,1	29,55%	70,45%
520	35	200	58,5	29,25%	70,75%
520	40	200	53,3	26,65%	73,35%

Currently to calculate the released energy (% Q loss) used the formula [7]:

$$Q\ loss = Q1 - Q2 + (V2^2 - V1^2) / (2.\ go.\ J) \quad (3)$$

where :

Q1 = energy released by jengkok tobacco before entering pyrolysis
Q1 = cp of jengkok tobacco x T jengkok tobacco
cp of jengkok tobacco = specific heat of jengkok tobacco (1.81 J/g^{0}K) Perry, 2008 [8]
T jengkok tobacco = temperature of jengkok tobacco
Q2 = energy released by charcoal of jengkok tobacco after leaving pyrolysis
Q2 = cp of charcoal of jengkok tobacco x T of charcoal of jengkok tobacco
cp of jengkok tobacco = specific heat of charcoal of jengkok tobacco (= 7.9320 KJ/kg^{0}C) Perry, 2008 [8]
T of charcoal of jengkok tobacco = temperature of jengkok
V1 = flow rate of jengkok tobacco (kg / h)
V2 = the flow rate of charcoal of jengkok tobacco (kg / h)
go = standard gravity speed = 981.46 cm/s^2
J = Conversion number; 778.16 ft.lb / BTU = 101.97 m.kg / k

The calculation of Performance Machines used the formula :

$$\frac{\text{weight of biochar (kg)}}{\text{Pyrolysis duration (hour)}} \times \text{length of the Reactor (m)} \quad (4)$$

The results of the calculation of the released energy and machine performance can be seen in the table 2 below:

Table 2. The Results of Calculation of Amount of Energy Released (Q Loss) and Machine Performance

Temp. (°C)	Time (minute)	Weight of Material (kg)	Weight of Biochar (kg)	Yield (%)	Component loss	Q loss (KJ/kg)	Machine Performance
510	30	200	59,7	29,85%	70,15%	-304.503	17,05714
510	35	200	59,9	29,95%	70,05%	-290.304	17,11429
510	40	200	56,4	28,20%	71,80%	-284.350	16,11429
515	30	200	56,8	28,40%	71,60%	-275.336	13,91100
515	35	200	49,7	24,85%	75,15%	-284.533	12,17212
515	40	200	52,4	26,20%	73,80%	-245.306	12,83339
520	30	200	59,1	29,55%	70,45%	-293.044	12,66365
520	35	200	58,5	29,25%	70,75%	-262.980	12,53509
520	40	200	53,3	26,65%	73,35%	-255.663	11,42086

Statistical Analysis

Data analysis was carried out to determine the correlation between temperature, duration, energy released, and machine performance. The correlation test results are presented in the Table 3 below.

Table 3. Correlation Factors

		Yield	Energy released	Machine Performance
Temp.	Correlation Coefficient	,415	,262	,371
	Sig. (2-tailed)	**,124**	,345	**,173**
	N	15	15	15
Time	Correlation Coefficient	-,265	,019	**-,548***
	Sig. (2-tailed)	,341	,947	**,034**
	N	15	15	15

From the Table 3, the correlation coefficient between the temperature and yield is 0.415 and the sig. value is 0.124. This sig value is smaller than 0.2 (20%) so that there is a significant relationship between temperature and yield. Besides temperature, it also has a significant relationship with machine performance. for the duration variable, the sig value is 0.034 with machine performance. The correlation coefficient between duration and engine performance is -0.548. This means that the longer the time, then lower the machine performance.

Temperature and Time Analysis of Yield

The purpose of this study is to analyze the effect of temperature and duration variables on yield, energy released, engine performance. In this experiment, a factorial experimental design was used with two factors: temperatures which consist of three levels, and duration which consist of three levels.

Table 4. Analysis on the Temperature and Duration of Yield

General Factorial Regression: Yield versus Temperature; Time

Factor Information

Factor	Levels	Values
Temp.	3	1; 2; 3
Time	3	1; 2; 3

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	6	208,22	34,703	2,36	0,130
Linear	6	208,22	34,703	2,36	0,130
Temp	4	190,42	47,605	3,23	0,074
Time	2	17,80	8,898	0,60	0,570
Error	8	117,88	14,735		
Total	14	326,09			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
3,83858	63,85%	36,74%	0,00%

Based on the factorial analysis table of temperature and duration to yield, the significance value (p-value) was obtained for the variable temperature of 0.074 and for the duration variable of 0.57. The sig value of the duration variable is smaller than 0.2 (20%) means there is no effect of duration on the yield value. The lowest yield value was resulted at the first temperatures level

(510°C). When the temperature was raised there was an increase in yield. The longer the time there yield was more likely to decrease. However, at the temperatures of 510°C and 515°C at the second level of time (35 minutes) there was an increase.

Analysis on the Temperature and Duration against Machine Performance

Table 5. Analysis of Temperature and Time Duration against Machine Performance

General Factorial Regression: machine performance versus Temp; Time

Factor Information

Factor	Levels	Values
Temp.	3	1; 2; 3
Time	3	1; 2; 3

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	6	135,54	22,590	3,68	0,047
Linear	6	135,54	22,590	3,68	0,047
Temp.	4	82,51	20,627	3,36	0,068
Time	2	53,03	26,517	4,31	0,054
Error	8	49,17	6,146		
Total	14	184,71			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2,47909	73,38%	53,42%	6,42%

The p-value (sig) of the temperature test and duration was 0.068 and 0.054. The p-value of these two variables was smaller than 0.2 so that there was a significant effect of temperature and duration variables againts performance. There was an increase in the machine performance when there was a temperature increase from temperature at level one (510^0C) to temperature at level three (520^0C). Then increase of temperature and duration did not always improve machine performance.

Analysis of Temperature and Duration of Released Energy

Table 6. Analysis of Temperature and Duration of Released Energy

General Factorial Regression: Energy release versus Temp.; Time

Factor Information

Factor	Levels	Values
Temp.	3	1; 2; 3
Time	3	1; 2; 3

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	6	851,5	141,9	0,30	0,918
Linear	6	851,5	141,9	0,30	0,918
Temp.	4	632,8	158,2	0,34	0,845
Time	2	218,8	109,4	0,23	0,797
Error	8	3747,3	468,4		
Total	14	4598,8			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
21,6428	18,52%	0,00%	0,00%

The p-value (sig) of the temperature and time tests are 0.845 and 0.797. The p-value of the two variables wass greater than 0.2, so there was no significant effect on the temperature and time variables on the energy released. An increase in temperature into third level (520°C) increased the energy released but at the first level temperature (510°C) there was a decrease in the energy released. Fluctuations occured when duration was changed. The biggest energy released occured at the second time (35 minutes), while at the third (40 minutes), there was decrease in the amount of energy released. It indicates the absence of clear pattern or fluctuations of the energy released when there was an increase in temperature and duration.

Conclusions

The results of the analysis carried out in the Biochar production process using Pyrolysis Machines for temperature and processing time can be concluded that there was a correlation and interplay between temperature and processing time with % yield, released energy and machine performance. At a temperature of 520 $^{\circ}$C and a time of 35 minutes, the energy released decreased while the machine performance increased and the % yield was higher.

Acknowledgements

Researchers acknowledges the supports from PT. Gudang Garam Tbk, all the staff and employees at the production process and the Laboratory, who have provided serious assistance, so that this research can be completed.

References

[1] J.G. Speight, *The chemistry and technology of coal, third edition*. 2012.
[2] C. Di Blasi, “Modeling chemical and physical processes of wood and biomass pyrolysis,” *Prog. Energy Combust. Sci.*, vol. 34, no. 1, pp. 47–90, 2008.
[3] M.T. Ali Sabit, “EFEK SUHU PADA PROSES PENGARANGAN TERHADAP NILAI KALOR ARANG TEMPURUNG KELAPA (Coconut Shell Charcoal),” *J. NEUTRINO*, 2012.
[4] J. Heizer and B. Render, “Principles of Operations Management,” *Genes Genet. Syst.*, 2006.
[5] F.D. Setiawan, *Perawatan Mekanikal Mesin Produksi*. Yogyakarta: Maximus, 2008.
[6] A. V Bridgwater, “Renewable fuels and chemicals by thermal processing of biomass,” *Chem. Eng. J.*, vol. 91, no. 2, pp. 87–102, 2003.
[7] D.Q. Kern, *Process Heat Transfer*. New York: McGraw-Hill, 1965.
[8] R.H. Perry, *Perry’s chemical engineers’ handbook*. McGraw-Hill, 2008.