COCONUT SHEEL CARBONIZATION PROCESS USING SMOKELESS KILN

by K M

Submission date: 26-Apr-2023 12:44AM (UTC-0400)
Submission ID: 2075826542
File name: 135-Article_Text-1437-1-18-20230413.docx (1.34M)
Word count: 3115
Character count: 17801

Journal of Applied Agricultural Science and Technology
x(x): x-x (xxxx)
E-ISSN: 2621-2528
ISSN: 2621-4709

COCONUT SHEEL CARBONIZATION PROCESS USING SMOKELESS KILN

Rudi Kurniawan Arief *[1], Armila[1], Arie Liswardi[1], Hanafi Yahya[1], Mahammadsalman Warimani[2], Perdana Putera[3]

[1]Department of Mechanical Engineering, Universitas Muhammadiyah Sumatera Barat, Bukittinggi, Indoneia
[2]Department of Mechanical Engineering, Arvind Gavali College of Engineering Satara, Maharashtra, India
[3]Department of Agricultural Technology, Politeknik Pertanian Negeri Payakumbuh, 50 Kota, Indoneia

*Corresponding author
Email: rudikarief@umsb.ac.id*

***Abstract**. Coconut shells charcoal has high economic and environmental value if processed properly. Activated carbon and bricquete are the most utilization of the coconut shell. This valuable products obtained after carbonization process of the coconut shell. The traditional carbonization process uses a kiln to burn the coconut shell, but this burning process creates plenty of smoke that pollutes the environment and disturbs human activities. To solve this problem and to increace its environmental value, a carbonization kiln in which produce less smoke is required. In this research, a kiln made of a steel drum equipped with a sealer belt to keep the burning smoke trapped inside the kiln is fabricated. The result showed that the addition of this belt effectively reduce the smoke significantly and more friendly to the environment. For the production efficiency of the charcoal, a 15 kg coconut shell produces 6 kg of charcoal, a 20 kg coconut shell produces 9 kg of charcoal, and a 20 kg coconut shell produces 12 kg of charcoal in 150 minutes, with a percentage of 40%, 45% and 48% carbonization respectively. Finally, it is proved that burning with a mass of 25 kg is the optimal result yielding 48% of charcoal content.*
Keywords: Smokeless kiln, coconut charcoal, carbonization

1. Introduction

Coconut (*Cocos nucifera*) is one of the most contributing plants to the local economy, where about 92 countries all around the world planted this variety on approximately 11.8 million hectares of land (Doe *et al*., 2022). Lies in the tropical area, Indonesia has become one of the largest coconut producers, with 3.37 million hectares of this coconut planted (Badan Pusat Statistik, 2021). The utilization of this plant is still being studied and developed to gain optimum result (Budi, 2011; Intara *et al*., 2021; Ahmad *et al*., 2022). The coconut consists of coconut water, meat, a shell and a thick coir, where the weight of the coconut shell is about 15-19% of the overall weight (Suhartana, 2006). Even though the coconut shells and coir are considered waste, all parts of this coconut still have economic value, and the shell can process as activated carbon or biofuel (Arena *et al*., 2016). In most Asian and African countries, the coconut is used as cooking ingredients while the shells are left unused and become waste. Coconut shell waste usually just piled up and could cause environmental issues (Ikumapayi *et al*., 2020; Ningsih & Hajar, 2019; Soka & Oyekola, 2020). It is considered to be essential to increase the value of coconut waste by converting it into more valuable products to help solve environmental issues especially when carbonized in a proper

Received xxxxx xx, xxxx; Accepted xxxxx xx, xxxx; Published xxxxx xx, xxxx
https://doi.org/10.32530/jaast.

way (Ahmad *et al*., 2022; Parshiwanikar & Handa, 2022). This effort could increase the local economy and in line with the world's SDG (Sustainable Development Goals) (Susanto *et al*., 2022). The charcoal also have several advantages such as can be stored for long time, high heating value and cheap (Sangsuk et al., 2020).

One of the easiest methods to increase the value of coconut waste is to process the coconut shell into charcoal. Processing coconut shells into charcoal is one of the business opportunities that can be considered because it has many functions such as fuel, beauty products, activated carbon, briquettes, water filters, and many others (Ikumapayi *et al*., 2020).

Coconut shells charcoal (CSC) has an excellent opportunity to produce as raw materials for activated carbon (AC) where production quantity in Indonesia alone could reach 66,200 tonnes annually, 12% of all the activated carbon raw materials source (Arena *et al*., 2016; Lutfi *et al*., 2021). The enormous application of AC for water purification and wastewater treatment has created a higher demand for this product, it is because of the excellent mechanical properties, high porosity and surface area of the AC made from CSC (Leman *et al*., 2021; Nyamful *et al*., 2021). The production of AC from CSC is relatively easy and can be produced by a small company or home industry (Lutfi *et al*., 2021).

Another utilization of the CSC is as raw materials for briquet. Briquet is an alternative energy in solid form by compacting process of charcoal, as an alternative source of fuel the charcoal source should have flammable elements (Setyawan & Ulfa, 2019). One of the best sources of raw materials for briquet is the CSC because it has good thermal diffusion properties (Pujasakti & Widayat, 2018). This briquet from Indonesia is known to have excellent quality and is in high demand by Turkey, Brazil and also from several Latin American and European countries (Indonesia, 2021). Because the CSC is made of natural resources then the availability of these raw materials can be planned and available locally (Sanjaya *et al*., 2016).

The CSC is made by using a carbonization process by gradually heating the CSC until 400°C to 600°C temperature reached (Jamilatun & Setyawan, 2014; Nurdin & Nurdiana, 2017; Parshiwanikar & Handa, 2022). The first process in this carbonization is the preparation of the coconut shell, this step is to clean up the impurity materials such as coconut fibres, sand, ashes and soil (Maryono *et al*., 2013). This cleaning process is vital because excessive impurity materials may block pores and produce low-quality CSC materials especially to make AC (Schröder *et al*., 2006).

The traditional carbonization process is using a kiln to burn the coconut shell. The kiln may be made of a brick furnace (Budi, 2011; Nurdin & Nurdiana, 2017), or a steel drum (Ekalinda, 2001; Hudaya & Hartoyo, 1990). A proper carbonization kiln could produce high yield and better quality chalcoal (Intara *et al*., 2021). The coconut shells burned out for 4 to 6 hours with the upper kiln left to be open until the smoke starts to clear. After being burnt out the shell is cooled down for 1 hour and then sorted to separate the charcoal and the half-burned shell (Hudaya & Hartoyo, 1990; Khambali *et al*., 2022; Maryono *et al*., 2013; Nurdin & Nurdiana, 2017). Not all 100% of raw coconut shells could be processed to become charcoal, most of them became ashes (Table 1). The disadvantage of this process is the smoke produced from the burning process of the coconut shell (Figure 1). The burning process created a lot of smoke that pollutes the air and disturbs human activities, therefore a new design of charcoal carbonization with less smoke is still required. This research aimed to develop a carbonization kiln using a steel drum that could reduce smoke produced by the process and produce maximum amount of charcoal from coconut shell by trapping the smoke inside of the kiln and examined the carbonization result.

Table 1. Percentage of charcoal produced from coconut shell

No	Researchers	Klin type	Char percentage
1	(Maryono *et al*., 2013)	Steel Drum	30%
2	(Hudaya & Hartoyo, 1990)	Steel Drum	37.2%
3	(Budi, 2011)	Brick Furnace	35%
4	(Soolany, 2017)	Steel Drum	21.4%
5	(Nurdin & Nurdiana, 2017)	Brick Furnace	30%
6	(Manatura, 2021)	Large Scale Industrial Steel Drum	35% -45%

Figure 1. The carbonization process created a lot of smoke that pollutes the air

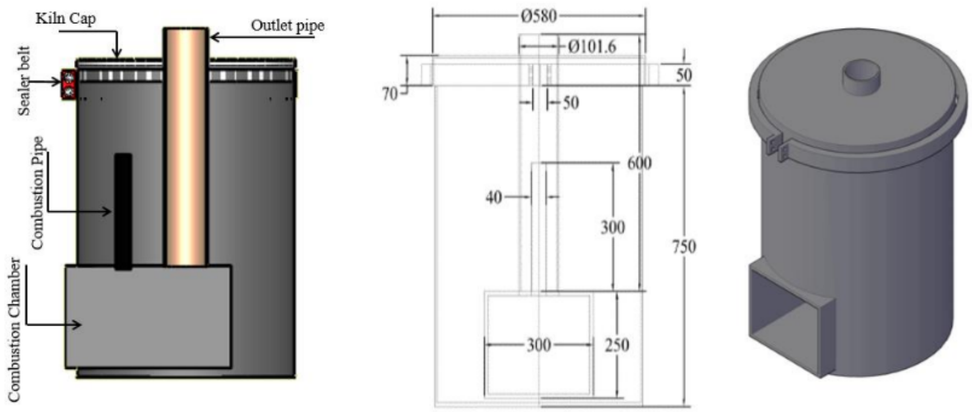
2. Methods

The kiln is designed based on previous research using a steel drum (Table 1) with modifications to keep the burning smoke trapped inside the kiln, this type already developed by Manatura *et al*. in industrial scale that might be too expensive for the home industry (Manatura, 2021).

Table 2. Comparison of kiln specifications

No	Configuration	Design by Manatura et. al.	Current Design
1	Insulator	Ceramic	No Insulation
2	Capacity	200 liter	200 liter
3	Kiln Material	Rolled steel sheet	Used lubricant drum

This kiln uses a used steel drum which is modified to add a combustion chamber system and the reactor lid (Figure 2). The combustion chamber uses two channels for better heat distribution, a small and short pipe used as the combustion channel and a big pipe to release the smoke from the combustion chamber. A closing lid was added to isolate the smoke and an additional sealer belt was also prepared for tighter smoke sealing. This sealer belt is made of steel plate coated with asbestos and tightened using 2 bolts to ensure no smoke escapes from the kiln when burned.



(a) (b) (c)

Figure 2. Smokeless carbonization kiln design

The kiln was tested by neatly arranging the coconut shell and then burning it to observe the amount of charcoal produced for 150 minutes (Figure 3). The smoke produced by the kiln during the process was also observed visually. The loss of heat is calculated by retrieval of data on the initial wall temperature and wall temperature during the burning process using equation (1) and the response data is taken every 15 minutes (Belu, 2020).

$$Q_L = U \cdot A(T_d - T_{link}) \quad (1)$$

The experiment was conducted 3 times using the capacity of 15kg, 20kg and 25kg using the coconut shells and the percentage of charcoal produced was calculated using equation (2).

$$P = \frac{output}{input} \times 100 \quad (2)$$

Figure 3. The coconut shells were arranged neatly to fill up the kiln.

3. Results and Discussion

3.1. Result

The temperatures during the process are recorded every 15 minutes during the carbonization process. The temperatures collected from the 3 experiments were then calculated to obtain the heat loss data (Table 3).

Table 3. Heat loss data

Heating Response Time (minute)	Capacity 1 (15 kg)	Capacity 2 (20 kg)	Capacity 3 (25 kg)
0	1,707.5	1,707.5	426.8
15	3,415.0	2,134.4	2,347.8
30	5,547.4	2,561.2	3,628.4
45	6,189.7	3,628.4	4,482.2
60	6,404.2	4,268.8	5,122.5
75	7,256.9	5,549.4	5,976.3
90	8,751.1	8,110.7	7,470.4
105	9,177.9	5,976.3	7,897.2
120	9,604.8	5,122.5	8,324.1
135	9,391.3	5,122.5	7,683.8
150	8,751.1	5,122.5	7,470.4
Total	76,196.9	49,304.2	60,829.9

The smoke was observed during the burning process with the kiln equipped with and without sealer. In the first experiment, the kiln without sealer still produces a large amount of smoke (Figure 4). For the second experiment, the sealer belt is installed, and very thin smoke still appears but is significantly reduced from the first attempt (Figure 5). Full kiln capacity of 25 kg yielding 48% of the charcoal (Table 4, Figure 6)

Figure 4. Thick smoke produced by kiln without sealer

Figure 5. Very thin smoke appears at the kiln with sealer

Figure 6. Kiln capacity before and after the carbonization process

Table 4. Result of the carbonization process

Experiment	Capacity (kg)	Result (kg)	Percentage (%)
1	15	6	40
2	20	9	45

3	25	12	48

3.3. Discussion

Observation during the burning process shows that the kiln with a kiln cap to close the upper side is not enough to reduce the amount of smoke released to the environment (Figure 4). Therefore the sealer belt needs to be installed. Figure 5 shows that the significance of smoke reduced during the process after the sealer belt was installed. Very thin smoke still appears as the effect of the wood used as burning fuel. Compared to other methods (Figure 1, Figure 4), the kiln with a sealer belt successfully reduces the smoke that pollutes the environment. This design is suitable to use by the home industry that does their production in the settlement, whereas before, they have to bring and burn the coconut shell far away from the settlement.

Table 1 shows that the more coconut shell burned, the less loss of heat value obtained. An anomaly was found in the 2nd data where heat loss decreased after minutes of 100, this oddity was caused by the wood fuel that ran out and no stock available to add. In the 3rd experiment, everything is maintained back to normal. The full capacity of a 25 kg coconut shell yields the lowest heat loss, which means that the heat produced could be utilized effectively to burn the coconut shell inside.

During the carbonization process, a 15 kg coconut shell produces 6 kg of charcoal, a 20 kg coconut shell produces 9 kg of charcoal, and a 20 kg coconut shell produces 12 kg of charcoal in 150 minutes, with a percentage of 40%, 45% and 48% respectively. Based on the test, it was found that burning with a mass of 25 kg is the optimal result yielding 48% of charcoal content (Table 3). This result set the highest production rate among other methods (Table 1).

4. Conclusions

Based on the observation, this kiln design shown significant reduction of the smoke produced during the coconut shell carbonization process. The smoke can not completely remove because of the effect of wood burning as fuel but highly reduce compared to other methods. Using the kiln to its maximum capacity of 25 kg was the best choice for having the lowest heat loss in the system and producing the most coconut charcoal after the carbonization process. This kiln could produce 48% coconut charcoal from 25 kg of coconut shell. Based on these results, this kiln is suitable to be used by homes and small industries located in the settlement area to help the industry to improve its productivity, reduce costs and be environmentally friendly. Further research requires to measure this result using air pollution measuring devices.

BIBLIOGRAPHY

Ahmad, R. K, Sulaiman, S. A., Yusup, S., Dol, S. S., Inayat, M., & Umar, H. A. (2022). Exploring the potential of coconut shell biomass for charcoal production. *Ain Shams Engineering Journal*, *13*(1), 101499. https://doi.org/10.1016/j.asej.2021.05.013

Arena, N., Lee, J., & Clift, R. (2016). Life Cycle Assessment of activated carbon production from coconut shells. *Journal of Cleaner Production*, *125*, 68–77. https://doi.org/10.1016/j.jclepro.2016.03.073

Badan Pusat Statistik. (2021). *Luas Tanaman Perkebunan Menurut Provinsi 2019-2021*. https://www.bps.go.id/indicator/54/131/1/luas-tanaman-perkebunan-menurut-provinsi.html

Belu, R. (2020). *Building Electrical Systems and Distribution Networks: An Introduction* (1st ed.). CRC Press. https://doi.org/https://doi.org/10.1201/9780429173455

Budi, E. (2011). Tinjauan Proses Pembentukan dan Penggunaan Arang Tempurung Kelapa Sebagai Bahan Bakar. *Jurnal Penelitian Sains*, *14*(4). https://doi.org/10.56064/jps.v14i4.201

Doe, B., Dacosta Aboagye, P., Osei-Owusu, P., Amoah, T., Aidoo, A., & Amponsah, N. (2022). Towards Circular Economy and Local Economic Development in Ghana: Insights from the Coconut Waste Value Chain. *Circular Economy and Sustainability*. https://doi.org/10.1007/s43615-022-00182-w

Ekalinda, O. (2001). *TEKNOLOGI PEMBUATAN ARANG TEMPURUNG KELAPA*. Balai Pengkajian Teknologi Pertanian Riau. http://riau.litbang.pertanian.go.id/ind/images/stories/PDF/arang.pdf

Hudaya, N., & Hartoyo. (1990). Pembuatan Arang Redemen Tinggi dari Tempurung Kelapa dengan Klin Drum. *Jurnal Penelitian Hasil Hutan*, *7*(4), 134–138. https://doi.org/10.20886/jphh.1990.7.4.134%20-%20138

Ikumapayi, O. M., Akinlabi, E. T., Majumdar, J. D., & Akinlabi, S. A. (2020). Chapter four - Applications of coconut shell ash/particles in modern manufacturing: a case study of friction stir processing. In K. Kumar & J. P. B. T.-M. M. P. Davim (Eds.), *Woodhead Publishing Reviews: Mechanical Engineering Series* (pp. 69–95). Woodhead Publishing. https://doi.org/10.1016/B978-0-12-819496-6.00004-X

Indonesia, C. G. in P. (2021). *Indonesian Coconut Shell Charcoal Are Constantly In Demand By The International Market*. https://kemlu.go.id/penang/en/news/13290/indonesian-coconut-shell-charcoal-are-constantly-in-demand-by-the-international-market

Intara, Y. I., Budiyanto, Caniago, Z., & Aldo, R. (2021). *Development of Type Drum Kiln to Make Charcoal and Wood Vinegar for The Utilization of Coconut Shell Waste BT - Proceedings of the International Seminar on Promoting Local Resources for Sustainable Agriculture and Development (ISPLRSAD 2020)*. 413–419. https://doi.org/10.2991/absr.k.210609.064

Jamilatun, S., & Setyawan, M. (2014). Pembuatan Arang Aktif dari Tempurung Kelapa dan Aplikasinya untuk Penjernihan Asap Cair. *Spektrum Industri*, *12*(1), 73–83. https://doi.org/http://dx.doi.org/10.12928/si.v12i1.1651

Khambali, I., Priyanto, B., Asih, R., Baqiya, M., Ramli, M., Osman, N., Tunmee, S., Nakajima, H., Triwikantoro, T., Zainuri, M., & Darminto, D. (2022). N-Doped rGO-Like Carbon Prepared from Coconut Shell: Structure and Specific Capacitance. *Journal of Renewable Materials*, *11*(4), 1–11. https://doi.org/10.32604/jrm.2023.025026

Leman, A. M., Muzarpar, M. S., Maghpor, M. M., Rahman, K. A., Mat Hassan, N. N., Misdan, N., & Zakaria, S. (2021). Development of Palm Shell Base Activated Carbon for Volatile Organic Compounds (VOCs) Emissions Absorption. *International Journal of Advanced Technology in Mechanical, Mechatronics and Materials*, *2*(1), 35–45. https://doi.org/10.37869/ijatec.v2i1.42

Lutfi, M., Hanafi, Susilo, B., Prasetyo, J., Sutan, S. M., & Prajogo, U. (2021). Characteristics of activated carbon from coconut shell (Cocos nucifera) through chemical activation process. *IOP Conference Series: Earth and Environmental Science*, *733*, 12134. https://doi.org/10.1088/1755-1315/733/1/012134

Manatura, K. (2021). Novel performance study of recirculated pyro-gas carbonizer for charcoal production. *Energy for Sustainable Development*, *64*, 8–14. https://doi.org/10.1016/j.esd.2021.07.002

Maryono, Sudding, & Rahmawati. (2013). Pembuatan dan Analisis Mutu Briket Arang Tempurung Kelapa Ditinjau dari Kadar Kanji. *Jurnal Chemica*, *14*(1), 74–83. https://doi.org/https://doi.org/10.35580/chemica.v14i1.795

Ningsih, A., & Hajar, I. (2019). Analisis Kualitas Briket Arang Tempurung Kelapa Dengan Bahan Perekat Tepung Kanji Dan Tepung Sagu Sebagai Bahan Bakar Alternatif. *Jurnal Teknologi Terpadu*, *7*(2), 101–110. https://doi.org/10.32487/jtt.v7i2.708

Nurdin, A., & Nurdiana, J. (2017). EVALUASI PEMBUATAN ARANG AKTIF DARI TEMPURUNG KELAPA. *Jurnal Teknologi Lingkungan*, *1*(2), 1–3.

Nyamful, A., Nyogbe, E., Mohammed, L., Zainudeen, N., Darkwa, S., Phiri, I., Mohammed, M., & Ko, J. (2021). Processing and Characterization of Activated Carbon from Coconut Shell and Palm Kernel Shell Waste by H3PO4 Activation. *Ghana Journal of Science*, *61*(2), 91–104. https://doi.org/10.4314/gjs.v61i2.9

Parshiwanikar, T., & Handa, C. (2022). Design and Development of Process Equipments for Extraction of Coconut Shell's Activated Carbon, Bio Oil and Syngas. *IOP Conf. Series: Materials Science and Engineering; International Conference on Advances in Mechanical Engineering-2022 (ICAME-2022)*, 1–7. https://doi.org/10.1088/1757-899X/1259/1/012019

Pujasakti, D., & Widayat, W. (2018). KARAKTERISTIK BRIKET CETAK PANAS BERBAHAN KAYU SENGON DENGAN PENAMBAHAN ARANG TEMPURUNG KELAPA. *Sainteknol: Jurnal Sains Dan Teknologi*, *16*(1), 21–31. https://doi.org/10.15294/sainteknol.v16i1.13717

Sangsuk, S., Buathong, C., & Suebsiri, S. (2020). High-energy conversion efficiency of drum kiln with heat distribution pipe for charcoal and biochar production. *Energy for Sustainable Development*, *59*, 1–7. https://doi.org/10.1016/j.esd.2020.08.008

Sanjaya, G. O. N., Joga, J. B. T., & Prasetya, B. (2016). EXPORT ENHANCEMENT PLAN OF COCONUT SHELL CHARCOAL BRIQUETTE BY PT. INDRATMA SAHITAGUNA SEMARANG. *JOBS; Journal of Bussiness Studies*, *2*(1). https://doi.org/10.32497/jobs.v2i1.641

Schröder, E., Christine, W., Klaus, T., & Vander, T. (2006). Experiments on generation of activated carbon. *Anal. Appl. Pyrolysis*, *79*(1), 106–111. https://doi.org/10.1016/j.jaap.2006.10.015

Setyawan, B., & Ulfa, R. (2019). Analisis mutu briket arang dari limbah biomassa campuran kulit kopi dan tempurung kelapa dengan perekat tepung tapioka. *Edubiotik: Jurnal Pendidikan, Biologi Dan Terapan*, *4*(2), 110–120. https://doi.org/10.33503/ebio.v4i02.508

Soka, O., & Oyekola, O. (2020). A feasibility assessment of the production of char using the slow pyrolysis process. *Heliyon*, *6*(7). https://doi.org/10.1016/j.heliyon.2020.e04346

Soolany, C. (2017). ANALISIS KEHILANGAN PANAS PADA PROSES PRODUKSI ARANG TEMPURUNG KELAPA DENGAN DRUM KILN. *Jurnal Teknologi*, *10*(2), 121–127. https://doi.org/https://journal.akprind.ac.id/index.php/jurtek/article/view/1419

Suhartana. (2006). PEMANFAATAN TEMPURUNG KELAPA SEBAGAI BAHAN BAKU ARANG AKTIF DAN APLIKASINYA UNTUK PENJERNIHAN AIR SUMUR DI DESA BELOR KECAMATAN NGARINGAN KABUPATEN GROBOGAN. *Berkala Fisika*, *9*(3), 151–156. https://doi.org/https://ejournal.undip.ac.id/index.php/berkala_fisika/article/view/3094

Susanto, A., Abdullah, Elma, M., & Putra, M. D. (2022). PALM KERNEL SHELL ACTIVATED CARBON USING PHOSPHORIC ACID FOR CRUDE PALM OIL CLARIFICATION: PROPERTIES AND APPLICATION. *European Chemical Bulletin*, *11*(4), 1–11. https://doi.org/10.31838/ecb/2022.11.04.001

COCONUT SHEEL CARBONIZATION PROCESS USING SMOKELESS KILN

ORIGINALITY REPORT

3%	3%	3%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	media.neliti.com Internet Source	2%
2	Jitendra Kumar Mishra, B M A Rahman, Vishnu Priye. "Rectangular Array Multicore Fiber Realizing Low Crosstalk Suitable for Next Generation Short Reach Optical Interconnects with Low Misalignment Loss", IEEE Photonics Journal, 2016 Publication	<1%
3	sciencepublishinggroup.com Internet Source	<1%
4	eprints.umsb.ac.id Internet Source	<1%
5	epa.oszk.hu Internet Source	<1%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		