International Journal of Industrial Electronics and Electrical Engineering, ISSN(p): 2347-6982, ISSN(e): 2349-204X
Volume-9, Issue-3, Mar.-2021, http://ijieee.org.in

ANALYSIS OF PALM SHELL MESH VARIATIONS WITH INCREASING PRODUCTIVITY OF LIQUID SMOKE USING AIR-COOLED REFRIGERATION SYSTEMS

[1]BAITI HIDAYATI, [2]RIMAN SIPAHUTAR, [3]IRWIN BIZZY, [4]MUHAMMAD FAIZAL

[1]Doctor Program of Engineering Science, Universitas Sriwijaya, South Sumatera, Indonesia
[2,4]Mechanical Engineering Department, Faculty of Engineering-University of Sriwijaya, South Sumatera, Indonesia
[3]Chemical Engineering Department, Faculty of Engineering, Universitas Sriwijaya, South Sumatera, Indonesia
E-mail: [1]bayy10@ymail.com, [2]rimansipahutar@ft.unsri.ac.id

Abstract - Liquid smoke increases in demand by the community and research is being carried out related to its various benefits, and is environmentally friendly. The raw material in making liquid smoke comes from waste, which can directly minimize the amount of waste in the world. The process of condensing the smoke into liquid smoke has been carried out using conventional water so that there is still a lot of smoke from pyrolysis that has not been condensed. Smoke condensation can be done with controlled low-temperature air. The refrigeration system is used in this study to increase the productivity of liquid smoke. The air temperature used in the smoke condensing process is between 10°C - 0°C for 360 minutes, with variations in the size of palm shell raw materials -3+4 mesh, -4+5 mesh, and -5+6 mesh. The best results were obtained in the smoke condensing process with -5+6 mesh, with the results of 23.26% liquid smoke, 5.16% tar, 61% charcoal, and 6.33% gas, with the yield of 56.18% phenol. These results indicate that the condensing process using low-temperature air is more effective for maximally condensing smoke than conventional water.

Keywords - Condensation, Liquid Smoke, Palm Shell, Refrigeration

I. INTRODUCTION

Indonesia is a country with the avast area, the vast area of land in this country is used in many ways to achieve human welfare, one of which is oil palm plantations. Oil palm plantations produce CPO (Crude Palm Oil), and waste reaches 43% [1]. Indonesian oil palm plantations increased from 10.6 million ha in 2013 to 13.7 million ha in 2020[2]. Oil palm with a capacity of 100 thousand tons of fresh fruit bunches (FFB) per year produces around 6 (six) thousand tons of palm shells, 12 (twelve) thousand tons of fibers, and 23 (twenty-three) tons of empty fruit bunches. This waste is very potential if it is developed into products that are useful and provide added value from economic as well as environmentally friendly aspects such as liquid smoke, fuel, briquettes, and others [3]. Palm kernel shell is one type of solid waste byproduct of the palm oil processing industry that currently still causes problems for the environment because this waste is produced in large quantities and is difficult to degrade/decompose naturally in the environment. [4]. Palm kernel shell contains lignin (29.4%), hemicellulose (27.7%), cellulose (26.6%) [3]. Disposal of large amounts of biomass waste is considered garbage and pollutants is a major problem of environmental management. Biomass waste must be converted into useful products to minimize environmental pollution. One way to use waste is to convert the waste into liquid smoke.

Liquid smoke is a result of condensation or condensation of smoke from combustion, directly or indirectly, from materials that contain lots of lignin, cellulose, and hemicellulose, and other carbon compounds. [5]. Liquid smoke is defined as the condensate liquid which has undergone storage to separate tar and certain materials. This technology has many advantages, especially that the main product is charcoal which can be developed into several products of economic value [6]. Liquid smoke is currently gaining popularity as a preservative for various food products and biopesticides to increase agricultural production. Moreover, liquid smoke is used to improve soil quality and neutralize soil acids, kill plant pests, and control plant growth, repel insects, and accelerate growth of roots, stems, tubers, leaves, flowers, and fruit [7]. Research related to liquid smoke on palm kernel shell raw materials is always carried out as is being done [8].

Pyrolysis is a process of decomposition of organic compounds through a heating process with little or no oxygen [9].

Pyrolysis can be defined as the thermal decomposition of organic material (in the absence of oxygen) which will cause the formation of volatile compounds. Pyrolysis generally starts at a temperature of 200^0C and lasts at temperatures around 450-500^0C[10].

Condensation is the process of changing the phase from gas to liquid. In this condensation process, heat release will occur. In the manufacture of liquid smoke, the condensing process is carried out using water as it is done [10], [11], [12], [13]. The condensation process of smoke into liquid smoke is carried out conventionally using water that is circulated using a continuous pump. In the process of making liquid smoke, there are still many gases that escape the environment because the water

temperature continues to increase [12].
The size of the palm kernel shell raw material in the production of liquid smoke will be one factor in increasing the yield of liquid smoke. Because the smaller surface area [14].
Refrigeration is generally used for the air conditioning process for convenience or for freezing a product.

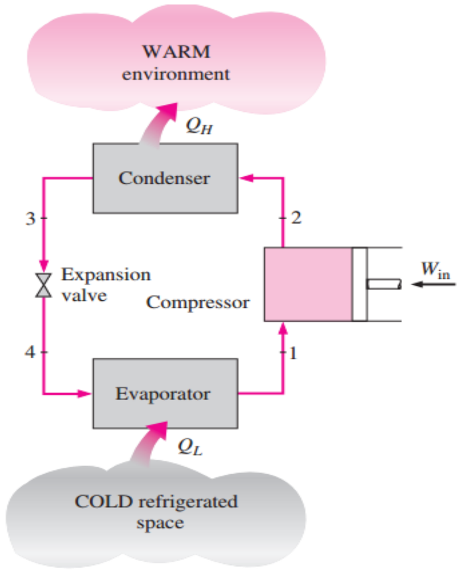

Figure 1. Refrigeration cycle

In this research, the process of making liquid smoke will be carried out with the smoke condensing method using low-temperature air, which combines the refrigeration system so that this study does not use water. Moreover, there will be variations in the size of the palm kernel shells in the liquid smoke production process. Therefore that it can increase the productivity of liquid smoke.

II. MATERIALS AND METHOD

The raw material used in the process of making liquid smoke is palm kernel shell waste which has been varied in size -3 + 4 mesh, -4 + 5 mesh, and -5 + 6 mesh. With the following in Table 1.

Compound	Percentage (%)
Selulosa	11,52
Hemiselulosa	2,68
Lignin	76,22
Kadar Air	12,18
Abu	3,19

Table 1. Palm shell compounds

The palm kernel shell will be subjected to a pyrolysis process at a temperature of 300^0C-400^0C. The smoke from the pyrolysis process will be directed to the smoke condensing place in the form of cold storage at a controlled temperature between 10^0C-0^0C. Cold Storage comes from a refrigeration system that uses a compressor, condenser, capillary tube, and evaporator. With a compressor capacity of ¾ HP. The smoke from the pyrolysis is cooled using cold air from the evaporator and distributed using a fan with a fan speed of 5.4 m / s. The results of this study are the percentage of liquid smoke, tar, charcoal, and gas that escaped.

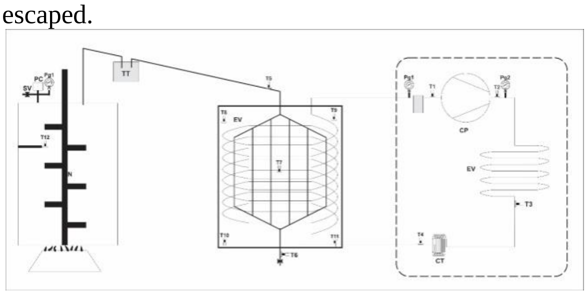

Figure 2. Schematic diagram of a liquid smoke maker with a refrigeration system

III. ANALYSIS

The results of the liquid smoke manufacturing process will be carried out by the GCMS lab test and the calculation of the percentage of liquid smoke.

$$m_{shell} = m_{liquid\ smoke} + m_{tar} + m_{charcoal} + m_{gas} \quad (1)$$

$$\text{Percentage of liquid smoke} = \frac{m_{liquid\ smoke}}{m_{shell}} \text{ x } 100\% \quad (2)$$

$$\text{Tar percentage} = \frac{m_{tar}}{m_{shell}} \text{x}100\% \quad (3)$$

$$\text{Charcoal percentage} = \frac{m_{charcoal}}{m_{shell}} \text{x}100\% \quad (4)$$

$$\text{Gas percentage} = \frac{m_{gas}}{m_{shell}} \text{x}100\% \quad (5)$$

Massa	-3+4 mesh (gr)	-4+5 mesh (gr)	-5+6 mesh (gr)
Palm shells	10000	10000	10000
Liquid Smoke	2007	2129	2326
Tar	380	413	516
Charcoal	6980	6507	6100
gas	633	951	1058

Table 2. Results of liquid smoke using the palm kernel shell raw material refrigeration system

IV. RESULTS AND DISCUSSION

Liquid Smoke

Based on the research results, the results are illustrated in the following table:

Massa	-3+4 mesh (gr)	-4+5 mesh (gr)	-5+6 mesh (gr)
Palm shells	10000	10000	10000
Liquid Smoke	2007	2129	2326
Tar	380	413	516
Charcoal	6980	6507	6100
gas	633	951	1058

Table 2. Results of liquid smoke using the palm kernel shell raw material refrigeration system

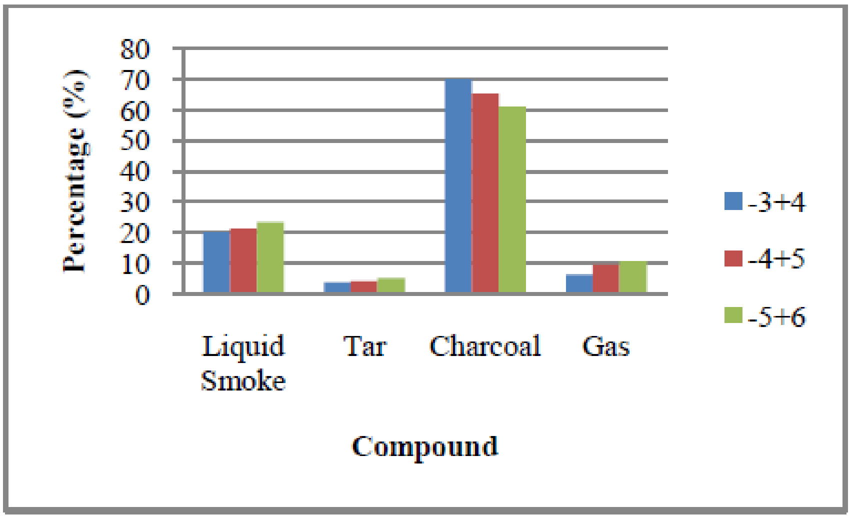

Figure 3. The result of smoke condensation of palm shell raw materials

Based on these data, the manufacture of liquid smoke made from palm kernel shells using the refrigeration system method with low-temperature air obtained different results from each mesh. The maximum yield of liquid smoke is obtained by raw material of palm kernel shells measuring -5 + 6 mesh with a liquid smoke yield of 23.26%.

Chemical Compounds

For each liquid smoke result, a GCMS laboratory test is carried out, and this is carried out on each liquid smoke production starting from the raw material of palm shells -3 + 4 mesh, -4 + 5 mesh, and -5 + 6 mesh.

RT	Compound	Percentage (%)
2.20	Hydrazine, ethyl	13.88
2.31	3-Methyl-6-(methylthio)hexa-1,5-dien-3-ol	0.51
2.47	Butanoic acid, 2-amino-, (S)	0.21
2.59	Ethanol, 2-nitro-, propionate (ester)	1.61
3.11	Pyridine	0.28
3.29	Butanoic acid	0.47
3.96	Furfural	9.83
4.21	3-Furanmethanol	0.46
4.34	2-Propanone, 1-(acetyloxy)-	0.27
4.95	2-Cyclopenten-1-one, 2-methyl-	0.58
5.01	Ethanone, 1-(2-furanyl)-	0.8
5.11	Anisole	0.27
5.81	2-Furancarboxaldehyde, 5-methyl-	0.3
6.08	Phenol	55.08
6.60	Butyric acid hydrazide	1.22
7.69	Phenol, 3-methyl-	2.16
7.89	Acetic acid, phenyl ester	0.54
8.24	p-Cresol	1.58
8.76	Phenol, 2-methoxy-	5.36
8.95	5-Amino-1-benzoyl-1H-pyrazole-3,4-dicarbonitri	0.17
10.06	Phenol, 3-ethyl-	0.21
10.30	Phenol, 3,4-dimethyl-	0.39
10.70	Phenol, 3,4-dimethyl-	0.28
10.94	Creosol	0.16
11.17	Creosol	1.27
11.29	Catechol	0.18
12.21	4-Methoxybenzene-1,2-diol	0.17
12.42	Phenol, 4-ethyl-2-methoxy-	0.67
13.21	Phenol, 2,6-dimethoxy-	0.91
14.09	Phenol, 4-methoxy-3-(methoxymethyl)-	0.16

Table 3.GCMS laboratory test results of liquid smoke palm shell raw material -3+4 mesh

Based on the results of GCMS laboratory tests on liquid smoke made from palm kernel shells -3 + 4 mesh, the value of phenol is 55.08%, this value is high when compared to the liquid smoke research conducted by [15] which researched liquid smoke with phenol yield 37,962%.

RT	Compound	Percentage (%)
2.23	Formic acid hydrazide	17.00
2.61	Ethanol, 2-nitro-, propionate (ester)	1.26
3.11	Pyridine	0.27
3.3	Propanedioic acid, propyl-	0.34
3.96	Furfural	3.60
4.21	3-Furanmethanol	0.25
4.33	2-Propanone, 1-(acetyloxy)-	0.26
4.94	2-Cyclopenten-1-one, 2-methyl-	0.23
5	Ethanone, 1-(2-furanyl)-	0.58
5.81	2-Furancarboxaldehyde, 5-methyl-	0.21
6.08	Phenol	56.59
6.52	Pyridine, 3-methoxy-	0.46
6.6	Butyric acid hydrazide	0.79
7.04	1,2-Cyclopentanedione, 3-methyl-	0.37
7.68	Phenol, 3-methyl-	2.40
7.88	Acetic acid, phenyl ester	0.29
8.22	p-Cresol	2.53
8.75	Phenol, 2-methoxy-	4.20
10.04	Phenol, 3-ethyl-	0.20
10.28	Phenol, 2,3-dimethyl	0.45
10.69	Phenol, 3,4-dimethyl-	0.44
11.16	Creosol	1.32
11.26	Catechol	0.66
12.19	1,2-Benzenediol, 3-methoxy-	0.39
12.41	Phenol, 4-ethyl-2-methoxy-	0.77
13.2	Phenol, 2,6-dimethoxy-	2.56
14.08	1,2,4-Trimethoxybenzene	0.62
14.15	Methylparaben	0.33
14.77	5-tert-Butylpyrogallol	0.31
14.84	1-(4-methylthiophenyl)-2-propanone	0.30

Table 4. GCMS laboratory test results of liquid smoke palm shell raw material -4+5 mesh

Based on the results of GCMS, laboratory tests on liquid smoke made from palm kernel shell -4 + 5 mesh yielded a phenol value of 56.59%, the phenol value increased due to the reduced size of the palm shell raw material so that the phenol compound was easily broken down compared to palm shell -3 + 4 mesh.

RT	Senyawa	Nilai (%)
2.19	Hydrazine, ethyl-	12.73
2.31	Butanoic acid, 2-ethyl-, 1,2,3-propanetriyl ester	0.29
2.47	Butanoic acid, 2-amino-, (S)-	0.21
2.59	Ethanol, 2-nitro-, propionate (ester)	1.43
3.12	Hexane, 3,3,4,4-tetrafluoro-	0.24
3.28	Propanedioic acid, propyl-	0.41
3.97	Furfural	8.3
4.21	3-Furanmethanol	0.48
4.34	2-Propanone, 1-(acetyloxy)-	0.28
4.94	2-Cyclopenten-1-one, 2-methyl	0.59
5	Ethanone, 1-(2-furanyl)-	0.71
5.81	2-Furancarboxaldehyde, 5-methyl-	0.24
6.06	Phenol	56.18
6.6	1,5-Heptadiene-3,4-diol	1.08
7.05	2-Cyclopenten-1-one, 2-hydroxy-3-methyl-	0.19
7.68	Phenol, 3-methyl	2.53
7.88	Acetic acid, phenyl ester	0.49
8.23	Phenol, 3-methyl-	1.99
8.76	Phenol, 2-methoxy- 9	5.94
10.04	Phenol, 3-ethyl-	0.23
10.28	Phenol, 2,3-dimethyl-	0.45
10.69	Phenol, 2,3-dimethyl-	0.33
10.93	Phenol, 2-methoxy-3-methyl-	0.19
11.16	Creosol	1.61
12.41	Phenol, 4-ethyl-2-methoxy-	0.81
13.21	Phenol, 2,6-dimethoxy-	0.93
14.09	Phenol, 4-methoxy-3-(methoxymethyl)-	0.24
21.21	Hexasiloxane, 1,1,3,3,5,5,7,7,9,9,11,11-dodecamethyl	0.44
21.47	Hexasiloxane, 1,1,3,3,5,5,7,7,9,9,11,11-dodecamethyl	0.21
21.83	Hexasiloxane, 1,1,3,3,5,5,7,7,9,9,11,11-dodecamethyl	0.24

Table 5. GCMS laboratory test results of liquid smoke palm shell raw material -5+6 mesh

Based on the results of GCMS laboratory tests on liquid smoke made from palm kernel shell -5 + 6 mesh, the value of phenol was 56.18%. This phenol value is slightly lower than the raw material for palm kernel shells -4 + 5, this is due to the possibility that the size of the raw material is too small so that the phenol compounds can pass into the air.

V. CONCLUSION

Based on the results of this study, it is found that in increasing the productivity of liquid smoke, the condensation process can use a refrigeration system with controlled low-temperature air fluids as an effort to save energy. Within 6 hours (360 minutes) of the pyrolysis process of 1000 grams of palm kernel shells for each experiment, with variations of -3 + 4 mesh, -4 + 5 mesh, and -5 + 6 mesh, the average yield of liquid smoke was 2154 gr (21.54%).), gas escapes an average of 8.81%, phenol average of 55.95%. The maximum results were obtained in the palm shell experiment -5 + 6 mesh with 23.26% liquid smoke, 5.16% tar, 61% charcoal, and 10.56% escaped gas with 56.18% phenol content. The condensing process of liquid smoke using controlled low-temperature air between 10-0^0C can minimize the gas escaping to the environment.

REFERENCE

[1] J. Elisabeth and P. S. Ginting, “Utilization of palm oil industry by-products as beef cattle feed ingredients,” Oil Palm-Cattle Integr. Syst. Work., pp. 110–119, 2003.

[2] M. A. Shahputra and Z. Zen, “Positive and Negative Impacts of Oil Palm Expansion in Indonesia and the Prospect to Achieve Sustainable Palm Oil,” IOP Conf. Ser. Earth Environ. Sci., vol. 122, no. 1, pp. 9–16, 2018, doi: 10.1088/1755-1315/122/1/012008.

[3] Fauziati, A. Priatni, and Y. Adiningsih, “the effect of various pyrolisis temperature of liquid smoke from palm shells as latex coagulant,” vol. 12, no. 2, pp. 139–149, 2018.

[4] sampepana Fauziati, “Characterization of the active component of the refined palm shell liquid smoke,” pp. 64–72, 2015.

[5] L. Ni’Mah, M. F. Setiawan, and S. P. Prabowo, “Utilization of Waste Palm Kernel Shells and Empty Palm Oil Bunches as Raw Material Production of Liquid Smoke,” IOP Conf. Ser. Earth Environ. Sci., vol. 366, no. 1, 2019, doi: 10.1088/1755-1315/366/1/012032.

[6] Z. Abdul Gani Haji, “Characterization of Liquid Smoke Pyrolyzed From Solid Organic Waste,” J. Teknol. Ind. Pertan., vol. 16, no. 3, 2006.

[7] B. Kılınç and Ş. Çaklı, “Growth of Listeria monocytogenes as Affected by Thermal Treatments of Rainbow Trout Fillets Prepared with Liquid Smoke,” vol. 290, pp. 285–290, 2012, doi: 10.4194/1303-2712-v12.

[8] J. E. Omoriyekomwan, A. Tahmasebi, and J. Yu, “Production of phenol-rich bio-oil during catalytic fixed-bed and microwave pyrolysis of palm kernel shell,” Bioresour. Technol., vol. 207, pp. 188–196, 2016, doi: 10.1016/j.biortech.2016.02.002.

[9] K. Endang, G. Mukhtar, Abed Nego, and F. X. A. Sugiyana, “Processing of Plastic Waste with the Pyrolysis Method into Fuel Oil,” Dev. Chem. Technol. Process. Indones. Nat. Resour., vol. ISSN 1693-, pp. 1–7, 2016.

[10] P. N. Sheth and B. V Babu, “Kinetic Modeling of the Pyrolysis of Biomass,” Environ. Eng. –, vol. 4, no. January, pp. 453–458, 2006.

[11] M. Faisal, A. Gani, F. Mulana, H. Desvita, and S. Kamaruzzaman, “Effects Of Pyrolysis Temperature On The Composition Of Liquid Smoke Derivied From Oil Palm Empty Fruit Bunches,” vol. 13, no. 1, pp. 514–520, 2020.

[12] K. Ridhuan, D. Irawan, and R. Inthifawzi, “Pyrolysis Combustion Process with Biomass Types and Characteristics of the Produced Liquid Smoke,” vol. 8, no. 1, pp. 69–78, 2019.

[13] Lisa Ginayati, M. Faisal, and Suhendrayatna, “Utilization of Liquid Smoke from Oil Palm Shell Pyrolysis as Natural Preservative of Tofu,” J. Chem. Eng., vol. 4, no. 3, pp. 7–11, 2015, doi: 10.32734/jtk.v4i3.1474.

[14] Ogunkanmi, “Extraction of bio-oil during pyrolysis of locally sourced palm kernel shells: Effect of process parameters,” Case Stud. Therm. Eng., vol. 122, 2018, doi: 10.1016/j.csite.2018.09.003.

[15] Desi Ardilla, Muhammad Tamrin, Basuki Wirjosentono, and Eddiyanto, “Identification Of Phenol Compounds Of Liquid Smoke Shell Oil At High Temperature Pyrolysis,” Agrium, vol. 49, no. 23–6, pp. 1–15, 2015, [Online]. Available: http://jurnal.umsu.ac.id/index.php/agrium/article/view/389.

★★★