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TECHNO ECONOMIC STUDY OF LIQUID SMOKE FROM CASHEW NUT SHELL WASTE

La Ifa[1], Nurdjannah[1], Andi Imam Ramadhana[1], Chayping Mardi Sayudi[1], Andi Rusnaenah[2],

[1]Chemical Engineering, Faculty of Industrial Technology, Universitas Muslim Indonesia
Campus II UMI ,Urip Sumoharjo Km 5 Street, Makassar
[2]Polymer Chemical Engineering,Politeknik STMI Jakarta, Jakarta 10510, Indonesia
E-mail:la.ifa@umi.ac.id, ljannah6907@yahoo.com, andiena@stmi.ac.id

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ABSTRACT

Liquid smoke has a very large use, it is a result of condensation or condensation of pyrolysis vapor, directly or indirectly from wood materials such as cashew nut shells. Cashew nut shell is an abundant biomass of cashew nut processing industry but its utilization is not optimal. The purpose of this study was to make liquid smoke from cashew nut shell waste (technological aspect) and conduct economic analysis (economic aspect) to determine economic feasibility. Liquid smoke is made by pyrolysis at a temperature of 150-450^{o}C in a simple batch type reactor. The results obtained were analyzed for its chemical components using Gas Chromatography-Mass Spectroscopy (GC-MC) spectrophotometer analysis. The largest liquid smoke production was obtained at a temperature of 450^{o}C and a time of 2.5 hours with a yield of 19.46%. The main chemical components contained in liquid smoke are phenol (36.310%), acid (12.947%) and carbonyl (16.715%) respectively. With a liquid smoke production capacity of 200 tons per year, liquid smoke products can be sold at a price of IDR 3,620,137,785/years. Total Production cost 2,572,976,800/years. Annual net profit 733,012,689. Investigation of the economic feasibility of liquid smoke production, seen from the Rate of Rate on Investment, is 15.65%, Pay Out Time is 2.99 years and Break Event Point is 49.05%.

Keywords: cashew nut shell waste, biomass, pyrolysis, liquid smoke, economic analysis

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Universitas Muslim Indonesia
Address :
UripSumoharjo Km. 5 Street (Campus II UMI)
Makassar Sulawesi Selatan.
Email :
Jiem@umi.ac.id
Phone :
+6281341717729
+6281247526640

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1. Introduction

Accordingdata from the Central Bureau of Southeast Statistics, cashew nut production from 2011 to 2013 has increased, with an area of 117,414 hectares. Cashew nut shell is an abundant biomass of cashew nut processing industry, but its utilization is not optimal. Traditionally, cashew nut shells are burned. This practice can be dangerous and if not managed seriously can cause environmental pollution(Lombok *et al.*, 2014).

Several researchers have previously made efforts to utilize cashew nut shells for biobriquettes(Mousa *et al.*, 2019; Ifa *et al.*, 2020), vernis (Ifa, Sabara, *et al.*, 2018), pesticide(La Tima, Yopi and Ifa, 2016). Cashew nut shell waste is biomass such as coconut shell that can be converted into bio charcoal and bio oil which can be condensed into liquid smoke, tar and non-condensed gas using the pyrolysis method.(Lombok *et al.*, 2014). Pyrolysis is one of the most economical and promising technologies to convert solid biomass into liquid (bio-oil), gas, and solid(Gao *et al.*, 2016). Bio-oil is referred by various terms for the liquid products presented in the literature including wood liquor(Oramahi *et al.*, 2018), pyroligneous acid (Pimenta *et al.*, 2018), pyrolysis distillate(Barbero-López *et al.*, 2019), liquid smoke(Wagiman, Ardiansyah and Witjaksono, 2014; Lombok *et al.*, 2014; Maryam, 2015; Budaraga, Marlida and Bulanin, 2016; Hadanu and Apituley, 2016; Tarawan *et al.*, 2017; Kailaku *et al.*, 2017; Abustam, Said and Yusuf, 2018; Aisyah *et al.*, 2018; Sari, Samharinto and Langai, 2018; Ifa, Sabara, *et al.*, 2018; Ifa, Yani, *et al.*, 2018; Maulina and Silia, 2018; Qomariyah *et al.*, 2019; Surboyo *et al.*, 2019; Swastawati *et al.*, 2019; Rakhmayeni, Yuniarti and Sukarno, 2020), bio-fuel oil, wood oil, wood refined,(Ozbay and Ayrilmis, 2017; Boer *et al.*, 2020). The constituent material for liquid smoke is obtained from the thermal degradation reaction of cellulose, hemicellulose, and lignin(Beker *et al.*, 2016; Hadanu and Apituley, 2016; Kailaku *et al.*, 2017).

Several studies have shown the usefulness of liquid smoke, among others, as an antioxidant(Budaraga et al., 2016), as a pesticide(La Tima, Yopi and Ifa, 2016; Sari, Samharinto and Langai, 2018), as an insecticide against larvae(Prabowo, Martono and Witjaksono, 2016)or a substitute for silica(Simanjuntak *et al.*, 2016),to reduce the content of Pb in soybean seeds(Hartati, Darmadji and Pranoto, 2015), as a flavoring and food preservative(Maryam, 2015),as an antimicrobial agent (supports bacterial growth)(Beker *et al.*, 2016),as an insecticide(Mustafiah and Jafar, 2017), natural preservative in fresh fish(Anggraini and Yuniningsih, 2017), as a material for making varnishes(Ifa, Sabara, *et al.*, 2018), an important role in healing oral trauma canker sores in people with diabetes mellitus(Surboyo *et al.*, 2019; Ayuningtyas *et al.*, 2020), to extract acetic acid(Siregar, Misran and Cahyadi, 2019), to suppress blood diseases in bananas and their effect on plant growth(Aisyah *et al.*, 2018), for the durability of tilapia dumplings(Handayani, Swastawati and Rianingsih, 2019).

This study examines the manufacture of liquid smoke from cashew nut shell waste by studying the effect of pyrolysis temperature on the yield of liquid smoke and assessing its economic feasibility.

2. Research Methods

Material

The main ingredient used in this research is cashew nut shell waste obtained from Muna Regency, Southeast Sulawesi. The material is dried in direct sunlight to reduce moisture content prior to pyrolysis. It is most economical to dry this moisture out as much as possible using the heat of the sun before the wood is carbonized (FAO, 1985).This is important in saving the cost of energy used during pyrolysis (Onchieku, Chikamai, & Rao, 2012). Compared to other mechanical drying processes, sun drying is the simplest and cheapest process for biomass drying. However, mechanical drying is the only way to remove biomass in the rainy season (Sen, Wiwatpanyaporn, & Annachhatre, 2016). Biomass is converted to liquid smoke using the pyrolysis method in a simple batch type reactor heated externally by LPG.).

Equipment

The main of producing liquid smoke is a pyrolysis reactor equipped with a thermocouple, condenser, tar, and a liquid container. Pyrolysis equipment specification is a pyrolysis reactor made of stainless steel plate with a height of 40 cm and a diameter of 27 cm. The condenser length is 1.07 m. The outer wall of the reactor is equipped with an insulating layer as thick as 1.5 cm according to the previous research tool (Ifa et al., 2020).

Data Processing and Analysis Methods

This research was conducted in several stages, like : sample preparation, the pyrolysis process of cashew nut shells and the characteristics of liquid smoke. The skin of the cashew seeds is cleaned of dirt and dried under the sun by drying it for 5 hours to reduce its moisture content. A total of 1.5 kg of cleaned and dried cashew nut shells was put into the reactor, then the reactor was closed. The reactor cover is connected to a pipe that allows smoke to escape from the reactor into the condensation system. When the set of tools has been installed perfectly, then the heater is turned on. After reaching a temperature of 150°C, it is left until the temperature is constant. Furthermore, the smoke resulting from the pyrolysis is condensed. The results of this pyrolysis obtained products, namely liquid brown to black and charcoal. The resulting liquid is put into a separating funnel for the purification process. The product liquid smoke was analyzed qualitatively for chemical components using a Gas Chromatographic Mass Spectrometry (GC-MS) analysis. The same procedure is carried out at temperatures of 250, 350 and 450°C. The gas product is obtained from the calculation based on the difference between the mass of waste cashew nut shells minus the mass of liquid smoke minus the mass of tar minus the mass of charcoal).The calculation of the yield of liquid smoke uses equation 1(Surboyo et al., 2019)

$$\text{Yield} = \frac{\text{Liquid Smoke (g)}}{\text{Waste Cashew Nut Shells (g)}} \quad (1)$$

Economic Analysis

Economic analysis is intended to determine whether the liquid smoke industry is profitable or not. The calculation of economic analysis is carried out with the following assumptions (Ifa et al., 2020):

(a). Liquid smoke production capacity is 200 tons /years. The raw requirement for waste seed shells is based on liquid smoke yield 19.46% namely 200,000kg/th/0.1946 or 1,100,000 kg/years

(b). The product's sold price consisits of liquid smoke and charcoal as byproduct. The factory location is in Muna Regency, Southeast Sulawesi, Indonesia.

(c). Fund 60% dan 40%.

(d). Bank interest 5.75%/years

(e). an Inflation rate of 3.18%/ years.

(f). The factory exixtance is estimated at five 5 years, with an annual 10% depreciation.

The level of profitability over the plant is evaluated based on:

1. Rate of Return on Investment
2. Pay Out Time
3. Break Even Point

In order to review the above factors, an estimate was made of:

1. Estimation Total Capital Investment (TCI)
2. Estimation Total Production Cost (TPC)
3. Analysis Profitability of appropriateness Project

3. Results and Discussion

Effect of Temperature on Liquid Smoke and Charcoal Yields

The results of the research on the effect of temperature on yiled liquid smoke and charcoal are presented in Table 1. The Effect of Pyrolysis Temperature on Chemical Components of Liquid Smoke is presented in Table 2. Economic analysis is presented in Table 3 to Table 7.

Table 1. Effect of Temperature to Pyrolysis Products Yiled at 150 Minutes

Temperatur (°C)	Yield Smoke Liquid (%)	Yield Tar (%)	Yield Charcoal (%)	Yield Gas (%)
150	4.89	0.27	65.44	29.40
250	9.84	1.27	57.42	31.47
350	14.77	1.40	33.67	41.15
450	19.46	10.67	27.54	42.34

Table 1 shows that the higher the pyrolysis temperature, the more liquid smoke is formed. This happens because the higher the pyrolysis temperature, the more compounds in the cashew nut shells are decomposed into liquid. The liquid that is formed consists of a phase, namely a heavy phase called residue and a light phase called liquid smoke. Table 1 shows that the largest liquid smoke is obtained at a pyrolysis temperature of 450^{o}C with yiled 19.46% in 2.5 hours (150 minutes). Simanjuntak et al. (2016) reported that the temperature of 450^{o}C is the pyrolysis temperature of rice husks to produce liquid smoke as a substitute for nitric acid for silica production giving a large liquid smoke yield of 54.4% (Surboyo et al., 2019). Also reported that at 400^{o}C, the yield of liquid smoke from coconut shell obtained pyrolysis products consisted of 51% liquid smoke, 7.28% tar and 33.87% charcoal, bagasse at temperature.400^{o}C (Boer et al., 2020) it is 49.67% (Boer et al., 2020). Different conditions occur with previous studies of coconut shell at temperature 575^{o}C (Gao et al., 2016)it is 75.74% (Gao et al., 2016), (Ozbay and Ayrilmis, 2017) 52.1% at temperature 500^{o}c (Ozbay and Ayrilmis, 2017)

Table 1 shows that the liquid yield (liquid smoke + tar) which increases with the higher the pyrolysis temperature at the same time period, the maximum yield is 32.52% by weight, obtained at 450^{o}C with a running time of 150 minutes. At a lower temperature of 400^{o}C, the liquid was found to be 23.43% by weight of the dry raw material. Lower liquid yields at a lower temperature than due to insufficient temperature to complete the decomposition of the feedstock. This is in accordance with what the previous researchers reported (Islam, Joardder, Hoque, & Uddin, 2013).

The pyrolysis liquid obtained in dark brown color with a pungent and smoky odor consists of two distinct parts: the liquid smoke and the tar phases. The term pyrolysis liquid used in this study is the total viscous liquid obtained from the results of pyrolysis (crude pyrolysis liquid). The results of this study are in line with the research (Maulina & Silia, 2018).

The lower temperatures increase the higher char yields; however, this reduces the liquid yield and vice versa. Pyrolysis temperature of 150^{o}C is the largest charcoal yield, which is 65.44%, decreasing to 27.54% at a temperature of 450^{o}C. (Table 1). This occurs because the higher the pyrolysis temperature, the more the components of the cashew nut shell are decomposed so that the charcoal is reduced. This phenomenon is as reported FAO, (1985) that when the wood (in this study using cashew nut shells) is in the pyrolysis reactor, the cashew nut shells go through certain stages on the way to conversion to charcoal. At temperatures of 20 to 110°C cashew nut shells absorb heat when drying by removing moisture as saturated steam water. The temperature remains at or slightly above 100°C until bone dry. At temperatures of 110 to 270^{o}C it begins to decompose releasing carbon monoxide, carbon dioxide, acetic acid and methanol. At 270 to 290°C this is the point where exothermic decomposition begins. (FAO, 1985).In general, the results of the study were obtained as reported (Ozbay & Ayrilmis, 2017) that pyrolysis temperature affects the distribution of pyrolysis products.

Effect of Pyrolysis Temperature on Chemical Components of Liquid Smoke

The main organic compounds present in the organic fraction of the pyrolysis fluid are given in Table 2

Table 2. Effect of Pyrolysis Temperature on Chemical Components of Liquid Smoke

Chemical Components	Region (%)			
	Temperature (^{o}C)			
	150	250	350	450
Phenols and the derivation	35.964	30.069	35.897	36.31
Acid	6.833	10.555	10.945	12.947
Carbonyl	9.102	22.566	37.892	16.715
Furan	5.592	19.604	0.961	5.153
Pirin	18.763	10.580	1.781	11.718

Table 2 shows that the greater the pyrolysis temperature, the greater the phenol content. The results of GC-MS analysis of liquid smoke resulted from pyrolysis of peanut seeds found that the phenolic compounds formed at 450^{o}C were more dominant, namely 36.31%.

From the interpretation of GC-MS data, it can be seen that the higher the pyrolysis temperature, the more phenol and other components of the compound will be produced. The total phenol content of liquid smoke from cashew seed waste was greater than the previously reported study of oil palm fronds.Maulina & Silia (2018) is 12.28% (Maulina & Silia, 2018). Liquid smoke from bamboo Komarayati & Wibowo (2015) 30.36% (Komarayati & Wibowo, 2015), cashew nut shells La Tima (2016)32,35% (La Tima et al., 2016), coconut shell Aisyah et al. (2018) 21.99% (Aisyah et al., 2018), (Sari et al., 2018) 22.67% (Sari et al., 2018) but smaller than the study of liquid smoke from coconut shell at temperature 350-420^{o}C Hadanu & Apituley. (2016)90.75% (Hadanu & Apituley, 2016), Faham Partogi Siregar et al. (2019) 47.07% (Siregar et al., 2019), liquid smoke from coconut shell pyrolysis temperature 400^{o}C Surboyo et al. (2019) is 48.3% (Surboyo et al., 2019)

3.1 Economic Analysis(Ifa *et al.*, 2020)

Economic analysis is using the discounted cash flow method, namely cash flow whose value is projected at the present time.

3.1.1 Estimation The Total Capital Investment (TCI)

Capital investment is an amount of money that must be spent to establish and operate a factory to produce a product from a raw material. TCI consists offixed capital investment and working capital investment. Fixed capital is the total cost of installing process equipment, buildings, auxiliary equipment and engineering involved in the construction of a new factor (Aries & Newton, 1955). The first step in calculating the FCI is determination the cost of the equipment. The equipment used includes: Belt Conveyor (hopper), pyrolysis reactor, dryer, mixer, liquid storage tank, liquid smoke storage tank, decanter, coconut shell warehouse, biobriquette press, pump. Price of Process equipment is IDR 481,372,719. The total equipment price is the total cost of process equipmentplus the price of utility equipment(10% of the total process equipment price) = IDR 529,509,991.

FCI consists of two main components, namely direct cost (D) and indirect cost (I). The FCI calculation as follows, first estimates the price of D by first determining the total equipment price (E). All costs of installing tools, installation, instruments and controls, plumbing, electricity, building and maintenance, repairs of objects, repair of facilities are each proportionate to the price of the equipment to the place (E) forms direct costs (D). Indirect costs (I) such as engineering and construction and construction costs are in percentage against E. Then the amount of the Contractor's fee and Contingency fee is determined based on a percentage of the total (D + I). FCI estimates can be seen in Table 3.

Tabel 3.The Estimation of Fixed Capital Investment (Peters & Timmerhaus, 2003)

Components		Cost (IDR)
The price of the tool arrived at the place	E	529,509,991
Tool installation, installation	39%E	206,508,897
Instrument and *control*	28%E	68,836,299
Pipe laying (installation)	31%E	164,148,097
Electrical (installation)	10%E	52,950,999
Building and maintenance	22%E	153,557,897
Repairing the yard	10%E	52,950,999
Facility improvements	55%E	291,230,495
The Land	6%E	31,770,599
Total Direct Cost	D	1,551,464,275
Engineering and supervision	32%E	169,443,197
Construction costs	34%E	180,033,397
Total Direct + *Indirect Cost*	D+I	1,900,940,869
Contractor fee	5%(D+I)	95,047,043
Unprediction expenses	10%(D+I)	190,094,087
Total *Fixed cost Investment*		2,186,081,999

where 1 USD = 13,971 IDR

The total of fixed capital investment for installation of process tools, buildings, tools and engineering is IDR 2,186,081,999

3.1.2 Working Capital Investment (WCI)

Working capital is defined as the costs required to do business. Working capital includes: Raw Material Inventory, In Process Inventory, Product Inventory, Exteded Credit dan Available Cash. In general, the amount of working capital is 10-15% of the total capital investment or 25% of the selling value of the annual production (Aries & Newton, 1955). For this process WCI taken 15% from TCI

$$WCI = 15\%\ TCI \quad (2)$$

$$TCI = FCI + WCI = FCI + 15\%\ TCI \quad (3)$$

$$TCI = \frac{FCI}{0.85} \quad (4)$$

The total amount of money that must be spent to set up and operate the factory is (TCI) =IDR2,571,861,176

3.2 Production Cost

Production costs are the total of Direct Manufacturing Cost,Indirect Manufacturing CostandFixed Manufacturing cost that occur on making product . General Expences (GE) are factory expenses expect manufacturing costs, in this case including administrative costs, product sales, research, and shopping costs. GE consist of administrative costs(3% MC), Distribution & marketing cost (5% MC), R&D cost (3.5% MC) and expenses (5% TCI). The calculation results Direct Manufacturing Cost, Indirect Manufacturing Cost dan Fixed Manufacturing cost and GE can show on the Table 4:

Table 4. Manufacturing Cost Component (Aries & Newton, 1955)

No	Components	Cost *(IDR)*
1	Raw material	264,970,853
2	Labor	648,000,000
3	Supervision	19,440,000
4	Maintenance	43,721,640
5	Plant supplies	6,558,246
6	Royalty and patens	36,201,378
7	Utilitas	362.013.778
Direct Manufacturing Cost (DMC)		1,380,905,896
8	Payroll overhead	324,000,000
9	Laboratory	129,600,000
10	Plant overhead	64,800,000
11	Packaging	144,805,511
Indirect Manufacturing Cost (IMC)		663,205,511
12	Depreciation	174,886,560
13	Property taxes	21,860,820
	Fixed Manufacturing Cost (FMC)	196,747,380
Manufacturing Cost (MC)		2,192,272,414
14	Administration (3%MC)	65,768,172
15	Distribution & marketing (5% MC)	109,613,621
16	R&D cost (3.5% MC)	76,729,534
17	Financing (5% TCI)	128,593,059
General Expences (GE)		380,704,386
Total Production Cost (TPC)		2,572,976,800

where 1 USD = 13,971 IDR
MC = 2,192,272,414 GE = IDR 380,704,386
TPC = MC + GE = IDR 2.192.272.414 + IDR 380,704,386
Total production costs (TPC) is IDR 2,572,976,800

3.4 Sales, Profits and Project Feasibility Profitability Analysis

Sales are products / factories that can be sold. Product sales price can be based on market prices. It is also possible that is based on the minimum price calculated by the factory, so that the difference againts the market price is an additional profit by the factory. Estimated gross and net profits are presented in Table 5. Based on the calculation in Table 5.

Table5. Estimated Profits (Aries & Newton, 1955)

Sales		IDR 3,620,137,785
Manufacturing Cost	IDR 2,192,272,414	
General expense	IDR 380,704,386	
Total Cost		IDR 2,572,976,800
Profit before taxes		IDR 1,047,160,985
Income taxes (30%)		IDR 314,148,295
Profit after taxes		IDR 733,012,689

where 1 USD = 13,971 IDR

Profit is a result obtained from the difference in sales and the total cost of production. Profit can be defined as excess income after deducting expenses. Net profit earned amount IDR 733,012,689 every year bigger than profit Stolarski et al. (2013) amount €30413 or IDR 483,997,300 every year (Stolarski et al., 2013).

3.4.1 Net Present Value (NPV)

NPV is the sum of each projected present value of net income each year which is used to simultaneously examine costs (cash outflow) and income (cash inflow) (Dhaundiyal & Tewari, 2015).NPV is a method of calculating the net value (net) at the present time. The present assumption is that it explains the initial time of the calculation to coincide with the time the evaluation is carried out or in the zero year period (0) in the calculation of investment cash flow. (Hakizimana & Kim, 2016). The formula for present value and present value interest factor is equal to 5:
(Satyasai, 2014).

$$NPV=-TCI+\sum\left(\frac{CF}{(1+i)^n}\right) \quad (5)$$

where
TCI = total capital investment, CF = cash flow at n^{th}-year, n = year, $1/(1+i)^n$ = discount factor

3.4.2 Rate of Return on Investment (ROI)

In addition to being oriented towards making a profit, companies must also be able to return their capital, especially if the capital comes from loans. The time to pay back capital is expressed as a percentage of ROI which is formulated as a ratio of profit to fixed capital

$$\sum=\left(\frac{CF}{(1+i)^n}\right)=TCI \quad (6)$$

where
CF = cash flow at n^{th}-year, n = year ,1/(1+i)n = discount factor

Table 6. Discounted cash flow for i value (Ifa & Nurdjannah, 2019)

n^{th}-year	Net Cash Flow (CF)	Trial i =
		Present Value
1	536,659,723	464,054,649
2	749,816,623	560,654,505
3	911,036,503	589,041,856
4	916,445,321	512,373,974
5	921,854,139	445,669,423
Total PV		2,571,794,407

where 1 USD = 13,971 IDR

$$Rasio=\frac{TPV}{TCI}=1 \quad (7)$$

(Peters & Timmerhaus, 2003)

$$Rasio=\frac{2,571,794,407}{2,571,794,407}=1 \quad (8)$$

To determine the correct interest rate (i) it can be achieved by plotting the ratio (total present value / initial investment) and guessing the interest rate (i) ratio must be = 1.0. If a price (i) is higher than the interest rate of the loan fund, the factory or project has potential (Peters & Timmerhaus, 2003). From the above calculations, it is obtained that the value = 15.65%/years. The value obtained is greater than the value for capital loans from banks (5.75%). A project / investment can be carried out if the rate of return is greater than the return received if we invest in a bank. This shows that the factory is feasible to be taken to the next stage. The ROI value of the results of this study is smaller than the ROI of the study Hakizimana and Kim., (2016) , it is 24.94 % (Hakizimana & Kim, 2016).

3.4.3 Pay Out Time (POT)

POT as rapid assessment of the time period for which investment capital is at risk (Short, Packey, & Holt, 1995). To calculate the POT, the accumulated investment is calculated as shown in Table 7 .

Table 7. Cumulative Cash Flow (IDR) (Ifa & Nurdjannah, 2019)

n^{th}-year	Net Cash Flow	Cumulative Cash
1	536,659,723	536,659,723
2	749,816,623	1,286,476,346
3	911,036,503	2,197,512,850
4	916,445,321	3,113,958,171
5	921,854,139	4,035,812,310

From Table 7 for FCI = IDR. 2,186,081,999, by interpolating between the fourth and fifth years, POT was obtain in 2.99 years. POTof this study is shorter than the POT of Hakizimana and Kim (2016) which is 5 – 6 years (Hakizimana & Kim, 2016).

3.4.4 Break Even Point (BEP)

BEP is a point where in that condition the company will not make a profit but also not cause a loss. If the factory operates at a capacity below the BEP point then the factory will suffer a loss. BEP is a condition that arises when the plant operates at full capacity. A good Break Even Point value for a chemical plant is usually in the range of 40% -60% (Aries & Newton, 1955). BEP analysis is used to determine the amount of production capacity where total production costs are the same as sales.

Table 8. Fixed Cost, Variable Cost, Semi Variable Cost, Sales (Ifa and Nurdjannah, 2019)

No	Description	IDR
1	Fixed Cost, FC	422,566,518
2	Biayavariabel, VC	
	a. Raw materials	264,970,853
	b. Utilities	362,013,778
	c. Packaging & shipping	144,805,511
	Royalty and patent	36,201,378
	Total variabelCost (VC)	807,991,521
3	Semivariabel Cost, SVC	
	a. Labor	648,000,000
	b. Supervision	19,440,000
	c. Maintenance & repairs	43,721,640
	d. Operating supplies	6,558,246
	d. Laboratory	64,800,000
	e. General Expences	380,704,386
	f. plant overhead cost	324,000,000
	Total Semivariable cost	1,487,224,272
4	Total Sales (S)	3,620,137,785

$$BEP = \frac{FC+0.3SVC}{S-0.7SVC-VC} \times 100\% \quad (9)$$ (Aries and Newton, 1955)

$$BEP = \frac{2{,}002{,}968{,}141 + 0.3(7{,}206{,}510{,}903)}{18{,}141{,}200{,}000 - 0.7(7{,}206{,}510{,}903) - 4{,}674{,}180{,}000} \times 100\%$$

$$= 49{,}05\%$$

where

FC : Fixed Cost, S : Sales, SVC : Semi Variable Cost, VC : Variable Cost

For the BEP value of 49.05 percent, it means that at a capacity of 49.05 percent x production capacity (200 tons / year) or at a capacity of 98.1 tons / year, the factory does not profit from loss (break even).The BEP value of this study is better than the BEP value of the Hakizimana and Kim research. (2016) namely 38.02 percent(Hakizimana & Kim, 2016). A good Break Even Point value for a chemical plant is usually in the range of 40% -60% (Aries & Newton, 1955).

4.Conclusion and Suggestion

4.1. Conclusion

In this study, cashew nut shell waste was used as raw material to produce liquid smoke using the pyrolysis method. The effect of pyrolysis temperature was studiedat a temperature of 150-450^{o}C. The distribution results of the pyrolysis products of liquid smoke, tar, charcoal and gas are strongly influenced byreaction temperature. The maximum liquid smoke yield of 19.46% is obtained at the final temperature of 450^{o}C. The results of the chemical composition test using GC-MS obtained three main components, namely phenol (36.310%), acid (12.947%) and carbonyl (16.715%). Liquid smoke from cashew nut shell waste can be considered as an important candidate for an alternative potential source of liquid smoke which can be further increased. With a liquid smoke production capacity of 200 tons per year, liquid smoke products can be sold at a price of IDR 3,620,137,785/years. Total Production cost 2,572,976,800/years. Annual net profit 733,012,689. Investigation of the economic feasibility of liquid smoke production, seen from the Rate of Rate on Investment, is 15.65%, Pay Out Time is 2.99 years and Break Event Point is 49.05%.

4.2 Suggestion

1. It is necessary to carry out further research with a better cooling system in order to obtain maximum liquid smoke and better activity so that it can be used in other applications5%.
2. The charcoal obtained needs to be carried out further research to obtain a product that is useful and is not wasted as waste.

Reference

Abustam, E., Said, M. I. and Yusuf, M. (2018) 'The Effect of Antioxidant Activity of Liquid Smoke in Feed Supplement Block on Meat Functional of Muscle Longissimus dorsi', *IOP Conference Series: Earth and Environmental Science*, 119(1), pp. 1–8. doi: 10.1088/1755-1315/119/1/012046.

Aisyah, I., Sinaga, M. S., Nawangsih, A. A., Giyanto, & Pari, G. (2018) 'Utilization of liquid smoke to suppress blood diseases on bananas and its effects on the plant growth', *Agrivita*, 40(3), pp. 453–460. doi: 10.17503/agrivita.v40i3.1390.

Anggraini, S. P. A. and Yuniningsih, S. (2017) 'Optimalisasi penggunaan asap cair dari tempurung kelapa sebagai pengawet alami pada ikan segar', *Jurnal Reka Buana*, 2(1), pp. 11–18.

Aries, R. S. and Newton, R. D. (1955) *Chemical Engineering Cost Estimation*. New York. Torononto. London: McGraw-Hill Book Co.

Ayuningtyas, N. F., Surboyo, M. D. C., Ernawati, D. S., Parmadiati, A. E., Hendarti, H. T., Mahdani, F. Y., … Harianto, I. A. (2020) 'The role of liquid smoke coconut shell in the proliferation phase of an oral traumatic ulcer', *Journal of Pharmacy and Pharmacognosy Research*, 8(6), pp. 549–557.

Barbero-López, A., Chibily, S., Tomppo, L., Salami, A., Ancin-Murguzur, F. J., Venäläinen, M., … Haapala, A. (2019) 'Pyrolysis distillates from tree bark and fibre hemp inhibit the growth of wood-decaying fungi', *Industrial Crops and Products*. Elsevier, 129, pp. 604–610. doi: 10.1016/j.indcrop.2018.12.049.

Beker, S. A., Machado, M. E., Maciel, G. P. S., Silva, R., Cataluña, R., Caramão, E. B., & M., B. F. 2016) 'Antimicrobial Potential of Bio-Oil for Use in Diesel Oil B10', *J. Braz. Chem. Soc*, 27(1), pp. 91–98.

Boer, F. D., Valette, J., Commandré, J. M., Fournier, M., & Thévenon, M. F. (2020) 'Slow pyrolysis of sugarcane bagasse for the production of char and the potential of its by-product for wood protection', *Journal of Renewable Materials*, 9(1), pp. 97–117. doi: 10.32604/jrm.2021.013147.

Budaraga, I. K., Marlida, Y. and Bulanin, U. (2016) 'Antioxidant Properties Of Liquid Smoke Cinnamon Production Of Variation Of Purification And Different Concentration', *INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH*, 5(6), pp. 266–273.

Dhaundiyal, A. and Tewari, P. C. (2015) 'Comparative Analysis of Pine Needles and Coal for Electricity Generation Using Carbon Taxation and Emission Reductions', *Acta Technologica Agriculturae 2*, 18(2), pp. 29–35. doi: 10.1515/ata-2015-0007.

FAO (1985) *Industrial charcoal making, FAO Forestry Paper No. 63. Mecahanical Wood Products Branch. Forest Industries Division. FAO Forestry Department.*

Gao, Y., Yang, Y., Qin, Z., & Sun, Y. (2016) 'Factors affecting the yield of bio - oil from the pyrolysis of coconut shell', *SpringerPlus*. Springer International Publishing, 5(333), pp. 1–8. doi: 10.1186/s40064-016-1974-2.

Hadanu, R. and Apituley, D. A. N. (2016) 'Volatile Compounds Detected in Coconut Shell Liquid Smoke through Pyrolysis at a Fractioning Temperature of 350-420 oC', *Makara Journal of Science*, 20(3), pp. 95–100. doi: 10.7454/mss.v20i3.6239.

Hakizimana, J. de D. K. and Kim, H. (2016) 'Peat briquette as an alternative to cooking fuel : A techno-economic viability assessment in Rwanda', *Energy*. Elsevier Ltd, 102, pp. 453–464. doi:

10.1016/j.energy.2016.02.073.
Handayani, E., Swastawati, F. and Rianingsih, L. (2019) 'Shelf Life of Tilapia (Oreochromis niloticus) Dumplings with addition of Bagasse Liquid Smoke during Storage at Chilling Temperature (±5°C)', *Jurnal Perikanan Universitas Gadjah Mada*, 21(2), p. 111. doi: 10.22146/jfs.42017.
Hartati, S., Darmadji, P. and Pranoto, Y. (2015) 'Penggunaan Asap Cair Tempurung Kelapa untuk Menurunkan Kadar Timbal (Pb) pada Biji Kedelai (Glycine max)', *Agritech*, 35(3), pp. 331–339.
Ifa, L., Sabara, Z., Mandasini, Nurjannah, N., Anas, A., & Madilao, W. (2018) 'Utilization of Liquid Smoke Produced through Sthe Pyrolysis of Cashew Nut Shells as Raw Materials for Varnish Manufacturing', in *IOP Conference Series: Earth and Environmental Science*, pp. 1–4. doi: 10.1088/1755-1315/175/1/012034.
Ifa, L., Yani, S., Nurjannah, N., Darnengsih, D., Rusnaenah, A., Mel, M., … Kusuma, H. S. (2020) 'Techno-economic analysis of bio-briquette from cashew nut shell waste', *Heliyon*. Elsevier Ltd, 6(9), p. e05009. doi: 10.1016/j.heliyon.2020.e05009.
Ifa, L. and Nurdjannah (2019) *ekonomi pabrik kimia*. Edited by T. W. Publish. Ponorogo Jawa Timur: WADE Group.
Islam, M. N., Joardder, M. U. H., Hoque, S. M. N., & Uddin, M. S.2013) 'A comparative study on pyrolysis for liquid oil from different biomass solid wastes', *Procedia Engineering*. Elsevier B.V., 56, pp. 643–649. doi: 10.1016/j.proeng.2013.03.172.
Kailaku, S. I., Syakir, M., Mulyawanti, I., & Syah, A. N. A. (2017) 'Antimicrobial activity of coconut shell liquid smoke', in *IOP Conference Series: Materials Science and Engineering*, pp. 1–8. doi: 10.1088/1757-899X/206/1/012050.
Kers, J., Kulu, P., Aruniit, A., Laurmaa, V., & Križan, P. (2010) 'Determination of physical , mechanical and burning characteristics of polymeric waste material briquettes', *Estonian Journal of Engineering*, 16(4), pp. 307–316. doi: 10.3176/eng.2010.4.06.
Komarayati, S. and Wibowo, S. (2015) 'Karakteristik Asap Cair Dari Tiga Jenis Bambu', *Jurnal Penelitian Hasil Hutan*, 33(2), pp. 167–174. doi: 10.20886/jphh.2015.33.2.167-174.
Lombok, J. Z., Setiaji, B., Trisunaryati, W., & Wijaya, K. (2014) 'Effect of Pyrolisis Temperature and Distillation on Character of Coconut Shell Liquid Smoke', in *Proceeding of International Conference On Research, Implementation And Education Of Mathematics And Sciences*, pp. 320–325. Available at: http://www.journalajst.com/sites/default/files/1576.pdf.
Maryam (2015) 'Applications of liquid smoke powder as flavor and food preservative (Case Study: Sponge Cake)', *International Journal on Advanced Science, Engineering and Information Technology*, 5(2), pp. 135–138. doi: 10.18517/ijaseit.5.2.503.
Maulina, S. and Silia, F. (2018) 'Liquid smoke characteristics from the pyrolysis of oil palm fronds', in *IOP Conference Series: Materials Science and Engineering*, pp. 1–6. doi: 10.1088/1757-899X/309/1/012073.
Mousa, E., Kazemi, M., Larsson, M., Karlsson, G., & Persson, E. (2019) 'Potential for Developing Biocarbon Briquettes for Foundry Industry', *Applied Sciences*, 9(5288), pp. 1–15.
Mustafiah, M. and Jafar, N. (2017) 'Pemanfaatan Asap Cair Dari Blending Limbah Biomassa Cangkang Sawit Dan Tempurung Kelapa Dalam Secara Pirolisis Menjadi Insektisida Organik', *Journal Of Chemical Process Engineering*, 2(1), pp. 36–44. doi: 10.33536/jcpe.v2i1.114.
Onchieku, J. M., Chikamai, B. N. and Rao, M. S. (2012) 'Optimum Parameters for the Formulation of Charcoal Briquettes Using Bagasse and Clay as Binder', *European Journal of Sustainable Development*, 1(3), pp. 477–492. doi: 10.14207/ejsd.2012.v1n3p477.
Oramahi, H. A., Yoshimura, T., Diba, F., Setyawati, D., & Nurhaida. (2018) 'Antifungal and antitermitic activities of wood vinegar from oil palm trunk', *Journal of Wood Science*. Springer Japan, 64(3), pp. 311–317. doi: 10.1007/s10086-018-1703-2.
Ozbay, G. and Ayrilmis, N. (2017) 'Effect of Pyrolysis Temperature on Bio-Oil Production from Vacuum Pyrolysis of Waste from Wood Industry', in *International Journal of Advances in Science Engineering and Technology*, pp. 56–58. Available at: http://iraj.in.
Peters, M. S. and Timmerhaus, K. D. (2003) *Plant Design And Economis For Chemical Engineers*. 4th edn. Singapore: McGraw-Hill Book Co. -.
Pimenta, A. S., Fasciotti, M., Monteiro, T. V. C., & Lima, K. M. G. (2018) 'Chemical composition of pyroligneous acid obtained from eucalyptus GG100 clone', *Molecules*, 23(426), pp. 1–12. doi: 10.3390/molecules23020426.
Prabowo, H., Martono, E. and Witjaksono (2016) 'Activity of Liquid Smoke of Tobacco Stem Waste As an Insecticide', *Perlindungan Tanaman Indonesia*, 20(1), pp. 22–27.
Qomariyah, N., Retnani, Y., Jayanegara, A., Wina, E., & Permana, I. G. (2019) 'Utilization of Biochar and Liquid Smoke to Increase Livestock Performance', *Watazoa*, 29(4), pp. 171–182. doi: 10.14334/wartazoa.v29i4.2077.
Rakhmayeni, D. A., Yuniarti, T. and Sukarno, S. (2020) 'Application of Liquid Smoke from Coconut Shell in Tandipang (Dussumeiria Acutta) Smoked Fish To Extend Shelf Life', *Jurnal Ilmiah Perikanan dan Kelautan*, 12(2), pp. 315–323. doi: 10.20473/jipk.v12i2.20790.
Sari, Y. P., Samharinto, S. and Langai, B. F. (2018) 'Use of Liquid Smoke of Oil Palm Empty Fruit Bunches as Phyto Pesticide to Control Leaf Damaging Pests of Mustard Plants (Brassica juncea L.)', *EnviroScienteae*, 14(3), pp. 272–284.
Satyasai, K. J. S. (2014) 'Application of Modified Internal Rate of Return Method for', in *Agricultural*

Economics Research Review, pp. 401–406.
Sen, R., Wiwatpanyaporn, S. and Annachhatre, A. P. (2016) 'Influence of binders on Physical properties of fuel briquettes produced from cassava rhizome waste', *International Journal of Environment and Waste Management*, 17(2), pp. 158–175. doi: 10.1504/IJEWM.2016.076750.
Short, W., Packey, D. J. and Holt, T. (1995) *A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies*. Colorado: National Renewable Energy Laboratory.
Simanjuntak, W., Sembiring, S., Pandiangan, K. D., Syani, F., & Situmeang, R. T. M. (2016) 'The use of liquid smoke as a substitute for nitric acid for extraction of amorphous silica from rice husk through sol-gel route', *Oriental Journal of Chemistry*, 32(4), pp. 2079–2085. doi: 10.13005/ojc/320435.
Siregar, R. F. P., Misran, E. and Cahyadi, I. T. (2019) 'Proses Ekstraksi Asam Asetat dari Distilat Asap Cair Tempurung Kelapa Menggunakan Pelarut Etil Asetat', *Jurnal Teknik Kimia USU*, 8(2), pp. 90–98. doi: 10.32734/jtk.v8i2.1964.
Stolarski, M. J., Szczukowski, S., Tworkowski, J., Krzyzaniak, M., Gulczynski, P., & Mileczek, M.2013) 'Comparison of quality and production cost of briquettes made from agricultural and forest origin biomass', *Renewable Energy*, 57, pp. 20–26. doi: 10.1016/j.renene.2013.01.005.
Surboyo, M. D. C., Arundina, I., Rahayu, R. P., Mansur, D., & Bramantoro, T. (2019) 'Potential of Distilled Liquid Smoke Derived from Coconut (Cocos nucifera L) Shell for Traumatic Ulcer Healing in Diabetic Rats', *European Journal of Dentistry*, 13(2), pp. 271–279. doi: 10.1055/s-0039-1693527.
Swastawati, F., Al-Baari, A. N. matullah, Susanto, E., & Purnamayati, L. (2019) 'The effect of antioxidant and antibacterial liquid smoke nanocapsules on catfish fillet (pangasius sp.) during storage at room temperature and cold temperature', *Carpathian Journal of Food Science and Technology*, 11(4), pp. 165–175. doi: 10.34302/2019.11.4.16.
Tarawan, V. M., Mantilidewi, K. I., Dhini, I. M., Radhiyanti, P. T., & Sutedja, E. (2017) 'Coconut Shell Liquid Smoke Promotes Burn Wound Healing', *Journal of Evidence-Based Complementary and Alternative Medicine*, 22(3), pp. 436–440. doi: 10.1177/2156587216674313.
La Tima, S., Yopi, Y. and Ifa, L. (2016) 'Pemanfaatan Asap Cair Kulit Biji Mete Sebagai Pestisida', *Journal Of Chemical Process Engineering*, 1(2), pp. 16–22. doi: 10.33536/jcpe.v1i2.66.
Wagiman, F. X., Ardiansyah, A. and Witjaksono, W. (2014) 'Activity of Coconut-Shell Liquid-Smoke as an Insecticide on the Rice Brown Planthopper (Nilaparvata lugens)', *ARPN Journal of Agricultural and Biological Science*, 9(9), pp. 293–296.