TEXT PUBLICATION

PRELIMINARY DESIGN OF BUTYL OLEATE PLANT FROM OLEIC ACID AND BUTANOL CAPACITY 15,000 TONS/YEAR

Compiledas Oneprerequisite toObtain
Stratatitle1Facultyof Engineering
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UNIVERSITAS MUHAMMADIYAH SURAKARTA

2014

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UNIVERSITAS MUHAMMADIYAH SURAKARTA

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Judul Skripsi : PRELIMINARY DESIGN OF BUTYL OLEATE PLANT FROM OLEIC ACID AND BUTANOL CAPACITY 15,000 TONS / YEAR

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Demikian persetujuan dibuat semoga dapat dipergunakan seperlunya.

Surakarta, Desember 2014

Pembimbing,

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ABSTRACT

Chemical plantof Butyl oleate from Oleic acid and Butanol as raw material with a capacity of 15,000 tons per year is planned to operate for 330 days per year. Butyl oleate-production process is carrie out in a Continuous Stirred Reactor Tank (CSTR) with liquidphasecatalyticesterificationwithH_2SO_4. In the reactor the reaction takes place in the liquid-liquid phase, reversible, exothermic, non-adiabatic and isothermal at 110^oC temperature and pressure of 1 atm. This plant is classified as a low risk because of it moderate operating conditions of atmospheric and easy product sales.

Oleic acid requirement for this plant is1532.29 kg per hour and needs butanol is 450.12 kg per hour to produce butyl oleate is 1893.94 kg per hour. The plant was planned establishedin Gresik, EastJava with a land area of 20.000 m^2. The selection of location due to some consideration, i.e,asraw material ofbutyloleateplant,butanol,to be importedfromthe United Statesand ,oleic acid,imported fromAustraliathroughthe port of TanjungPerak. Whilesulfuricacidraw materialfromPT.SulfindoAdiusahaandsodiumhydroxidewas purchasedfromPT.Sidowaru. The number of employees 110 people. Utilities supporting processes include water supply of 5,605.24 kg per hour which are processed from Bengawan Solo River, provision of saturated steam per hour 1,567.04 kg. The plant's electricity needs of 500 kW, in the form of diesel fuel requirements of 238.1 liters/hour, and the need for compressed air for instrumentation of 50 m^3/h.

Chemical plantof Butyl oleat using fixed capital as much as Rp 369,418,206,279.36and working capital as much as Rp141,928,507,967.97. From the economic analysis of this plant showed a profit before tax of Rp84,782,608,336 per year and after taxes 30% profit reachedRp59,347,825,835 per year. Percent Return On Investment (ROI) before tax 22.95 % and 16.07 % after tax. Pay Out Time (POT) before tax 3.03 years and after tax 3.84 years. Break Even Point (BEP) of 53.9 %, and Shut Down Point (SDP) of 27.92 %. Discounted Cash Flow (DCF) as much as 38 %. From the data above feasibility analysis concluded that the plant is profitable and feasible to set up.

Keywords: Butyl Oleate, Oleic Acid, Butanol, Continuous Stirred Reactor Tank (CSTR), Sulfuric Acid (H_2SO_4)

A. INTRODUCTION

1. Background

Indonesiais a developing countrythat iscurrently being activelycarry outdevelopmentinvariousfields. Among themisthe constructionindustry, which isone ofthe chemicalindustry. Indonesia's developmentis still more focused on theoil and gassector. Given that oil is a natural resource that can not be updated, and its use is increasing every year, so supplies are running low, the government issued a discretion to release dependence on oil and gas sector. Policiesthathave a positive impactto encouragethe establishment ofvariouskinds ofchemical plantsorientedtoprocess raw materials intointermediatematerialsandfinished material. One of the products of the chemical industry is plastic. Plastic is one product that has an important role for the community, then its use is likely to increase. One of the ingredients that have an important role in the plastic factory is butyl oleate, butyl oleate function as plasticizers. Plasticizers are materials which serves to raise the employability and flexibility of plastic

The basic ingredients of butyl oleate are butanol and oleic acid. The manufacture of oleic acid is widely available in Indonesia, for example: cotton seed, sunflower seed, palm oil. Factoryof butyl oleate is one of the factories in the field of chemical engineering whose needs are still required by the domestic market . Butyl ester of oleic is one that is generated by the esterification process.

When seen from a comparison of raw materials and products, economically presence of butyl oleate profitable industry as raw material factory of butyl oleate is butanol to be imported from the United States and oleic acid imported from Australia through the port of Tanjung Perak, it raw materials are relatively inexpensive and sulfuric acid and sodium hydroxide raw materials found in East Java, namely PT . PKG and PT.Sidowaru Gresik, Indonesia. Thus enabling the establishment.

2. Design Capacity

Determination ofproductioncapacitywill need to considervarious factors, namely by looking at theBPS datain table1andalsothe databutyl oleatplantmanufacturersalready

Table 1. Data Import ofButyl Oleate

Product	Year	Import (tons/year)
Butyl oleate	2008	422.141
	2009	853.786
	2010	512.746
	2011	1256.971
	2012	1352.193

(BadanPusatStatistik, 2008-2012)

Table 2. ManufacturerButyl OleateAbroad

Nameplant	**Capacity(tons /year)**
Victorian Chemicals	9,000
Megachem	7,000
Lambent Technologies Corp	10,000
Mohini Organics Pvt. Ltd	9,000
Anar Soap & Chemical Co.	10,000

From all of the information above and it is seen that the data import or national requirement at last 5 years show an increasing trend. Based on the above considerations planned in factory established butyloleate from oleic acid and butanolto meet the needs of butyloleate in Indonesia with a capacity of 15,000 tons/year. If the needs of butyl oleate in Indonesia has reached every year, so it remains will be exported to abroad.And plannedfactorywas establishedin Gresik, EastJava

B. DESCRIPTION OF PROCESS

1. Step-by-Step Process

Basicallydividedinto 3parts, among others:

a. Basicreaction

The reaction occurs in a continuous stirred tank reactor (CSTR)byoleicacidreacting($C_{17}H_{33}C$ OOH) and Butanol(C_4H_9OH) forms ButylOleate($C_{17}H_{33}COOC_4H_9$) with the aid ofsulfuric acid(H_2SO_4).

b. Operating conditions

Pre-design operating conditionsatthe factorybutyloleateis temperature 100^oC and pressure 1 atm.

c. Characteristic of the reaction

Reviewof thermodynamics
The heat of reactionat100°C
Dataon theheat of formationtemperature of 25^oC (Yaws, 1999).

ΔHf $C_{17}H_{33}COOH$ = -160.5606 kcal/gmol

ΔHf C_4H_9OH = -65.6295 kcal/gmol

ΔHf $C_{17}H_{33}COOC_4H_9$ = -203,0000 kcal/gmol

ΔHf H_2O = -57,5700 kcal/gmol

ΔH_R 100^oC = ΔH_1 + ΔH_R -25^oC +ΔH_2

ΔH_1 = Cp_1 x (25-100)K

= 205.939 kcal/(kmolK) x (-75) K

= -15445.425 kcal/mol

ΔH_R 25^oC = ΔHfproduct - Δ Hfreactant

=(-260.5700 kcal/gmol)-(-226.1901 kcal/gmol)

= -34.3799 kcal/gmol

= -34379.9 kcal/kmol

ΔH_2 = Cp_2 x (100-25) K

=664.2150 kcal/(kmolK) x (75)K= 49816.1250 kcal/mol

So ΔH_R -100^oC = - 9.2 kcal/mol = -38.22 kJ/mol
Kvaluesobtainedfromexperimentsint he literature, andfromthe graphobtainedXaepoint. Xaevalueas 0.99. So :

$$K = \frac{\text{butyl oleate x water}}{\text{Oleic acid x butanol}}$$

$$= \frac{0.98}{0.084}$$

K = 11.62

From thecalculationsabove is known thatthe reactionof

oleicButylformationisreversible, sincethe value ofkissmall.

C. SPECIFICATIONTOOLS

1. MIXER TANK 01:

Code : MT-01

Function : Mixingoleicacidfrom therecycleofFlashdrums andfreshbait

Operation : Continuous

Quantity : 1 piece

Temperature : 35°C

Pressure : 1 atm

Diameter : 0.75 m

Height : 0.75 m

Volume : 0.42 m3

Type : Verticalcylindricalta nkstirred

Typeof head : Torispherical dished head

Materialof construction : Steel SA-283 Grade C

Mixer :

Type : Turbinebladewith6a nd4baffles

Speed : 270.05rpm

Diameter : 0,75 m

Power of motor : 0.75 hp

- Price : US $ 11,542.07

2. MIXER TANK 02

Code : MT-02

Function : Butanolfrom therecycleofDistillationTo werandfreshbait.

Operation : Continuous

Quantity : 1 piece

Temperature: 35°C

Pressure : 1 atm

Diameter : 0.93 m

Height : 0.93 m

Volume : 0.84 m3

Type : Verticalcylindricaltan kstirred

Type ofhead: Torispherical dished head

Materialof construction:Steel SA-283 Grade C

Mixer

Type : Turbinebladewith6 and4baffles

Speed : 176.67 rpm

Diameter : 0,32 m

Power of motor : 0.75 hp

Cooling Jacket :

Ingredients : Water

Diameter : 0.93 m

Inlet temperature : 25^{o}C

Outlet temperature:50^{o}C

High-jacket : 0.82 m

Price : US $ 11,542.07

3. REAKTOR

Code : R

Duties : Reactingoleicacidandbutanolto producebutyloleatewith thehelp ofSulfuric Acid

Type : ContinueousStirredTankReactor (CSTR)

Quantity : 1 piece

Volume : 23.39 m^{3}

Materialof construction: CarbonSteel SA 212 Grade B

Condition: Pressure: 1 atm

Temperature: 100 ^{o}C

Dimensions :

The diameter ofthe tank:2.82 m

High-tank : 3.46 m

Shellthickness : 0.1875 in

Dimensionshead :

Shape : Elliptical

Thickhead : 0.1875 in

Highhead : 0.46m

Mixer :

Type : Turbinewith6bladeswith4baffles

Quantity : 1 piece

Diameter : 0.94 m

Speed : 67.68 rpm

Power : 7.5 hp

Cooling jacket :

Ingredients: Water

Diameter : 3.06 m

Inlet temperature : 30^{o}C

Outlet temperature : 40^{o}C

High-jacket : 2,59 m

Price : US $ 253,697.05

4. NETRALIZER

Code : N

Duties : Neutralizesulfuricacidcatalystwithsodium hydroxide

Quantity : 1 piece

Temperature : 47.28^{o}C

Pressure : 1 atm

Diameter : 1.70 m

Height : 1.70 m

Volume : 4.95 m^{3}

Type : ContinueousStirredTankReactor (CSTR)

Type of head : Torispherical dished head

ConstructionMaterials : Steel SA-283 Grade C

Mixer

Type :Bladediskturbinewith6standard

Speed : 106.19 rpm

Diameter : 0.57 m

Power of motor :3 hp

Price : US $ 21,255.70

5. DECANTER

Code : D

Function : SeparatingbutyloleateandH_2O

Operation : Continuous

Quantity : 1 piece

Temperature : 47.28 °C

Pressure : 1 atm

Diameter : 1.16 m

Lenght : 3.47 m

Volume : 3.03 m^3

Type : HorizontalCylinders

ConstructionMaterial: Stainless steel SA-167 (type of 304)

Price : US $ 5,713.90

6. DISTILLATION TOWER

Code : DT

Duties : Separatingbutanolfromthe mixtureafterexit decanter

Type : Tower sieve tray

Numberplate : 36 plate

Material : Low Alloy Steel SA 203 Grade C 2 1/2 Ni

Dimensions :

Diameter Top : 0.78 m

Diameter Bottom : 1.26

Height : 17.121 m

Shell Thickness : 0.1875in

Dimensions Head

Type : Torispherical Dished Head

Thick Head : 0.1875 in

High Head : 0.28 m

Operating Conditions:

Top :Temperature : 118.33^oC Pressure : 1 atm

Bottom :

Temperature : 146.0937^oCPressure : 1 atm

Price : US $ 103,421.55

7. FLASH DRUM

Code : FD

Duties :PurifyButylOleateasthe productofoleicacid

Type : Vessel Vertical

Quantity : 1 piece

Volume : 2.27 m^3

Material : Steel SA-212 Grade B

Condition : Pressure : 1 atm

Temperature : 196.78^oC

Dimensions :

TankDiameter : 1.95 m

High-tank : 7.8 m

Shellthickness : 0.1875in

DimensiHead :

Type : Elliptical

Thick Head : 0.1875 m

Price : US $ 68,566.77

D. UTILITY

Utilitiesorcommonly called thesupport unitprocessisone factor thatplays an important rolein industryorfactory. Atthisplant, utilitiescandivided into:

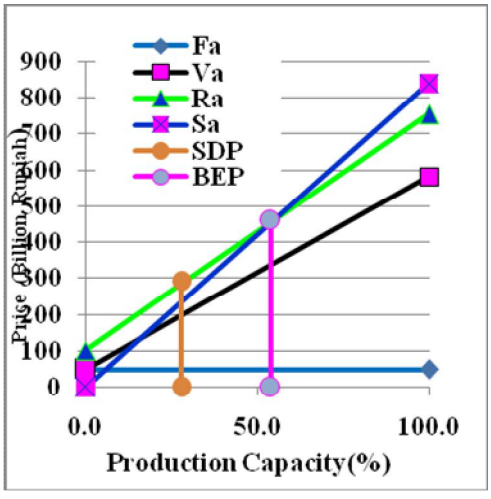
1. Unitwater supplycoming fromthe area neartheplantis Bengawan Soloriveras much as5605.24 kg/hourand the unit of supplying steamas much as1567.04 kg/hour.
2. Unitssupplyingelectricity wereforthisplant as much as 500 kW withfuelat238.1 L/hour.
3. Compressed air unitsindirectlyservesto drive theinstrumentationas much as 50m^3/hour.

E. ECONOMIC ANALYSIS

Aplantwill not beable tostand up wellwhennotplanorconducteconomic analysisin advance. Factoryof butyl oleate thatwillstandincludesplantis easily madebecauseone ofthe advantages isits strategic locationclose to therawmaterial, so itwouldmakemore economiceconomic value. Here aresomeeconomiccriteriaasfollows:

1. The value of FCI reachesRp369,418,206,279.36and the value ofWCas much as Rp141,928,507,967.97.
2. This plant showed a profit before tax of Rp84,782,608,336per year and after taxes 30% profit reachedRp59,347,825,835 per year.

3. ROIforbutyl oleateplantwhichisbeforetaxas much as 22.95% and after tax as much as16.07%. As for the factory butyl oleate POT is at 3.03 years before taxes . After taxes,POT is at3.84years.Criteriafor theROIof at least20% anda maximum of POTis5years.
4. BEP, SDP, andDCFforbutyl oleateplantisrespectively53.90%, 27.92%, and35.9%. BEPvaluestypicallybetween40-60%.



F. CONCLUSION

From theanalyzes ofplanteconomicsbutyl oleateabove, it appears thattheplanthas met the criteriaexpected. So thatthe planned establishment ofthe factoryof butyl oleatecapacity of 15,000tons/yeariseconomicallyprofitableandfeasibletoset up.

REFERENCES

BadanPusatStatistik, 2012, StatistikPerdaganganLuarNegeri Indonesia, EksporImpor, Jakarata.Accessed 12May 2012, at6.34pm WIB.

Aries, R.S., Newton, R.D., 1955, *Chemical Engineering Cost Estimation*, McGraw., -Hill Book Company, New York

Branan, C.R., 1944, *Rule of Thumb for Chemical Engineers*, Gulf Publishing Company, Houston

Brownell, L.E., Young, E.H., 1959, *Process Equipment Design Vessel Design*, Michigan

Coulson, J.M., and Richardson, J.F., 1989, *An Introduction to Chemical Engineering*, Allyn and Bacon Inc., Massachusets

Donald, E.G., 1989, *Chemical Engineering Economics*, Van Nostrond, New York

Geankoplis, C.J., 2003, *Transport Processes and Unit Operations*, 4th ed., Prentice-Hall International, Tokyo

Kern, D.Q., 1950, *Process Heat Transfer*, McGraw Hill

International Book Company, Singapura

Kirk, R.E., Othmer, V.R., 1999, *Encyclopedia of Chemical Technology*, John Wiley & Sons Inc., New York

Ludwig, E.E., 1965, *Applied Process Design for Chemical and Petrochemical Plants*, volume 1, Gulf Publishing Company, Houston

Othmer, Donald F. and Rao, SnajeevAnanda, n-Butyl Oleate from n-Butyl Alcohol and Oleic Acid, *Industrial and Engineering Chemistry*, vo.42, No.9, New York

Perry, R.H., Green, D., 1997, *Perry's Chemical Engineers' Handbook*, 7th ed., McGraw-Hill Companies Inc., USA

Peters, M.S., Timmerhaus, K.D., West, R.E., 2003, *Plant Design and Economics for Chemical Engineers*, 5 th ed., McGraw Hill, New York

Powell, S.T., 1954, *Water Conditioning for Industry*, 1st ed., McGraw Hill Book Company, Inc., New York

Raymond, D.L., 1999, *Water Quality and Treatment*, 5thed, McGraw Hill, USA

Rase, H.F., Holmes, J.R., 1977, *Chemical Reactor Design for Process Plant, vol 2: Principles and Techniques*, John Wiley and Sons Inc, Kanada

Smith, J.M., Van Ness, H.C., Abbott, M.M., 2001, *Introduction to Chemical Engineering Thermodynamics*, 6thed, McGraw Hill Book CompanyInc, New York

Ullmann's, 1999, *Encyclopedia of Industrial Chemistry*, vol.A11, VCH Verlagsgesellschaft, Weinheim

Ullrich, G.D., 1984, *A Guide to Chemical Engineering Process Design and Economics*, John Wiley & Sons, New York

Vilbrant, F.C., Dryden, C.E., 1959, *Chemical Engineering Plant Design*, 4th ed., McGraw Hill Book Company

Walas, S.M., 1988, *Chemical Process Equipment*, 3rded, Butterworths series in chemical engineering, USA

Yaws, C.L., 1999, *Chemical Properties Handbook*, McGraw Hill Companies Inc, USA

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www.the-innovation-group.com

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