CHAPTER I
INTRODUCTION

A. Background

Indonesia is a developing country that is currently being actively carry out development in various fields. Among them is the construction industry, which is one of the chemical industry. Indonesia’s development is still more focused on the oil and gas sector, which is the mainstay of foreign exchange earnings. 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. Policies that have a positive impact to encourage the establishment of various kinds of chemical plants oriented to process raw materials into intermediate materials and finished 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 plant is butyl oleate, butyl oleate function as plasticizers. Plasticizers are materials which serves to raise the employability and flexibility of plastic. The addition of plasticizers to lower the melt viscosity and elasticity modulus of plastic. Another benefit of butyl oleate used in the manufacture of synthetic rubber, paint factories, oil manufacturers, polyester factories even as an additive in cosmetics and other factories. Therefore, it was realized that the butyl oleate needed today with increasing plastic plant.

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.

Based on the above considerations, it is expected that the plant will have a bright prospect in the future. Elections to establish this plant for the following reasons:
1. There is no need to import the need plasticizers for plastics plant again, thus saving foreign exchange.
2. Encourage the establishment of other plant, which processes the basic fundamentals of plant material that is widely available in Indonesia into oleic acid and oleic butyl plant processing into finished products.

B. Review of Literature

Butyl ester of oleic acid is an organic insoluble in water, so colorful and a bit smelly. Esterification reaction between the alcohol and the acid can be divided into two kinds:
1. Esterification liquid phase
   a. Liquid phase catalytic esterification with $\text{H}_2\text{SO}_4$
      $\text{H}_2\text{SO}_4$ catalyst preferably use in industry, although the possibility of the polymerization reaction conditions are not suitable. $\text{H}_2\text{SO}_4$ catalyst is one catalyst that is widely used because of the following considerations: a relatively low cost, have high activity, and easy to come back after the reaction.
   b. HCl Liquid phase esterification catalyst HCl
      Catalyst for HCl is widely used in the industry. Catalyst for HCl has a high corrosive properties, so we need the tools that are relatively expensive process. Economically the use of catalytic HCl in less profitable industries, in addition to the use of HCl catalyst will cause adverse reactions of alkyl chlorides.
2. Esterification vapor phase
   Vapor phase esterification reaction is one alternative of concern, because in this phase is generally larger, than the liquid phase esterification. This is probably due to the occurrence of collisions between reactants in the vapor phase is much greater than in the liquid phase. Given the reaction is run in the vapor phase reactor will require complex design and advanced technology in handling. Based on the above considerations, the application in
the industry was never implemented. In plant design butyl oleate of oleic acid and butanol, selected liquid phase esterification reaction with H₂SO₄ catalyst. reactor used is a stirred tank reactor.

Reaction formation of butanol and butyl oleate oleic acid, is a reversible reaction, therefore to get great results quickly sought equilibrium is not achieved or the reaction shifts to the right. Efforts that can be done to enlarge the results:

1. Since the reaction is reversible, then to get the maximum conversion is to remove one or both of the results is formed.

2. One of the substances that react created excess, so it will increase the average speed of the reaction. In the reversible reaction reagent ratio greater than stoichiometric requirement will cause the equilibrium to shift to the right, resulting in an average speed of reaction will increase in size and the products obtained are also great. In the manufacture of butyl oleate, oleic acid ratio of butanol to the permitted between 1: 1 to 10: 1.

Variables that affect the manufacture of butyl oleate (Othmer and Rao, 1950):

1. The reaction temperature

Reaction between butanol and oleic acid is a reversible reaction order of 2 in the temperature range 100-150°C. At a temperature of 80°C, the reaction rate is slower than expected, while at a temperature of 80-100°C, an increase in the reaction rate constants are very fast, so the reaction is not controlled and the temperature 150°C, adverse reactions and unexpected backlash. Therefore the reaction temperature allowed for the manufacture of butyl oleate between 100-150°C.

2. Comparison of reagent

Molar ratio of butanol to oleic acid molar effect on conversion. Conversion price will decrease with increasing molar ratio of butanol to
oleic acid. For the price it sought conversion ratio gives optimum reagent. Good conversion on the molar ratio of butanol to oleic acid (2:1) (Othmer and Rao, 1950).

3. Catalytic amount of $\text{H}_2\text{SO}_4$

If the reaction of butanol and oleic acid without using a catalyst $\text{H}_2\text{SO}_4$, the results obtained only 22.86%, the amount of butanol and oleic acid will enhance the results obtained. $\text{H}_2\text{SO}_4$ amount above 1.2% will cause adverse reactions and backlash. Butyl oleate formation reaction is reversible and the reaction order of 2, the equation is as follows:

$$
\text{C}_{17}\text{H}_{33}\text{COOH} + \text{C}_4\text{H}_9\text{OH} \xrightarrow{100-150^\circ\text{C}} \text{C}_{17}\text{H}_{33}\text{COOC}_4\text{H}_9 + \text{H}_2\text{O}
$$

Oleic acid  Butanol  Butyl oleate  Water

Testing graphically by plotting various functions with respect to time, for the second order reaction rate equation will be obtained following reaction (Othmer and Rao, 1950):

$$
k.t = \frac{X}{A_0(A - X)}
$$

Where : $k$ = reaction rate constant, $\left(\frac{1}{\text{mol}.\text{min}}\right)$

$A_0$ = initial oleic acid, (mol/l)

$A$ = residual oleic acid, (mol/l)

$X$ = amount of oleic acid is changed in the time interval t (mol/l)

When $\frac{X}{A_0(A - X)}$ plotted against time (t) will be obtained straight line.

Reaction rate constant is a linear function of the concentration of sulfuric acid catalyst (wt%) and the molar ratio of butanol to oleic acid
molar (Othmer and Rao, 1950). At a molar ratio of the molar oleic butanol under 10, the concentration of sulfuric acid between (0.5 to 1.2%) and the reaction temperature 100-150°C, obtained the following empirical formula (Othmer and Rao, 1950).

\[
k_r = \left(0.0007 - 0.048C + 0.05435 \frac{B}{A}\right)10^{7.522-15.83/T}
\]

where :
- \(k_r\) = Reaction rate constant prediction \(\left(\frac{1}{\text{mol.menit}}\right)\)
- \(C\) = Sulfuric acid (wt%)
- \(B\) = Butanol (mol)
- \(A\) = Oleic acid (mol)
- \(T\) = Temperature (K)

Derivative empirical equation would predict the reaction rate with an accuracy of ± 4% for the molar ratio of butanol / oleic acid is not more than 10, to 0.5 to 1.2% catalyst concentration and reaction temperature above 100°C. While the equilibrium constant is as follows (Othmer and Rao, Ind. Eng. Chem. 1950):

\[
K = \frac{\text{Butyl oleate concentration} \times \text{Water concentration}}{\text{Oleic acid concentration} \times \text{Butanol concentration}}
\]

Selection of process

From a variety of existing processes as well as comparing the advantages and disadvantages, then the pre-draft process plant selected butyl oleate liquid phase esterification with sulfuric acid as a catalyst:

1. By using the liquid phase esterification reactor design will be cheaper and simpler than using vapor phase esterification process.
2. When using the vapor phase esterification process will require a great conversion so that in terms of the economy are less profitable.
3. Catalyst \(\text{H}_2\text{SO}_4\) easily found in the market at a price that is relatively inexpensive when compared with \(\text{HCl}\). In addition, when we use the \(\text{HCl}\) will corrode due process tools \(\text{HCl}\) corrosive properties. In terms
of economical use of HCl as a catalyst less profitable because of the selection process corrosion resistant equipment which require substantial funds.

C. Capacity

Oleic acid demand worldwide increased by about 4% per year in the past 10 years and has reached approximately 3,000,000 tons per year, and only about 100,000 tons of oleic acid is used in production of butyl oleate. To meet the needs of butyl oleate, Indonesia still imports from abroad (Biro Pusat Statistika Indonesia).

Determination of butyl oleate plant capacity refers to the plant that has been standing in the world as well as the needs of Indonesian imports.

Table 1.1 Butyl oleate plant that has been established in the world

<table>
<thead>
<tr>
<th>Name plant</th>
<th>Capacity (tons/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victorian Chemicals</td>
<td>9,000</td>
</tr>
<tr>
<td>Megachem</td>
<td>7,000</td>
</tr>
<tr>
<td>Lambent Technologies Corp</td>
<td>10,000</td>
</tr>
<tr>
<td>Mohini Organics Pvt. Ltd</td>
<td>9,000</td>
</tr>
<tr>
<td>Anar Soap &amp; Chemical Co.</td>
<td>10,000</td>
</tr>
</tbody>
</table>

(http://www.the-innovation-group.com)

Of the import data obtained from BPS, it is known that Indonesia is still importing butyl oleate. As shown in the table below:

Table 1.2 Data Import Butyl Oleate

<table>
<thead>
<tr>
<th>Product</th>
<th>Year</th>
<th>Import (tons/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butyl oleate</td>
<td>2008</td>
<td>422,141</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>853,786</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>512,746</td>
</tr>
<tr>
<td></td>
<td>2011</td>
<td>1,256,971</td>
</tr>
<tr>
<td></td>
<td>2012</td>
<td>1,352,193</td>
</tr>
</tbody>
</table>

(Biro Pusat Statistika Indonesia, 2008-2012)
Final report
Preliminary Design of Butyl Oleate Plant of Oleic Acid and Butanol
Capacity of 15,000 Tons/Year

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 plant established butyl oleate from oleic acid and butanol to meet the needs of butyl oleate 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.

D. Location of Plant

Planned plant was established in Gresik, East Java. Selection is based on the consideration, among others:

1. Primary Factor
   a. Ease of supply of raw materials
      
      As raw material plant butyl oleate is butanol to be imported from the United States and oleic acid imported from Australia through the port of Tanjung Perak. While sulfuric acid raw material purchasable from PT. Sulfindo Adiusaha Serang and sodium hydroxide was purchased from PT. Sidowaru Gresik.

   b. Marketing
      
      Marketing a product is to meet domestic needs and the rest is exported out of the country.

   c. labor
      
      Gresik industrial area is an industrial area with a high enough population than that near the area of Surabaya and Central Java that needs workers, both skilled and unskilled labor can be easily.

   d. Utilities
      
      Utilities needed is power, water and air. Electricity needs to come from the local power and our generator power plant. The fuel can be obtained from Kaltim Prima Coal (KPC) as a supplier of coal fuel.

   e. Waste disposal
Waste previously processed first plant to comply with environmental quality standards. Once the value of BOD, COD, TSS waste qualified environmental standards then plant waste can be disposed to Solo River.

2. Secondary Factor

Things that need to be considered in the layout of the plant space is :

a. Plant expansion

The expansion of the plant and the possibility of building additions in the future. Expansion of the plant must be included in the initial calculations before the problem needs a big problem in the future. A number of specific areas should be prepared to be used as an expansion of the plant when the plant is possible to add equipment to increase capacity or add equipment to process the raw materials themselves.

b. The price of land

The price of land is a factor that limits the ability of the initial provision. When the high land prices, it is necessary to use a high efficiency of the room. Use of place must be adapted to the available area. When you need the room to be graded, so as to save space.

c. The quality, quantity and location of buildings

The quality, quantity and location of the building must meet the standards as plant buildings both in terms of physical strength building and its equipment, eg ventilation, insulation and installation. Regularity placement of the building will help ease the work and care.

d. Safety factor

The most important factor is the safety factor. Although it has been equipped with safety devices, such as hydrant, adequate water reservoir, retaining the explosion and plant insurance. Factors such prevention should remain available raw material tank, and fuel products must be placed in a special area with the distance between ample space for places prone to explosion and fire.

e. Highway Facility
Final report
Preliminary Design of Butyl Oleate Plant of Oleic Acid and Butanol
Capacity of 15,000 Tons/Year

Highway for transportation of raw materials, products and other materials indispensable. Placement should not be menganggu way or the smoothness of the process through.