CHAPTER I

INTRODUCTION

1.1. Background

In this globalization era, Indonesia as a developing country continue to show rapid growth especially in the construction industry. One type of industry that is growing in Indonesia is chemical industry. Indonesia still has to import many kinds of chemicals to meet the needs. Chemical production Indonesia is not currently able to meet domestic demand which continues to increase every year. Upstream industries that produce chemicals supporter or raw materials should have been able to support the rapid growth of downstream industries that produce finished products, therefore the need for the development of the chemical industry in Indonesia. With the establishment of the chemical plant, can save foreign exchange and create new jobs in the effort to help reduce unemployment and poverty in Indonesia.

Propylene Glycol with another name 1,2-propanediol is one of the chemicals widely used in various industries both as raw materials and auxiliary materials. Usage is very broad in various industries such as food preservative in the food industry, as softener and moisturizer in the cosmetics industry, as one of the formulas in the pharmaceutical industry, and as additives in paint products industry (Kirk and Othmer, 1992).

Based on the description above, the propylene glycol is a chemical that is very potential to be produced and the necessary establishment propylene glycol manufacturing plant in Indonesia. Given the magnitude of the needs in the country and there is no chemical industry that produces Propylene glycol in Indonesia.

1.2. Production Capacity

In determining the production capacity of propylene glycol can reviewed from various aspects, such as the needs of propylene glycol, industrial capacity which is already in operation, and the availability of raw materials.

To meet the need of society for propylene glycol, Indonesia importing from other countries. The need for chloroform in Indonesia from 2011 to 2015 can be seen at the Table 1.1.

Table 1.1. Import of propylene glycol in Indonesia from 2011 to 2015 (BPS, 2015)

Years	Propylene glycol import (kg)
2011	2,564,245
2012	3,081,940
2013	3,038,056
2014	2,978,595
2015	2,934,817

The increased in the imports of propylene glycol are consistent with the equation of a straight line:

$y = 63780x - 1E+08$

From this equation, it can be estimated that propylene glycol import in 2020 will equal to 28,835.6 Tones/year. Based on that estimated need for propylene glycol above, the plant capacity is then determined to reach 60,000 tons/year.

Table 1.2 Data of propylene glycol production capacity abroad (Chern, 1993)

No.	Producer	Location	Annual capacity, 10^3 t
1	ARCO Chemical Company	Bayport, Texas USA	163
2	Dow Chemical USA	Freeport, Texas USA	113
3	Dow Chemical USA	Plaquemine, Los Angeles	68
4	Eastmen Chemical Company	S. Charleston, West Virginia, USA	36
5	Olin Corporation	Brandenburg, Kentucky, USA	32
6	Texaco Chemical Company	Beaumon, Texas, USA	68

1.3. Site selection

There are several factors which affect selection of locations where propylene glycol manufacturers should be established and Gresik is the right choice for the following reasons:

1. Sources of the Raw Materials

   The plant of propylene glycol belongs to the process of weight reduction and thus the plant should be built near the sources of raw material. The main raw materials include Propylene oxide from Zhangdian Petrochrm China, Sulfuric acid from PT. Petrokimia Gresik, Sodium Hydroxide from PT.Perdana Mulia Jaya Surabaya, Methanol from PT. Kaltim Methanol Industry Kalimantan and Water from Brantas and Bengawan Solo river.

2. Product Marketing

   East Java is an industrial area, both small and large industrial industry which is a potential market in the production of propylene glycol.

3. Transportation

To supply the raw materials, it can be carried out using sea transportation is used through Tanjung Perak port which has adequate facilities. As for product marketing, Gresik near from Surabaya, and Surabaya has a very complete transportation by land, sea and air is very supportive for marketing.

4. Labor Force

The labor force of the plants is requited from Gresik and its surrounding areas, in which the population in this area is high, marketing it a potential source of labor force.

1.4. Literature Reviews

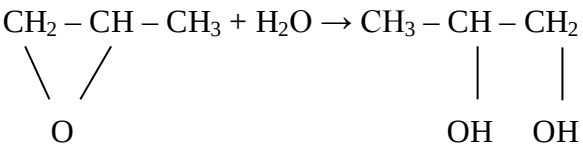
Propylene glycol can be produced by the hydrolysis of propylene oxide with excess water. Can also by adding methanol as a diluent for propylene oxide is not soluble in water.

1.4.1. Types of Processes

Production of propylene glycol can be done with 3 processes, among others:

a. Hydration of propylene oxide without a catalyst

Reaction :



$$CH_2 - CH - CH_3 + H_2O \rightarrow CH_3 - CH - CH_2 \quad (1.2)$$

O OH OH

The conversion of propylene oxide hydration process without catalyst reaches 90%. This process takes place at temperatures of 120-190°C at a pressure of 2,170 kPa (Kirk and Othmer, 1992).

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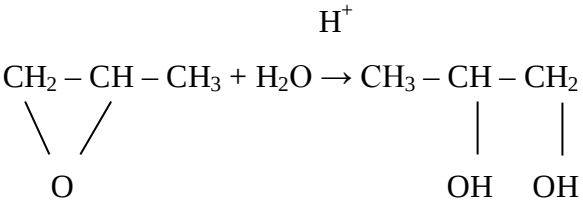
b. Hydration of propylene oxide with a catalyst

Reaction:



$$CH_2 - CH - CH_3 + H_2O \xrightarrow{H^+} CH_3 - CH - CH_2 \quad (1.3)$$

O OH OH

At Chan and Seider study in 2004 using the reaction of propylene oxide ratio as much as 43.04 lbmole with water and methanol as lbmol 802.8 71.87 lbmol and sulfuric acid as a catalyst of 20 lbmol. The process operating conditions on the use temperature of 77-93°F with a pressure of 1 atm, obtained a conversion of 99% (Chan and Seider, 2004)

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So, by looking at the process conditions and the resulting conversion on every production process propylene glycol above, the selected process is the hydration of propylene oxide with an acid catalyst.

1.4.2. The Use of Product

Propylene glycol known antimicrobial and is an effective food preservative. Propylene glycol also finds use as a solvent in elixirs and pharmaceutical preparation containing some water soluble ingredients, and as solvent and coupling agent in the formulation of sunscreen lotion, shampoos, shaving creams and other similar products. The industrial grade of propylene glycol is an important intermediate in the production of alkyd resins for paints and varnish (Kirk and Othmer, 1992).

1.4.3. Physical and Chemical Properties

A. The Primary Raw Materials

1. Propylene Oxide

a. Physical properties of Propylene Oxide (Kirk and Othmer, 1992) :

Molecular weight	: 58.10 g/gmol
Density	: 0.82 g/cc
Purity	: 99.95%
Melting point	: -111.93°C
Boiling point at 1 atm	: 34.27778°C
Viscosity in 10°C	: 0.36 cp

b. Chemical properties of Propylene Oxide :

- Reaction with water

  Propylene oxide reacts with water, either with an acid catalyst or a base catalyst even without a catalyst
- reaction with ammonia

  If it reacts with ammonia to form mono-, di-, tri-isopropanalamine. reacts with primary amines to form secondary and tertiary amines.
- reaction with organic acids

  If it reacts with organic acids to form glycol mono-ethers
- reaction with natural products

  If it reacts with the hydroxyl groups in the sugar cellulose and glycol with an alkaline catalyst, it forms hydroxyl propyl ether and ether and glycol derivatives.

2. Water

a. Physical properties of Water (Perry, 1999) :

Molecular weight	: 18.01 g/gmol
Melting point at 1 atm	: 0°C
Boiling point at 1 atm	: 100°C
Critical pressure	: 218 atm
Critical temperature	: 374.20°C
Heat of fusion	: 1.43 kkal/gmol
Heat of vaporization	: -68.31 kkal/gmol
Refractive index	: 1.33
Density at 25°C	: 1.02 g/cc
Viscosity	: 0.69 cp

a. Chemical Properties of Water :

- Easy dissolving liquid, solid or gas
- As a hydrolyzes reagent in the hydrolysis process

3. Sulfuric Acid

a. Physical properties of Sulfuric Acid (Perry, 1999) :

Molecular weight	: 98.08 g/mol
Purity	: 98%
Phase	: Liquid
Boiling point at 1 atm	: 340°C
Melting point	: 10.49°C
Density	: 1.84 g/ml

b. Chemical Properties of Sulfuric Acid (Fessenden, 1992) :

- If reacted with HNO_3 will produce nitrite ions / nitronium (NO_2^+) are useful in the nitration reaction
- $HONO_2 + 2H_2SO4 \rightarrow 2H_2SO_4^- + NO_2^+ + H_3O^+$ (1.5)
- H_2SO_4 in the nitration reaction has the function of preventing HNO_3 to form hydrogen ions (H^+) and nitrate (NO_3^-) and form the nitronium ion (NO_2^+)
- H_2SO_4 has a pull force of the water and generates a large hydrate compounds such as $H_2SO_4.H_2O$ and $H_2SO_4.2H_2O$

4. Sodium Hydroxide

a. Physical Properties of Sodium Hydroxide (Kirk and Othmer, 1992) :

Molecular weight	: 39.99 g/mole
Purity	: 50%
Phase	: Liquid
Boiling point at 1 atm	: 1.388°C
Melting point	: 318°C
Density at 20°C	: 2.13 g/ml
Latent heat	: 167.40 kJ/mole

b. Chemical Properties of Sodium Hydroxide (Fessenden, 1992) :

In this process NaOH as neutralizer of nitric acid

Reaction:

$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$ (1.6)

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$ (1.7)

5. Methanol

a. Physical Properties of Methanol:

Molecular weight	: 32.04 g/mole
Purity	: 99.98%
Phase	: Liquid
Color	: Colorless
Boiling point at 1 atm	: 64.75°C
Melting point	: -97°C
Density at 30°C	: 782.81 kg/m^3
Viscosity at 30°C	: 0.51 CP
Critical temperature	: 239.43°C
Critical pressure	: 79.81 ATM
Purity	: > 85% w of methanol
Impurity	: < 15% w of water

b. Chemical Properties of Methanol:

- The reaction with methanol occurs by breaking the C-O group and -H bond.

B. Main Products

1. Propylene Glycol

a. Physical Properties of Propylene Glycol (Kirk and Othmer, 1992) :

Molecular weight	: 76.09 g/gmole
Purity	: 99.50%
Melting point at 1 ATM	: -60°C
Boiling point at 1 ATM	: 187.40°C

Heat of vaporization	: 12.94 Kkal/gmole
Refractive index	: 1.43
Density at 25°C	: 1.03 g/cc
Viscosity	: 0.58 cp
Specific heat	: 0.59 kal/g°C

a. Chemical Properties of Propylene Glycol :
   - Propylene glycol is used as an initiator in the base catalyst to produce mono (primary and secondary) and Dieter (polyether polyols)
   - Propylene glycol condensation with the aldehyde produce a cyclic acetyl or 4 methyl 1.3 dioxin
   - Propylene glycol esterified with maleic, fumaric or similar results acids like halide or anhydride acid produces mono and di-esters with peroxide catalyst at low pressure with adhesive.