CHAPTER I

INTRODUCTION

1.1. Background

Free trade era has begun in Indonesia, it is required to compete with other countries in the industry. Industrial development in Indonesia is very influential on the resilience of the Indonesian economy. Chemical industry has a role in advancing industry in Indonesia. Innovation of production processes and the construction of a new plant oriented on reducing our dependence on foreign products and to increase foreign exchange is indispensable.

As a developing country, Indonesia undertakes construction and development in various sectors, such as industry sector. With the advancement in the industrial sector is expected to improve the welfare of the community. Governments and companies have to cooperate in the construction and development in the industrial sector.

Polymers or macromolecules are large molecules built by the repetition of small parts and simple chemistry. That part is equivalent or nearly equivalent to the monomer, which is the basic ingredient of polymer maker. Polyethylene is a thermoplastic polymer that is widely used in daily life. Polyethylene is insoluble in any solvent at room temperature. This polymer is also resistant to acids and bases but cannot be broken by concentrated nitric acid.

Polyethylene’s name is derived from its constituent monomers, ethylene. Polyethylene was first synthesized accidentally of heating diazomethane by German chemist Hans von Pechmann named in 1898. By industry, polyethylene was first synthesized by EW Fawcett in 1936 in the laboratory of Imperial Chemical Industries, Ltd. (ICI), in the UK on an unexpected trial, polyethylene form by ethylene reaction at pressure $1446.52 \text{ kg/cm}^2$ and temperature $170^\circ\text{C}$. In 1940, the polymer was
introduced commercially, and the first ethylene polymer is traded with a low density polyethylene and high pressure. After experience growing the production of low-density polyethylene expanding rapidly. In 1953, Ziegler managed to find a way of making it organometallic polyethylene and a year later successfully it was produced. Polyethylene produced by the Ziegler without big pressure polyethylene. Until now, polyethylene is the type most widely produced polymer.

The increase of chemical industry in Indonesia and in the world, affect the increase of raw materials. Due to a lack of investors engaged in the industrial sector and raw material shortages, Indonesia's dependence on imports is increasing, one of which is importedis polyethylene products. PT. Chandra Asri Petrochemical was in public exposure to the 2012 annual report of the issuer's press conference. Polyethylene gives 50% of the revenue of 2011. Based on data from Nexant, total demand growth Polyethylenewas expected more than 4% in the 2012-2018. While the capacity of the plant is 336,000 tones / year of data Nexant, total demand growth forecast for Polyethylene in Indonesia of 4.6% from the period of 2012-2018 (estimate) by increasing the national requirement. Without new investment and increased utilization of existing production capacity, the industry is threatened not to develop.

The rapid development of industrial process technologies to produce products as raw material for polyethylene is pushing to establish this industry. The establishment of the polyethylene plant in Indonesia is expected to provide the following benefits:

a. The present of LLDPE industry will reduce the need for imports while is likely to increase each year so it will save foreign exchange and reduce dependence on other countries.

b. Establishment of LLDPE is opportunities for the development of the industry with LLDPE raw materials such as plastic films, wrapping cables, chairs, etc.
c. Establishment of LLDPE plant will create jobs in order to improve human resources.

d. The increase investors in the country, especially the polymer industry

1.2. Design Capacity

In determining the design capacity of the polyethylene plant, there are several considerations i.e. the capacity of the existing plant, availability of raw materials, estimated product needs and total import and export products. The Indonesia’s Export and Import LLDPE Data 1999-2013 (unit: tons / year) can be seen in Table 1.

<table>
<thead>
<tr>
<th>No</th>
<th>Year</th>
<th>Export</th>
<th>Import</th>
<th>Δ (E-I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1999</td>
<td>575,636</td>
<td>1,536,261</td>
<td>-960,625</td>
</tr>
<tr>
<td>2</td>
<td>2000</td>
<td>3,796,042</td>
<td>1,054,674</td>
<td>2,741,368</td>
</tr>
<tr>
<td>3</td>
<td>2001</td>
<td>832,441</td>
<td>648,393</td>
<td>184,048</td>
</tr>
<tr>
<td>4</td>
<td>2002</td>
<td>570,511</td>
<td>414,658</td>
<td>155,853</td>
</tr>
<tr>
<td>5</td>
<td>2003</td>
<td>1,920,150</td>
<td>329,372</td>
<td>1,590,778</td>
</tr>
<tr>
<td>6</td>
<td>2004</td>
<td>502,065</td>
<td>243,037</td>
<td>259,028</td>
</tr>
<tr>
<td>7</td>
<td>2005</td>
<td>887</td>
<td>83,032</td>
<td>-82,145</td>
</tr>
<tr>
<td>8</td>
<td>2006</td>
<td>93,122</td>
<td>27,656</td>
<td>65,466</td>
</tr>
<tr>
<td>9</td>
<td>2007</td>
<td>358,551</td>
<td>751,872</td>
<td>-393,321</td>
</tr>
<tr>
<td>10</td>
<td>2008</td>
<td>56,249</td>
<td>1,862,392</td>
<td>-1,806,143</td>
</tr>
<tr>
<td>11</td>
<td>2009</td>
<td>30,436</td>
<td>886,906</td>
<td>-856,470</td>
</tr>
<tr>
<td>12</td>
<td>2010</td>
<td>15,723</td>
<td>1,348,812</td>
<td>-1,333,089</td>
</tr>
<tr>
<td>13</td>
<td>2011</td>
<td>2,250</td>
<td>848,297</td>
<td>-846,047</td>
</tr>
<tr>
<td>14</td>
<td>2012</td>
<td>250</td>
<td>2,609,906</td>
<td>-2,607,656</td>
</tr>
<tr>
<td>15</td>
<td>2013</td>
<td>1,501</td>
<td>2,637,624</td>
<td>-2,636,123</td>
</tr>
<tr>
<td>16</td>
<td>2014</td>
<td>91,799</td>
<td>2,588,613</td>
<td>-2,496,814</td>
</tr>
</tbody>
</table>

Source: (BPS, 2014)
From Table 1, Indonesia at 1999-2002 can export the LLDPE more than 500,000 ton, but after 2003 the export product is decreasing until below 10,000 more over at 2005 and 2012 under 1,000 ton. The decreasing of export cause by increasing local requirement of LLDPE.

On the other hand, the import data (Table 2) show in the 2004 our requirement increase. Import requirement of LLDPE always above 500,000 ton/year, without additional domestic production the number of import will be increased.

Total domestic production showed at Table 3 is 736,000 ton/year from 3 big factories in Indonesia. In reality that production can’t solve requirement if Indonesia requirement.

Table 2: Domestic and International production

<table>
<thead>
<tr>
<th>No</th>
<th>Producer</th>
<th>Country</th>
<th>LLDPE Production (ton/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PT Chandra Asri Petrochemical Tbk</td>
<td>Indonesia</td>
<td>336,000</td>
</tr>
<tr>
<td>2</td>
<td>PT Lotte Chemical Titan Tbk</td>
<td>Indonesia</td>
<td>200,000</td>
</tr>
<tr>
<td>3</td>
<td>PT Petrokimia Nusantara Interindo</td>
<td>Indonesia</td>
<td>200,000</td>
</tr>
<tr>
<td>4</td>
<td>Chevron Phillips Chemical Co</td>
<td>USA</td>
<td>500,000</td>
</tr>
<tr>
<td>5</td>
<td>Eastern Petrochemical Co</td>
<td>Saudi Arabia</td>
<td>500,000</td>
</tr>
<tr>
<td>6</td>
<td>INEOS Grangemouth</td>
<td>UK</td>
<td>330,000</td>
</tr>
<tr>
<td>7</td>
<td>INEOS Koeln</td>
<td>Germany</td>
<td>270,000</td>
</tr>
<tr>
<td>8</td>
<td>SASOL Co</td>
<td>South Africa</td>
<td>220,000</td>
</tr>
<tr>
<td>9</td>
<td>Saudi Ethylene and Polyethylene Company</td>
<td>Saudi Arabia</td>
<td>400,000</td>
</tr>
<tr>
<td>10</td>
<td>Total Petrochemical</td>
<td>USA</td>
<td>400,000</td>
</tr>
</tbody>
</table>

Sor: (annual plant repot, 2014)

Europe, North America and Middle East had been produced LLDPE in the range of 400 to 500 kton per year and Africa just 200 kton. East Asia and south east Asia didn’t build big amount yet, world can make more than
200 ktons profitable then if Indonesia use the technology we can fulfill the domestic demand of LLDPE.

![Graph showing export and import of polyethylene from 2005 to 2014](image)

**Figure 1. Export import of polyethylene 2005-2014**

Predicted that every year LLDPE demand rise 3% (ICN, 2008), so that the government and the company continue to improve its LLDPE production. Using comparison BJS data from 10 year ago until now (2005-2014) we got Graph 1., for namely 2005 as 1 and 2014 as 10 point at X direction, we get $y = 28805x - 219816$ for Import and $y = -10857x - 124789$, after that if we want to operation the new plant in 2027 (22 point) we get import requirement $y = 28805(22)-219816 = 413,894$ Ton/year or simply become 400,000 tones/year.

1.3. Location Selection

The location of Cilegon was chosen based on the following considerations primary factors and secondary factors. The primary factors directly affect the main purpose of the plant which includes the production and distribution of products and arranged according to the kind and quality, time and place required by customers at an affordable price level while the plant is still obtain a reasonable profit.
1.3.1. Primary factors

There are several factors that must be considered to determine the location of the plant to build in order to be technically viable and economically profitable. The location of a plant has considerable influence on the smoothness of industrial activity. Linear low density polyethylene factory is planned to be established in the plant planning location in Industrial Area Cilegon, with the following considerations.

a. Sources of raw materials

The raw material is a major factor in determining the location of the plant. Polyethylene factory will be set up in the industrial area of Cilegon exactly at St. Sunan Bonang with 200m² area, as close to the harbor as a means of trading venues, ethylene was sent from PT. Chandra Asrithat just ± 3 km from our plant area and catalyst imported from PT. Shell Company Ltd. Type Super High Activity Catalyst (SHAC) 201.

b. Market Share

Cilegon is a strategic area for the establishment of a plant because it is a big city and the center of trade and business in Indonesia.

c. Facilities and transport

The place of Cilegon, plant established with consideration of the case of transportation. Cilegon is an industrial city that land and sea transportations can be reached easily. For sea transportation we can use Banten dock and land transportation we can use st. Letnan Jendral R. Suprapto as major way.

d. Labor

Labors supply in Cilegon is not difficult because of the year-over-year employment figures increased and good qualified
e. Utility

The location in the beach is a source of water that is needed for system utilities. Industry’s Cilegon region also has support facilities in the operation of a plant that is electricity and clean water (a vital means for a factory), thereby living plant hire supplies the facility.

![Figure 2. Screen shoot of plan plant location](image)

1.3.2. Secondary factors

a. Plant Expansion

Plant establishment should consider the plant expansion plans over the next 10 or 20 years, because the expansion in region, the plant is not difficult in finding land for the company.

b. Characteristics of The Location

Location factory is located on the waterfront in and protected small islands in front of the beach to be calm and avoid big waves.
c. Government Policy

According with government policy Cilegon City will develop the industry as a facilitator, the Government would provide easiness in licensing, tax, and others related to the technical implementation of the establishment of a factory.

d. The available of facilities and services for general industry

The purpose of the service industry here is the workshop industry and other public facilities such as hospitals, schools and places of worship.

e. Level of tax and labor laws

For areas that will advance society typically impose waivers, as well as in Indonesia. Cilegon status as an industrial area, making the location of the enacting relieves that this reduces the fixed expenses that must be paid (taxes), while the law on labor is still accepted by the company.

f. Attitude Surrounding Communities

Publics’ attitude is about quite openly in the presence of a new plant. It is driven partly because of an increase in the welfare of the community after the factories stand.

g. Waste Plant

Waste water from the process can be channeled back into the sea to be processed first in Waste Water Treatment to meet environmental quality standards.
1.4. Literature Review

1.4.1. Type of process

Polymerization of ethylene large molecular mass polymers was first performed by Fawlet and Gibson Ltd. in England in 1933 using high-pressure techniques. This study was followed by Zeigler and Natta, 1953, which found the low-pressure process.

Polyethylene products are often called polythene, based on the density and weight of its constituent molecules, the basic groups name are Low Density Polyethylene (LDPE), Medium Density Polyethylene (MDPE) and High Density Polyethylene (HDPE). Our concern about LLDPE, several methods for producing the LLDPE, namely (Akers, 2010):

a. High Pressure Process

Two reactors available for this process are autoclave reactor and jacketed tube reactor. Reaction process condition is at Temperature 1400–1900°C, Pressure 150-200 Mpa and residence time 30-60 seconds. From safety aspect, this process has no advantages.

b. Liquid Process

This process was developed by DuPont Co. The raw material of ethylene dissolved in diluents, such as cyclohexane and pumped into the reactor at 10 MPA. The reaction is adiabatic and reaction temperature at 200-260 °C. Feed mixture containing 25% by weight and 95% is converted into polyethylene, polyethylene solution out of the reactor treated by deactivating agent and passed on bed-bound alumina catalyst which is absorbed (Kirk and Othmer, 1981). This process is slowly being replaced by gas process, in terms of safety and production efficiency gas process is better.
c. Suspension (Slurry) Process

The formation of polyethylene suspended in a hydrocarbon diluent to first patented by Ziegler. At a certain pressure Ziegler catalyst (titanium alkyl aluminum) can produce high yields, decreasing the temperature (80-110°C) and the pressure (0.5-4 Mpa) with Diluent hexane, this process is usually called Philip type.

d. Gas Phase Process (UNIPOL)

The reaction system consists of a fluidized bed reactor, acycle gas compressor and cooler, and product discharge tanks. Ethylene, co-monomers and a recycle stream fromthe vent recovery system are fed continuously to thereactor. Polyethylene is removed from the reactor by thedischarge tanks and sent to a purger where interstitial and dissolved hydrocarbons are stripped from the resinand are sent to the vent recovery system. The purgedresin is sent to the pelleting system. Pressure operation process is 0.7-2 Mpa and temperature reaction process is 80-100°C.

Table 3. Polyethylene process production

<table>
<thead>
<tr>
<th>Process</th>
<th>High Pressure Process</th>
<th>Liquid Process</th>
<th>Suspension (Slurry) Process</th>
<th>Gas Phase Process (UNIPOL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>150-200 MPa</td>
<td>10 MPa</td>
<td>0.5-4 Mpa</td>
<td>0.7-2 MPa</td>
</tr>
<tr>
<td>Temperature</td>
<td>1400°C – 1900°C</td>
<td>200-260°C</td>
<td>(80-110°C)</td>
<td>80-100°C</td>
</tr>
<tr>
<td>Reactor</td>
<td>Autoclave or Tubular reactor</td>
<td>CSTR</td>
<td>Loop reactor</td>
<td>Fluidized Bed</td>
</tr>
<tr>
<td>Residence time</td>
<td>30 sec- 2 mnt</td>
<td>2-5 mnt</td>
<td>1-5 hour</td>
<td>1-5 hour</td>
</tr>
</tbody>
</table>

1.4.2. Application of the product

Polyethylene (–CH₂–CH₂)n is a semi-crystalline solids that are thermoplastic, which is product of the polymerization reaction of ethylene (CH₂H₄) by using a catalyst at a certain temperature and pressure
conditions. Polyethylene is a polymer compound thermoplastic that has heat resistant properties, high tensile strength and insoluble in organic solvents. Polyethylene is widely used in industry as a raw material in various plastic industries.

LLDPE is chosen as main product, LLDPE has advantage. Excellent resistance to dilute and concentrated Acids, Alcohols, Bases and Esters, good resistance to Aldehydes, Ketones and Vegetable Oils, limited resistance (moderate attack suitable for short term use only) to Aliphatic and Aromatic Hydrocarbons, Mineral Oils and Oxidizing Agents and Poor resistance and not recommended for use with Halogenated Hydrocarbons. LLDPE is commonly used for food, plastic packaging and bottles. The mechanical properties of LLDPE is kind of strong, transparent, flexible and somewhat greasy surface, at a temperature of 60 degrees is very resistant to chemical reactions, power protection against moisture quite well, can be recycled and good for items that require flexibility but strong. The goods is made from LLDPE is difficult to destroy, but still good for the food because it is difficult to react chemically with foods that are packed with this material.

1.4.3. Physical properties of raw, materials and products

A. Physical properties of raw materials

- Ethylene

Physical properties at 1Atm

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase</td>
<td>Gas</td>
</tr>
<tr>
<td>Color</td>
<td>Colorless</td>
</tr>
<tr>
<td>Molecular Weight</td>
<td>28.06 g/mole</td>
</tr>
<tr>
<td>Molecular formula</td>
<td>C₂H₄</td>
</tr>
<tr>
<td>Boiling point (1atm)</td>
<td>-103.77°C</td>
</tr>
</tbody>
</table>

(Nist, 2014)
B. Physical properties of supporting material

-Titanium Tetrachloride (TiCl4)

Phase : Liquid (Fuming liquid)
Color : Colorless to light yellow
Odor : Pungent. (Strong.)
Molecular Weight : 189.73 g/mole
Boiling Point (1atm) : 136.4°C
Melting Point (1atm) : -24.1°C
Specific Gravity : 1.726 (Water = 1)
Vapor Pressure : 10 mm of Hg (@ 20°C)
Vapor Density (1atm) : 6.6 (water = 1)

(Tnist, 2014)

-Triethylaluminum (TEAL)

Phase : Liquid
Color : Colorless
Odor : Odorless
Molecular Weight : 114.17 g/mol
Chemical Formula : C6H15Al
Boiling Point (1atm) : 186°C
Melting Point (1atm) : -52°C
Flammability : Extremely flammable
Specific gravity (@ 25 °C) : 0.832
Viscosity (@ 25 °C) : 2.5 MPa
Solubility in water : Reacts violently

(Tnist, 2014)
- Hydrogen

Phase : gas
Color : Colorless
Odor : Odorless
Molecular Weight : 2.016
Chemical Formula : H$_2$
Boiling Point (1 atm) : -252.8°C
Freezing Point (1 atm) : -259.2°C
Gas Density (70 F and 1 atm) : 0.08342 kg/m$^3$
Solubility In Water : 0.019(Vol/Vol At (15.6°C))
Specific Volume : 11.99 m$^3$/kg

(Nist, 2014)

- Butene-1

Physical properties at 1Atm

Phase : Gas
Color : Colorless
Molecular Weight : 56.108
Molecular formula : C$_4$H$_8$
Freezing Point (1 atm) : -185.3°C, -301.6°F
Boiling Point (1 atm) : -6.5°C, 20.7 °F
Vapor Pressure : 162KPa (Gauge), 23.5 Psig @ 21.1°C
Specific Volume : 0.418 M$^3$/Kg, 6.7Ft$^3$/Lb @ 1 atm, 21.1°C

(Nist, 2014)
C. Physical properties of product
- Linear Low Density Polyethylene

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase</td>
<td>Solid pellets</td>
</tr>
<tr>
<td>Color</td>
<td>Colorless</td>
</tr>
<tr>
<td>Odor</td>
<td>negligible</td>
</tr>
<tr>
<td>Density (1 atm)</td>
<td>0.910 - 0.940</td>
</tr>
<tr>
<td>Melting Point (1 atm)</td>
<td>120~1306°C</td>
</tr>
<tr>
<td>Flash Point (1 atm)</td>
<td>340°C</td>
</tr>
<tr>
<td>Decomposition Temperature</td>
<td>&gt;400°C</td>
</tr>
<tr>
<td>Spontaneous Temperature</td>
<td>3406</td>
</tr>
<tr>
<td>Solubility In Water</td>
<td>Insoluble</td>
</tr>
</tbody>
</table>

(Nist, 2014)

1.4.4. Process Overview

Raw material of ethylene, Co-monomer, Co-catalyst and Hydrogen are mixed through the pipe toward the fluidized bed reactor with operating conditions of 75°C and 25 Atm. TiCl₄ catalyst is introduced to the reactor, the conversion of reaction per pass is 5%. The main reaction is ethylene production.

\[ n \text{CH}_2 \rightarrow -(\text{CH}_2 - \text{CH}_2) - n \]

Unreacted ethylene is recycled to the reactor from the top of the reactor however the pressure and temperature conditions are adjust using a compressor and HE period to mix again with fresh feed. Polyethylene products formed flowed into purge bin to remove the residual entrained. Polyethylene then flowed into extruder and pellete then keep in warehouse before marketed.