FINAL PROJECT

PRELIMINARY DESIGN OF LINEAR LOW DENSITY POLYETHYLENE (LLDPE) USING UNIPOL PROCESS CAPACITY OF 400,000 TONS/YEAR

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ABSTRACT

Linear Low Density Polyethylene (LLDPE) factory with a capacity of 400,000 tons/year is planned to operate for 330 days per year. The manufacturing process of LLDPE utilise solid catalyst $TiCl_4$-$MgCl_2$. The reaction takes place in a fluidized bed reactor in the gas-solid phase. It is exothermic, adiabatic and non-isothermal at inlet and outlet temperature of 75℃ and 80℃ and pressure of 25 atm. Products exit the reactor in the form of a solid resin with a conversion per pass of 5%. Factory is classified as a high risk due to plant operating conditions with high pressure.

Polymerization formation reaction of LLDPE of ethylene takes place through three stages, namely the initiation stage in which the reaction occurs between ethylene gas with free radicals from the activation of the catalyst with a co-catalyst. The second stage is the propagation reaction and the last is the termination stage. Raw material of ethylene required for the plant is 50,596.785kg per hour, butene-1 is 3.400 kg per hour, hydrogen is 0.8162 kg per hour, catalyst TiCl4-MgCl2 as much as 2.5252 kg per hour and co-catalyst TEAL ($Al(C_2H_5)_3$) totals is 37.9959 kg per hour. The products of LLDPE is 50505.0505 kg per hour. Supporting utilities include water supply of 367,003.12 kg per hour were obtained from Grogol river water, the provision is 5,255.325 kg per hour of saturated steam were obtained from the fuel boiler with fuel oil amounted to 621.371 liters per hour, the need for compressed air of 100 m^3 per hour, the demand for electricity is obtained from the PLN and a generator set of 500 kW in reserve. The factory was established in Cilegon, Banten with a land area of 15,779 m^2 and the number of employees 202 people.

LLDPE factory requires a fixed capital of IDR 598,874,667,292 and working capital of IDR 478,453,884,401. The economic analysis of this plant show a profit before tax of IDR 429,859,745,392 per year after taxes 30%, The profit reached IDR 300,901,828,074 per year. Percent Return On Investment (ROI) before tax and after tax are 71.81% and 50.27%. Respectably Pay Out Time (POT) before tax and after tax for 5 years are 1.25 and 1.72. Respectably Break Even Point (BEP) is 49.35%, and Shut Down Point (SDP) amounted to 41.34%. Discounted Cash Flow (DCF) accounted for 31.01%. From the above data of feasibility analysis, it can be concluded that the plant is profitable and feasible to be established.

Keywords: *Linear Low Density Polyethylene, fluidized bed reactor, $TiCl_4$-$MgCl_2$ catalyst.*

A. Introduction

1. Background

The growth of the world population continues to increase so that the growth of food, clothing, and shelter also increased. in addition to the primary needs, secondary needs also increased this affects the development of new industries in the world and in Indonesia. though Indonesia is a country rich in resources, Indonesia is still very dependent on imports to meet the needs of their needs, Indonesia is able to meet the domestic needs if Indonesia can manage their own natural resources. in other words Indonesia should make industry in the country

LLDPE is a plastic resin for human needs to eat or store certain chemicals continuously increasing demand in Indonesia. Formation of LLDPE producers in Indonesia will reduce import, provide employment and increase state revenues

2. The Designed Production Capacity

Factors that influence to determine the production capacity is:

a Raw Material Availability

Ethylene as a raw material in the manufacture of LLDPE can get PT Chandra Asri, hydrogen as an adjuvant can get at PT Gas Depo Industry, while TEAL from china.

b Minimum Design Capacity

Total domestic production showed at Table 3 is 736.000 ton/year from 3 big factory in Indonesia. In reality that production cant solve requirement of Indonesia requirement.

Table 1. Domestic Production

Factory (PT.)	LLDPE Production (ton/year)
Chandra Asri Petrochemical	336.000
Lotte Chemical Titan	200.000
Petrokimia Nusantara Interindo	200.000
TOTAL	736.000

Sor: annual data report each plant

Table 2. International Production

Country	LLDPE Production (ton/year)
USA	500.000
Saudi Arabia	500.000
UK	330.000
Germany	270.000
South Africa	220.000
Saudi Arabia	400.000
USA	400.000

Sor: annual data report each plant

We choose 400,000 ton/year because in other county is available

3. Site Selection

The choice of location in Cilegon based on the following considerations primary factor and secondary factor. 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.

4. Kind of Process

Table 3. Polyethylene Process Production Type

Process	Suspension (Slurry) Process	Gas Phase Process (UNIPOL)
Pressure	0.5-4 Mpa	0.7-2 MPa
Temperature	(80-110^{o}C)	80-100^{o}C
Reactor	Loop reactor	Fludized Bed
Residence time	1-5 hour	1-5 hour

B. Literature Review

1. Product and Material Specification

- Ethylene

Concentration: 99.96 %w

-Titanium Tetrachloride ($TiCl_4$)

Concentration 97 %w

-Triethylaluminum (TEAL)

Composition:97.2%w

-Hydrogen

Composition:98%w

-Butene-1

Concentration 99.9%w

2. Proses Concept

The reaction was performed in a fluidized bed reactor which reacts to the pressure of 25 atm and temperature 75°C. Branching molecules and molecular weight polyethylene is very dependent on the operating pressure and temperature. If the pressure is raised to be produced with high density polyethylene (HDPE), whereas if the low operating pressure will be produced with low density polyethylene (LDPE). This process called UNIPOL process.

Needs TiCl4.MgCl2 catalyst used was 103 volumes per unit mass of catalyst polyethylene (Ullmans, 2003), while mole ratio Ti/TEAL was 50 mol/mol. To produce LLDPE with a melt index of 1 g/10 minutes and density of 0.919 g/mL, the selected reactor operating conditions with the temperature and pressure of 25 atm 75°C. Gas coming out of the top of the reactor is cooled by the cooler after continuously compressed and mixed with fresh feed stream before entering the reactor. Products exit the reactor in the form of solid resin with a conversion per pass of 5%.

Polyethylene polymerization reaction of ethylene using the fluidized bed reactor Unipol process. reaction is based of the polyethylene chain growth manufacture, known as addition polymerization. The reaction occurs in three stages Initiation, Propagation, Termination

The thermodynamics concept, Ethylene to polyethylene polymerization reaction is irreversible reaction, this can be explained as follows: Polymerization reactions including interfacial reactions that runs in the same direction, Polymerization reaction with free radicals tend to be reactive, so the reverse reaction cannot occur, To remove the polymerization results that occur from free radicals requires large energy, then the reaction is irreversible, Conversion large with a short residence time indicates that the polymerization reaction of ethylene into polyethylene running in the same direction, Ethylene polymerization reaction heat is already known from existing literature is 3.34kJ/g (-93.6kJ/mol). So it can be concluded ΔG reaction need not be considered, Exothermic reactions take place and non isothermal adiabatic reactor, the temperature conditions of the reactant gases enter the reactor at a temperature of 95 ° C selected from the range of 70 ° C-100 ° C so that the temperature in the reactor did not reach more than 70°C range.

The Kinetics concept, Ethylene polymerization reaction occurs through the addition of coordination mechanisms for using transition metal catalysts are $TiCl_4$ and co catalyst are $Al_2(C_2H_5)_3$

Suppose transition metal = T, metal alkyl = AR and monomer = M

Adsorbs to form the active site

$$T + AR \overset{K_1}{\leftrightarrow} T - AR$$

$$T + M \overset{K_2}{\leftrightarrow} T - M$$

Initiation

$$M - T - AR \overset{k_i}{\rightarrow} T - A - M - R$$

Propagation

$$M - T - A - M_X - R \overset{k_D}{\rightarrow} T - A - M_{X+1} - R$$

Termination

$$M - T - A - M_X - R \overset{k_1}{\rightarrow} -T - A - M - + M_X R$$

Adsorbs equation:

$$\theta_A = \frac{K_1[AR]}{1 + K_1[AR] + K_2[M]}$$

$$\theta_M = \frac{K_2[AR]}{1 + K_1[AR] + K_2[M]}$$

Due propagation of the most decisive stage in the reaction speed of the above equation simplifies to:

$$-\frac{d[M]}{dt} = k_p.[AR][M]$$

From the Arrhenius equation

$$k = A.e^{-\frac{E_a}{RT}}$$

With k = reaction rate constant, A = collision factor, Ea = activation energy, R = gas constant, T = temperature

It is known that when the reaction temperature is increased the reaction rate constant prices will be even greater, this will result in the faster the reaction.

3. Proses Flow Diagram

Polyethylene formed process can be divided into three stages. First raw material preparation step, second forming product step and last one is product purification step

C. Equipment Specification

1. Reactor
   Code : R-01
   Task : Reaction area
   Type : Fluidized bed reactor
   Height of top head: 1.52 m
   disengaging : 7.88m
   Quantity : 1
   Price : IDR 33,981,104,639

2. Product Purge Bin
   Code : B-01
   Task : accommodate the polyethylene resin products and deactivation of TEAL.
   Diameter (D) : 2.8586 m
   Height total : 21.9380 m
   Shell thickness: 0.02243 m
   Head thickness: 0.02230 m
   Quantity : 1
   Price : IDR 1,574,135,319

3. Cyclone
   Code : H-01
   Task: separate the polyethylene resin with gases.
   Diameter : 0.7143 m
   Length cylinder: 1.4287 m
   Length of cone: 1.4287 m
   Price : IDR 102,693,898

4. Cyclone
   Code : H-02
   Task : separate the polyethylene resin with gases.
   Diameter : 3.5014 m
   Length cylinder: 7.0028 m

Length of cone: 7.0028 m
Price : IDR 1,404,447,536

5. Product Blow Tank
   Code : F-04 and F-05
   Task : polyethylene resin container of the reactor.
   Diameter : 2.7790 m
   Heightl : 15. 6615m
   Quantity : 2
   Price : IDR 1,173,024,667

D. Utility and Laboratory

1. Process Support Unit (Utilities)

Process support unit is often called utility unit is an important part to support the course of a process in a factory. Utilities in a factory is very influential in the smooth production process. Process support unit include: water supply unit (cooling water, sanitary water, boiler feed water and water for offices and housing), steam, electricity and fuel procurement.

Process support unit required in this plant include:

- Unit Supply and Water Treatment
  Serves as boiler feed water, water sanitation offices, housing and water for cooling water in the cooling process used on cooler and pelletizer.
- Steam Supply Unit
  Used for process heating in heater, steam for product purge bin and extruder.
- Fuel Supply Unit
  Function provides the fuel for boilers and generators
- Power Supply Units
  Serves as a driving force for the process equipment, process control instruments and lighting. Electricity derived from PLN and Generator Set as a backup if the PLN impaired.
- Compressed air supply unit
  Compressed air is needed for pneumatic control device. Tools such as the provision of compressed air compressors and blowers.
- Waste processing unit
  Serves good plant to treat waste in the form of solid, liquid and gas.

2. Laboratory

Laboratory is a very important part in supporting the smooth production process and maintain product quality. While the other role is to control environmental pollution, waste either gas, liquid or solid. Liquid waste such as waste from

cooling water process. Chemical laboratory is a means to conduct research of raw materials, processes and production. This is done to improve and maintain the quality or the quality of the product of the company. Analysis carried out in the framework of quality control includes the analysis of raw materials and processes as well as products.

E. Management

The factory of LLDPE is planned to be established:

Type of Company

: Limited Liability Company (.Ltd)

Business field

: Polymers industry

Location of the company

: Cilegon, Banten

The reason for choosing this company type is based on several factors as follows (Daniel Robey, Carol A. Sales, designing Organization, 1994):

1. Easier to raise capital by selling shares of the company.
2. The responsibility of investor is limited so smooth production is only held by the head of the company.
3. The owners and administrators of the company apart from one another, where the owner is the company investor and management company workers supervised by the board of commissioners.
4. The survival of the company is more secure, because it is not affected by the cessation of investor, and employees.
5. The efficiency of management, because investor can choose people who are experts on the trustee board and the President director
6. Wider business opportunities, a limited liability company can attract a very large capital from the public, so that in this capital of PT can expand his own efforts.

F. Economic Analysis

Table 4. Economies Analysis

Description	Calculation
ROI before tax	71.81 %
ROI after tax	50.27 %
POT before tax	1.25
POT after tax	1.72
Break Even Point (BEP)	49.35 %
Shut Down Point (SDP)	41.34 %
Discounted Cash Flow	31.01 %

From the economic analysis carried out can be calculated:

1. Percent Return On Investment (ROI) after tax of 50.57 %

2. Pay Out Time (POT) after tax for the year 1.72
3. Break Event Point (BEP) amounted to 49.35 %
4. Shut Down Point (SDP) amounted to 41.34 %
5. Discounted Cash Flow of 31.01 %

So, Linear Low Density Polyethylene plant with a capacity of 400,000 tonnes / year deserves to be established.

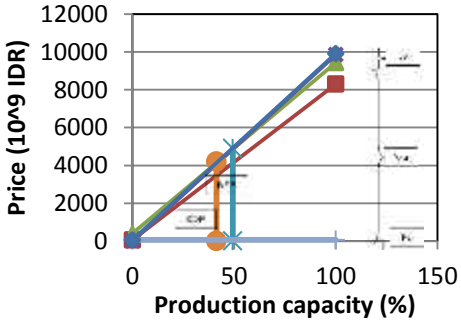

Figure 1. Graph of feasibility analysis

G. Conclusion

In Preliminary Des`ign of Linear Low Density Polyethylene From Ethylene Using UNIPOL Process With Capacity of 400,000 Tons / Year can be concluded:

1. Establishment of Linear Low Density Polyethylene Plant From Ethylene Using UNIPOL Process With Capacity 400,000 Tons / Year motivated by a reduction in the value of imports or reliance Linear Low Density Polyethylene from abroad as well as a provider of raw materials for other factories.
2. Linear Low Density Polyethylene Plant is in the form limited liability company (PT) was established in the area of Cilegon, Banten, on a land of 15,779m^2, operated for 330days/year with 202 employees.
3. The results of the economic analysis are as follows:

a. Gains:

Profit before tax and IDR 429,859,745,392

Profit after tax of IDR 300,901,828,074

b. Return of Investment (ROI):

Percentage ROI before tax of 71.81.%, and ROI after tax of 50.27% . Requirement of ROI for chemical plant with a low risk of age is 11%.

c. Pay Out Time (POT):

POT before tax 1.25 for 5 years and POT after tax 1.72 during the year. Terms POT before tax for the chemical plant with a low risk of maximum is 5 years.

d. Break Event Point (BEP) at 49.35%, and Shut Down Point (SDP) at 41.34%. BEP for chemical plants in general is 40-60%

e. Discounted Cash Flow (DCF) of 31.01%

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