CHAPTER I
INTRODUCTION

1.1. Back Ground

Linear alkyl benzene (LAB) or linear dodecyl benzene is usually used as raw material for the manufacture of linear alkyl benzene sulphonic (the main component of making soap and detergent). The development of industries that use raw materials LAB is quite rapidly. This can be seen from the increase production of detergents, shampoos and cosmetics. Along with the rapid demand for chemical products in Indonesia (domestic) market, most industries began using raw materials LAB to replace branch alkyl benzene because it is more environmental friendly.

In developed countries, branch alkyl benzene usage is not allowed .Therefore the chemical experts are conducting research to produce a detergent that does not cause environmental pollution. One of the result is the production of LAB that does not cause environmental pollution. Considering the importance and usefulness of LAB economic value the establishment of this chemical plant is very beneficial, other reasons are :

1. There is only one industry producing linear alkyl benzene in Indonesia and Southeast Asia. It is PT.Unggul Indah Cahaya Tbk.
2. Provides more opportunity to establish other industries that using linear alkylbenzene as raw material.
3. The opportunities for the unemployed.
4. The opportunities to export linear alkyl benzene to overseas.

1.2. Production Capacity

The determination of production capacity is based on the availability of raw materials, manufacturing capacity that has been established in the market and the needs of the linear alkyl benzene as shown in the table below :

Table 1.1. Linear alkylbenzene needs in Indonesia based on the import data

Year	Import Data (tons /year)
2008	1,453,176
2009	445,019
2010	211,527
2011	169,768
2012	534,856

Source: *BPS Indonesia*

Industry sources said demand for LAB in the Asian and Middle East markets was expected to rise by 3-5% in 2013 from 2012 . Currently demand for LAB in Asia is estimated at 1.4m tonnes/year, while the total consumption in the Middle East and North Africa is said to be above 4,000,000 tonnes/year according to industry sources.(Source: ICIS)

The minimum design capacity may be,estimated from similar plant that has been established. From Table 1.2 the capacity of 5,000 tons/year has been quite favourable.

Table 1.2 LAB plants capacity that has been established (tons/year)

Company	**Location**	**Capacity**
Lukoil Neftochim Burgas	Burgas, Bulgaria	5,000
Emalab	Jebel Ali, Dubai	30,000
Ameriya Petroleum Refining	Ameriya, Egypt	50,000
Formosan Union Chemical	Lin Yuan,Taiwan	90,000
CEPSA Quimica	San Roque, Spain	220,000
Sasol	Louisiana, US	125,000

SOURCE: ICIS plants & projects

LAB industry is planned to be built in 2016 with a capacity of 20,000 tons per year. The capacity is expected to be:

a. able to fulfill the needs of the domestic market and overseas.
b. Able to save considerable foreign exchange due to reduced import LAB and reduce reliance on other countries.

1.3. Plant Location

The location of the plant is very influential on the existence of a project industry in terms of both commercial and future possibilities. Many factors must be considered in selecting the plant location. the establishment of LAB plant is planed in Cilegon Banten. The following are the main factors effecting the selection of the location in terms of economy and the operation that definitely needed by all types of existing industries below:

a. Supply of raw materials

Supply of raw materials is relatively easy because benzene can be obtained from the industrial area in Cilegon, Banten. Whereas, the 1-dodecene is purchased from International petrochemical companies such as Exxon, Chevron and Arco.

b. Marketing

This product is the raw material for the manufacture of detergents, so its marketing is expected not only to be used in the detergent plant established in java but also can be exported, so the plant location is selected nearly the port.

1.4. Literature Review

Linear alkyl benzene or LAB has emerged as the dominant detergent intermediate since the early 1960s driven by the environmental need to produce biodegradable detergents.

Commercially, in the past, there were two major catalysts for the alkylation of benzene with higher alpha or internal mono-olefins (C_{10}-C_{16} detergent range

olefins), hydrogen fluoride HF and $AlCl_3$. The HF-based process became more prevalent than ones based on aluminum chloride. The potential for accidental release of hydrofluoric acid raised environmental concerns (Clear Air Act Amendment) and by the introduction of a solid catalyst system in 1995, commercially known as the DETAL process, which eliminates the problem of catalyst neutralization and disposal of HF, the LAB industry has adopted the solid catalyst-based process as the "preferred process". Since 1995, most of the new LAB plants have employed the DETAL process.

1.4.1. LAB processes

The four routes used to produce LAB commercially are detailed :

- Chlorination of *n*-paraffins to monochloroparaffins followed by benzene alkylation with aluminum chloride ($AlCl_3$) catalyst (Friedel-Craft Alkylation).
- Chlorination of *n*-paraffins to monochlorinated paraffins followed by dechlorination to produce olefins and subsequent benzene alkylation (process is however no longer commercially employed). Disadvantage of those two processes are difficult to control, a lot of side product, and there is a residual catalyst (Farn, 2006). LAB is a low quality.
- Dehydrogenation of *n*-paraffins to internal olefins followed by benzene alkylation using HF catalyst (UOP/HF *n*-Paraffin Process). The advantages of this process are highly efficient catalysts and LAB product quality is very good. However, disadvantage of this process is requires special metallurgical equipment to be resistant HF necessary handling and retrieval of HF used. This case causes the equipment and operational costs to be expensive (Spitz, 2004). HF waste is also harmful to the environment.
- Dehydrogenation of *n*-paraffins to internal olefins followed by benzene alkylation using a fixed-bed catalyst (DETAL). The advantages of this process is very efficient catalyst, the process is more simpler than others,

safe and easy to operate, not metallurgy materials with special needs so that the necessary capital less, no hazardous waste, low maintenance costs, very good quality LAB.

Comparing the natures of the four alternative processes above then selected Detal process.

1.4.2. Product application

LAB is sulfonated to produce linear alkyl benzene sulfonate (LAS), a biodegradable surfactant. LAS replaced branched dodecylbenzene sulfonates, which were phased out because they biodegrade more slowly.

1.4.3. Physical and chemical properties

1. Raw materials

- Benzene

Physical and chemical properties of benzene :

Physical state and appearance: Liquid

Odor	: Aromatic, gasoline-like, rather pleasant.
Molecular formula	: C_6H_6
Molecular Weight	: 78.11 g/mole
Color	: Clear Colorless. Colorless to light yellow.
Boiling Point	: 80.1 (176.2°F)
Melting Point	: 5.5°C (41.9°F)
Critical Temperature	: 288.9°C (552°F)
Specific Gravity	: 0.8787 @ 15 C (Water = 1)
Vapor Pressure	: 10 kPa (@ 20°C)
Odor Threshold	: 4.68 ppm
Water/Oil Dist. Coeff.	: More soluble in oil; log(oil/water) = 2.1
Dispersion Properties	: Solubility in water, diethyl ether, acetone.
Solubility	:Miscible in alcohol, chloroform, carbon disulfide oils, carbon tetrachloride, glacial acetic acid, diethyl ether, acetone. Very slightly soluble in cold water.

- 1-Dodecene

Physical and chemical properties of 1-dodecene :

Physical state and appearance: Liquid

Molecular formula	: $C_{12}H_{24}$
Molecular Weight	: 168.36 g/mole
Color	: Clear Colorless
Boiling Point	: 213°C (415°F)
Melting Point	: -35°C (-31°F)

Critical Temperature	: 288.9°C (552°F)
Specific Gravity	: 0.787 @ 15 C (Water = 1)
Vapor Pressure	: 0.35 kPa (@ 65°C)
Solubility	: Soluble in hydrocarbon solvents; insoluble in water.

2. Product

- Linear alkylbenzene (dodecylbenzene)

  Physical and chemical properties of dodecylbenzene :

  Physical state and appearance: Liquid.

Molecular formula	: $C_{12}H_{25}C_6H_5$
Molecular Weight	: 246.43 g/mole
Color	: Clear Colorless.
Boiling Point	: 290°C (554-770°F)
Melting Point	: -70°C (-94°F)
Critical Temperature	: 501°C (933.8°F)
Specific Gravity	: 0.8687 @ 15.5 °C (Water = 1)
Vapor Pressure	: 0.013 hPa (@ 25°C)
Water/Oil Dist. Coeff.	: 7.5 – 9.12 @ 25 °C
Solubility	: Slightly soluble in water.

(Sciencelab.com)

1.4.4. General process overview

Raw material benzene and 1-dodecene enter to the reactor in the liquid phase. Reactor used is the fixed bed reactor. the reactor operating conditions are allowable temperatures between 80 - 280°C with 5 - 50 atm pressure. Mole ratio of benzene to 1-dodecene = 1:2 – 1:20, with 98% 1-dodecene conversion (Wang, 2002).

reaction :

$$C_{12}H_{24} + C_6H_6 \rightarrow C_{12}H_{25}C_6H_5$$

Product from reactor is fed to the distillation column for separating benzene and 1-dodecene from LAB. Benzene and 1-dodecene are recycled to the reactor. The main product obtained is LAB.