Report of Cooperative Education

Feasibility Study of NGL Solvent Production at GSP's Stabilizer No.1

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รายงานสหกิจศึกษาฉบับสมบูรณ์

การศึกษาความเป็นไปได้ของโครงการผลิตตัวทำละลายจากก๊าซโซลีนธรรมชาติที่หอกลั่นStabilizer หมายเลข1ของโรงแยกก๊าซธรรมชาติ ระยอง

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Abstract

The gas separation plant needs to increase the value of NGL, it is suitable for White Spirit production. White Spirit is a solvent which used in the rubber industry and as a cleaning agent. In the system of gas separation plant, there is one has a Stabilizer Column that is not used. Therefore, the Stabilizer Column was brought to distillate NGL to produce White Spirit. This project studies the feasibility of White spirit production by simulating the production process using the Aspen hysys (Version 9.0) and the modification of the device in the Condensate Stabilizer unit. Then, evaluated the feasibility of the project by finding the IRR, NPV, and PBP of the each cases. The validity of these simulating vlatas would to useful for the real white spirit production

Keywords: NGL, Whit spirit

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Samritt Suksawatt

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CHAPTER I

INTRODUCTION

Background

PTT is the largest gas separation operator in Thailand. We run six gas separation plants to separate various hydrocarbons from the natural gas which in turn maximizes value of the gas from the Gulf of Thailand. The Gas Separation Plant Units 1-3, 5 and 6 are located in Tambon (Sub-district) Mab Ta Phut, Amphur (District) Mueng, Rayong Province and the fourth Unit in Amphur Khanom, Nakhon Sri Thammarat Province. Presently, PTT's gas separation plants have a nameplate capacity of 2,660 million cubic feet per day (MMSCFD). The first Unit's capacity is 350 MMSCFD; the Second and the Third Units (including increment from the ethane separation plant) have a capacity of 750 MMSCFD. As for the Fourth Unit, its capacity is 230 MMSCFD, while the Fifth and the Sixth Units have a capacity of 530 and 800 MMSCFD, respectively. The last plant, the Sixth Unit has a capacity to process 800 MMSCFD. Due to continuous effort to improve efficiency of the gas separation plants, a combined processing capacity of every unit in 2012 is 2,740 MMSCFD.

Since Rayong Gas Separation Plant needs to increase the value of natural gas liquid (NGL), the NGL of the gas separation plant is condensate, which mixed with natural gas delivered from natural gas wells. Then condensate is separated by Stabilizer column. In the present, the gas separation plant has increased the gas pipeline from the wells, so the gas separation plant needed to build 2 stabilizer column to enough for gas that sent from wells. After that, the unused stabilizer column will be used in the white spirit production process to increase the value of the NGL. At present, NGL can be added to the value. 1. Distillation to gasoline. 2. Distillation to solvents, white spirit, which use in industry. White spirit is a hydrocarbon compound in the C7-C12 NGL range. The NGL component of the Rayong Gas Separation Plant is suitable for the White Spirit production by using stabilizer column. White spirit is used in industries example a lacquer industry, thinner industry, cleaning industry, and rubber industry etc.

1.2 Objectives

1.2.1 To study Thailand's solvent industry which is suitable for GSP NGL.

1.2.2 To increase value added of NGL by producing new solvent.

1.2.3 To utilize existing stabilizer column(currently shut down) to produce new solvent.

1.3 Scopes of Work

1.3.1 Study the GSP NGL data and find the appropriate Solvent production.

1.3.2 Distillation Solvent is divided into 3 types is 1. C_6-C_{12}, 2. C_7-C_{12}.

1.3.3 Test Solvent samples then evaluate Solvent which should produce.

1.3.4 Plant Simulation to determine the value of CAPEX and OPEX.

1.3.5 Feasibility study of the project by using economic analysis.

1.4 Expected Outputs

1.4.1 Simulation field of White spirit process.

1.4.2 The result of white spirit project feasibility.

CHAPTER II

LITERATURE REVIEW

2.1 Natural Gasoline (NGL) (PTT Rayong Gas Separation Plant, 2017)

Natural Gasoline (NGL) consists of Pentane, hexane and other compounds with carbon content ranging from C_5 upwards. NGL is refined into gasoline (Motor Gasoline). For Pentane Hexane Heptane and other compounds, which have the properties of liquid evaporation faster. It will be sent to the petrochemical industry as a raw material for the solvent in chemical experiments, Paint, lacquer, and rubber industries.

Rayong Natural Gas Separation Plant receives natural gas from drilling rigs. The pressure is reduced and the heavy is in the liquid form. Before the natural gas enters the gas separation plant, it must pass a pipetype slugcatcher to filter impurities from natural gas wells. After that, natural gas passes through the control valve to lower the pressure so the heavy becomes a liquid and then separates it at the knockout drum. The light part will be off the top of the Knock out drum and into the gas separation unit 1-6. The liquid from the bottom of the knockout drum into the stabilizer column. The stabilizer column is a distillation column for lightweight (C_3-C_4) separation from heavyweight (C_5+). After passing through the Stabilizer tower, the light is then transferred to the gas separation plant 1-6. The liquid from the bottom of the stabilizer column is NGL as shown in Figure 1.

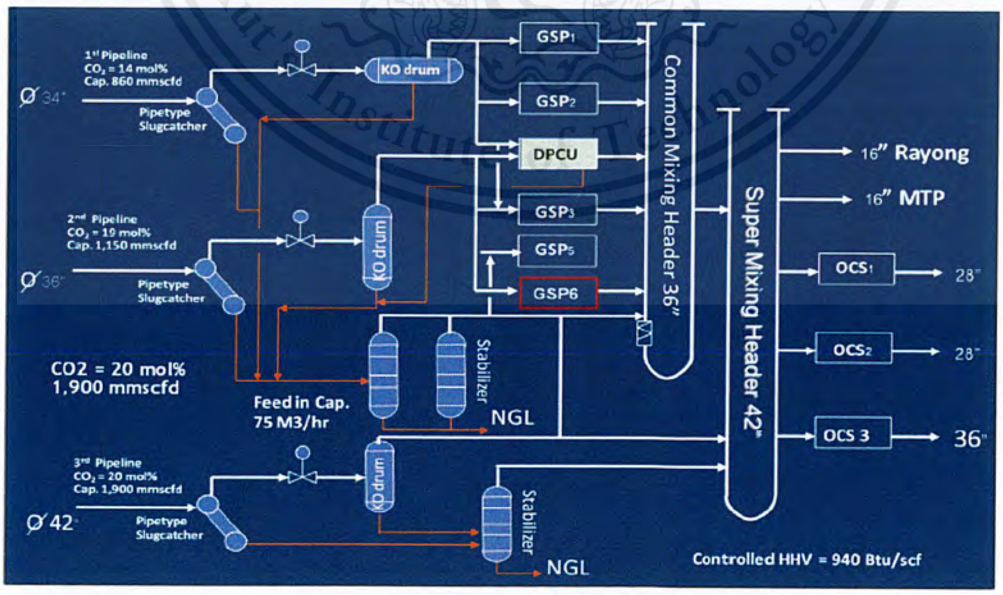

Figure 2.1 Overview of gas separation plant

2.2 White spirit or Mineral spirit (IPSC International Programme on Chemical Safety: Online)

White spirit or Mineral spirit is the same hydrocarbon solvent, but it is different because of the white spirit is called in the United Kingdom. Mineral spirit is called in the United States. White spirit is derived from the hydrocarbon solvents in the range of Solvent naphtha (aliphatic and alicyclic hydrocarbons C_7-C_{12}) through the removal of contaminants. The purpose is to be used as a solvent in the artisan or industrial work. White Spirit or Mineral Spirit consists of C_7-C_{12} hydrocarbons containing aliphatic and alicyclic alcohols 80-85%, aromatic 15-20%, and sulfur as shown in Figure 2.2.

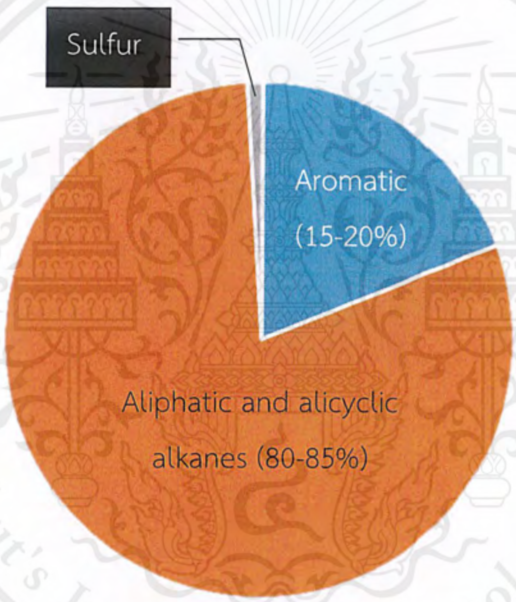

Figure 2.2 Composition of White spirit

2.2.1 Type of White spirit

The white spirit is divided by the removal of contaminants and Aromatic in the White spirit. The higher the type, the White Spirit will be, the impurity and Aromatic percentage is reduced. There are 4 types.

2.2.1.1 Type 0 is a white spirit through the process of removal of contaminants, but not through the process of sulfur removal and Aromatic removal, so the White spirit is the same as Figure 2.2.

2.2.1.2 Type 1 is a white spirit that removes contaminated and desulfurized to remove sulfur from the white spirit so that the white spirit does not have a pungent odor.

2.2.1.3 Type 2 is a white spirit that removes contamination, desulfurization and solvents extraction to remove sulfur and aromatic in the white spirit. The aromatic in Type 2 is less than 5%.

2.2.1.4 Type 3 is a white spirit that removes contaminated, Desulfurization, Solvent extraction and Hydrogenation. In order to get rid of Sulfur and Aromatic in the white spirit. The aromatic in Type 2 must be less than 1%.

2.2.2 Grade of White spirit

The grade of white spirit is divided by the fire of the White spirit, which is divided into 3 grades.

2.2.2.1 Low flash grade with flash point at 21-30 °C and initial boiling point at 130-144 °C

2.2.2.2 Regular grade with a flash point of 31-54 °C and an initial boiling point of 145-174 °C

2.2.2.3 High flash grade with flash point greater than 55 °C and initial boiling point 175-200 °C

Table 2.1 Physical Properties of the Grade of White Spirit.

Physical properties	Low flash	Regular	High flash
Initial boiling point (IBP) (°C)	130-144	145-174	175-200
Final boiling point (°C)	IBP+21, max. 220		
Average relative molecular mass	140	150	160
Relative density (15°C)	0.765	0.780	0.795
Flash point (°C)	21-30	31-54	> 55
Vapor pressure (kPa, 20°C)	1.4	0.6	0.1
Volatility (n-butyl acetate=1)	0.47	0.15	0.04
Auto ignition temperature (°C)	240	240	230
Explosion limits (% by volume in air)	0.6-6.5	0.6-6.5	0.6-8
Vapor density (air=1)	4.5-5	4.5-5	4.5-5
Refractive index (at 20°C)	1.41-1.44	1.41-1.44	1.41-1.44
Viscosity (cps, 25°C)	0.74-1.65	0.74-1.65	0.74-1.65
Solubility (% by weight in water)	< 0.1	< 0.1	< 0.1
Kauri-butanol value	29-33	29-33	29-33
Aniline point (°C)	60-75	60-75	60-75
Odour threshold (mg/m^3)	-	0.5-5	4

2.2.3 Application of White spirit (Poul Bo Larsen, 2014 : 62)

2.2.3.1 Wood impregnation

In vacuum impregnation (in contradiction to high pressure impregnation) of wood the use of white spirit cannot be substituted by water in the wet impregnation process where white spirit is the main constituent in the impregnation solvent. Vacuum impregnation of wood has to be conducted on plants approved by the Danish Impregnation Inspection and due to strict standards and new technology the use of impregnation solvent has decreased from 125 kg per m^3 wood in 1970 to 26 kg per m^3 wood in 2000.

Further measures are available for either recycling white spirit (condensation) or removal of vapors from the emitted air by use of active carbon filters or burning after concentration of the emitted vapors (Danish EPA 2000).

2.2.4 Marketing information, import and export of white spirit (กรมศุลกากร, 2560 : ออนไลน์)

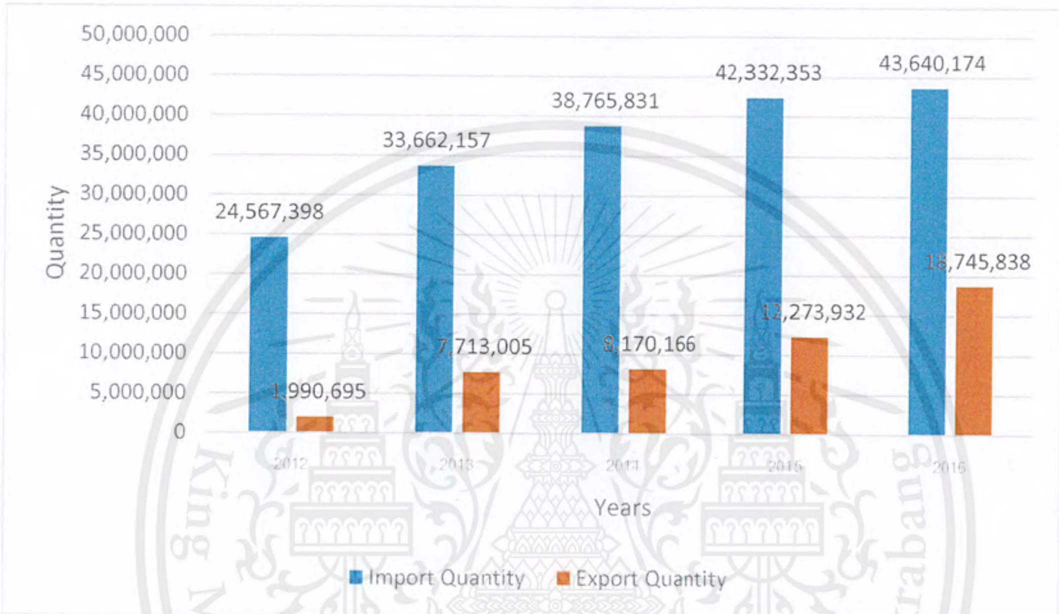

Figure 2.3 The relationship between the volume of imports and exports of White spirit in Thailand from 2012-2016.

From Figure 2.3 The white spirit in Thailand shows that in the past 5 years, the import and export volume of White spirit in Thailand has grown by the average import and export as the following.

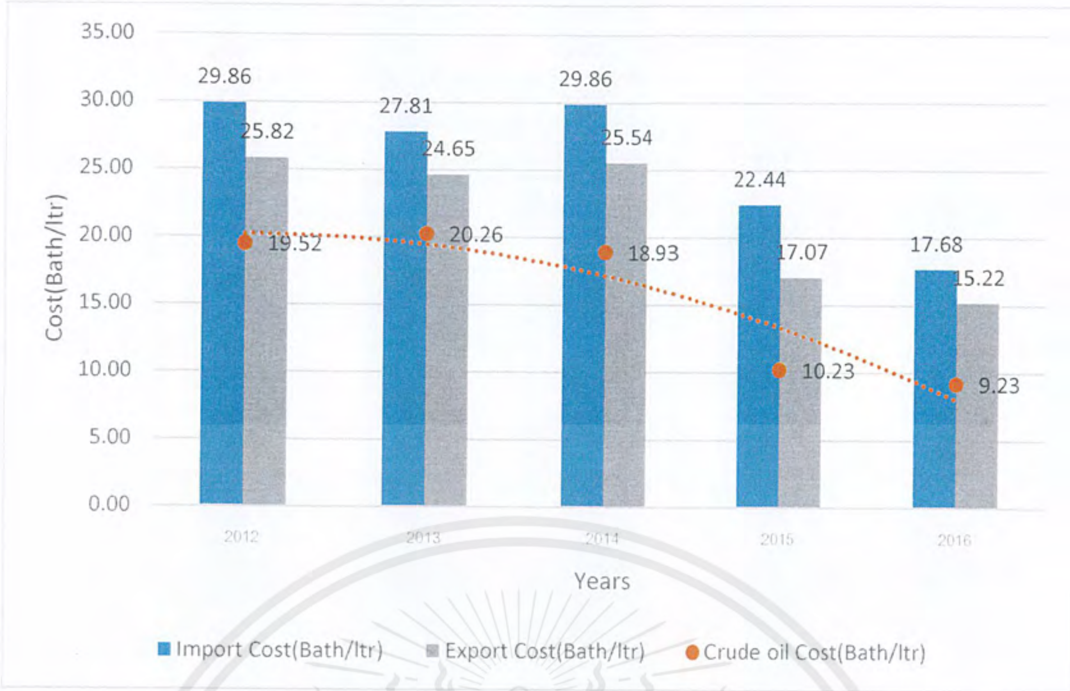

Figure 2.4 The relationship between the price per liter, import and export of White spirit in Thailand and the price of crude oil per liter from 2012-2016.

From Figure 2.4 shows that the price per liter of white spirit imported and exported has decreased because of the lower price of oil. Because of the production of White spirit is produced from crude oil. The long-term global crude oil prices are fell by 3 factors.

1. The boom of oil production in the United States and elsewhere in the world has fueled the US and other parts of the world, resulting in more oil entering the market, pushing prices down. While OPEC members produce more consistent amounts of oil, others produce more and the US leads the way.

US oil production has increased dramatically. In the past the advantage of the revolution of shale oil drilling. With new technologies such as horizontal drilling, this gives access to hydrocarbons beneath the surface of the earth. Resulting in the United States. Crude oil production per day is almost double that of the mid-twentieth century.

In addition to US oil production in other countries. As Canada increased its production capacity from about 2.5 million barrels per day in 2009 to more than 3.3 million barrels a day in 2013, Russia increased its production from around 9.5 million barrels a day in 2009 to more than 10 million. Barrels per day in 2013. Libya is increasing its crude oil production to normal. After facing a civil war in 2011.

2. Demand or Buy Demand for Oil Declines in Many Countries like Japan and many European nations. With the fact that. While in the United States Recovery from the recession up. But many other countries do not. They are experiencing problems. That affects the demand for oil.

3. Advances in fuel efficiency of vehicles. Current car in the US uses less fuel than before. Because cars are more efficient, in 2014, US cars have an average fuel consumption of 25.3 miles per gallon. Better than in 2008, 1 gallon of fuel could make the car run only 20.8 miles.

2.3 Equipment in Condensate stabilizer unit (PTT Rayong Gas Separation Plant, 2017)

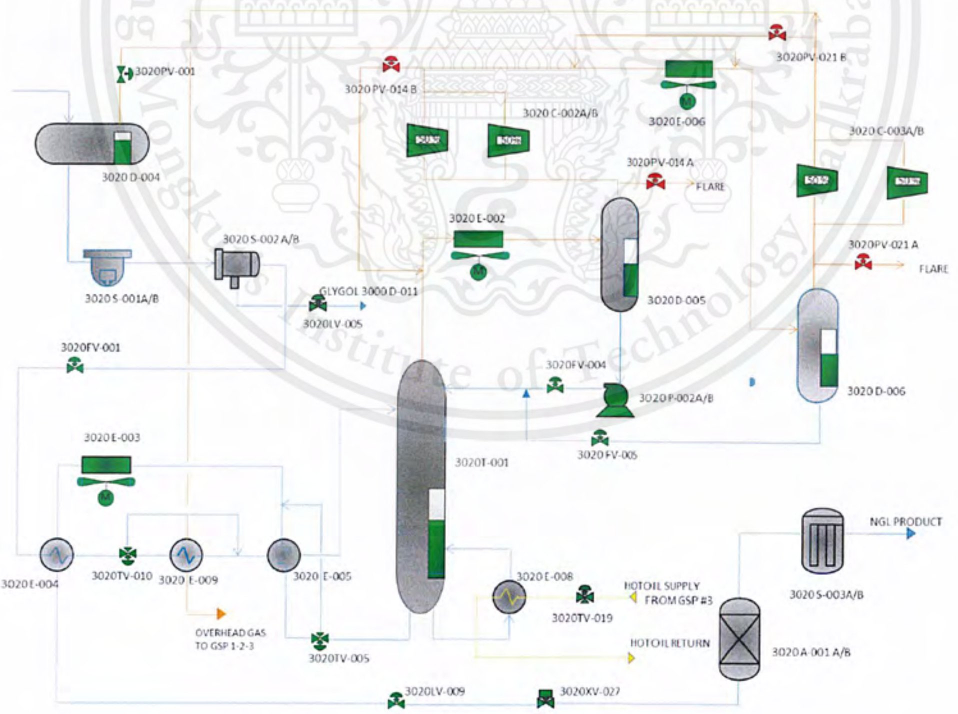

Figure 2.5 Process flow diagram of NGL

From Figure 2.5 shows the process flow diagram of the device, which separates the light from the heavy using the Stabilizer column. There are following devices.

2.3.1 Fin fan heat exchanger (E-003)

Heat exchanger type Fin fan by using air to cool the exchanger substance (E-005).

Fin fan heat exchanger (E-003), acting heat exchanger of White spirit passed through the Heat exchanger (E-005) with air to reduce the temperature of White spirit, but because of the heat White spirit is not enough to exchange with NGL in heat exchanger (E-004) Therefore, Fin fan heat exchanger(E-003) is not necessary.

2.3.2 Shell & tube heat exchanger (E-004)

Heat exchanger (E-004) is a type of Shell & tube. Fluid in Tube and Shell, which are fed into the Stabilizer column and White Spirit through the Fin fan heat exchanger (E-003), respectively.

The heat exchanger (E-004), acting heat exchange of White spirit through heat exchanger fan from Fin (E-003) with NGL to preheat. Before sending it to Heat exchanger (E-005) to make preheat before feed into the Stabilizer column.

2.3.3 Shell & tube heat exchanger (E-005)

Heat exchanger (E-005) is a type of Shell & tube. Fluid in Tube and Shell, which are the white spirit from the bottom Stabilizer column (T-001) and the NGL feed into the Stabilizer column, respectively.

The heat exchanger (E-005), acting heat exchange of White spirit through heat exchanger fan from Fin (E-003) with NGL to preheat before feed into the Stabilizer column.

2.3.4 Stabilizer Column (T-001)

The distillation tower used to be a light distillery C3-C4 separated from the heavy to be imported into the gas separation plant to produce LPG and the bottom of distillation column will be the substance C5 upward or NGL, but since the gas separation plant has added gas pipelines from natural gas wells in order to increase its capacity to provide natural gas to the natural gas separation plant, so the natural gas separation plant increase the Stabilizer column to separate the C3-C4, resulting the Stabilizer column is not operating, so it will be refined NGL to White spirit.

2.3.5 Fin fan heat exchanger (E-002)

Fin fan heat exchanger acts as a condenser on top of Stabilizer (T-001).

2.3.6 Reflux Drum (D-005)

Reflux Drum (D-005) serves to separate the reflux and distillate parts. The reflux is sent to the reflux pump for feed into the Stabilizer column.

2.3.7 Reflux Pump (P-002A/B)

Reflux Pump (P-002A / B) acts to increase the pressure in the reflux line so that there is sufficient pressure to feed it to the Stabilizer column.

2.3.8 Shell & tube heat exchanger (E-008)

Heat exchanger Shell & Tube (E-008) serves as a reboiler. Inside the Tube and Shell of the Heat exchanger are Hot Oil and the substance coming out from the bottom of the Stabilizer column respectively. The gas is then sent back to the Stabilizer column. The liquid part is then sent to preheat NGL at the heat exchanger E-004 and E-005.

2.4 Estimating Equipment Costs by Scaling (Max S. Peters Klaus D. Timmerhaus et al., 1991 : 169)

It is often necessary to estimate the cost of a piece of equipment when no cost data are available for the particular size of operational capacity involved. Good results can be obtained by using the logarithmic relationship known as the six-tenths-factor rule, if the new piece of equipment is similar to one of another capacity for which cost data are available. According to this rule, if the cost of a given unit at one capacity is known, the cost of a similar unit with X times the capacity of the first is approximately $(X)^{0.6}$ times the cost of the initial unit.

$$\text{Cost of Equipment A} = \text{Cost of Equipment B}\left(\frac{\text{Capacity of Equipment A}}{\text{Capacity of Equipment B}}\right)^{0.6}$$

The previous equation shows that the log-log plot of the capacity versus the equipment cost for the given equipment should be a straight line with a slope of 0.6. Figure 2.6 shows the plot the shell-and-tube heat exchangers. However, the application of regulatory clause 0.6 for most purchased devices is making the cost concept too valuable because the actual value of the cost factor is changing from less than 0.2 to more than 1.0 as shown. In Table 2.2, factor 0.6 should be used only if no other information is available. Generally speaking, the concept of cost-effectiveness is not. It should exceed 10 times the capacity and be careful to ensure that these two devices are similar to the type of building materials, construction, temperature and pressure. And other related variables.

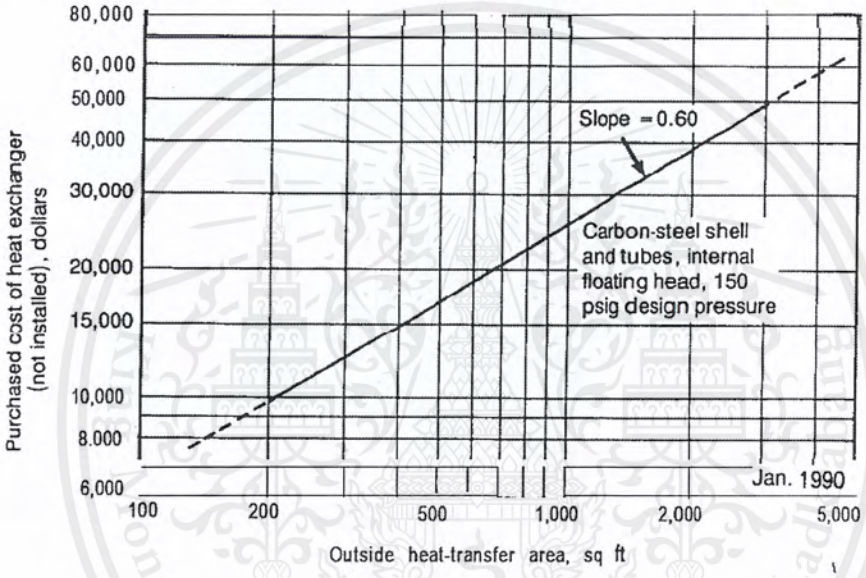

Figure 2.6 Application of "six-tenth-factor" rule to costs for shell-and-tube heat exchangers.

Table 2.2 exponents for equipment cost vs. capacity

Equipment		Exponent
Blender, double cone rotary, C.S.	SO-250 ft^3	0.49
Blower, centrifugal	10^3-10^4 ft^3/min	0.59
Centrifuge, solid bowl, C.S.	10-10^2 hp drive	0.67
Crystallizer, vacuum batch, C.S.	500-7000 ft^3	0.37
Compressor, reciprocating, air cooled, two-stage, 150 psi discharge	10-400 ft^3/min	0.69
Compressor, rotary, single-stage, sliding vane, 150 psi discharge	10^2-10^3 ft^3/min	0.79
Dryer, drum, single vacuum	10-10^2 ft^2	0.76
Dryer, drum, single atmospheric	10-10^2 ft^2	0.40
Evaporator (installed), horizontal tank	10^2-10^4 ft^2	0.54
Fan, centrifugal	10^3-10^4 ft^3/min	0.44
Fan, centrifugal	2×10^4-7×10^4 ft^3/min	1.17
Heat exchanger, shell and tube, floating head, C.S.	100-400 ft^2	0.60
Heat exchanger, shell and tube, fixed sheet, C.S.	100-400 ft^2	0.44
Kettle, cast iron, jacketed	250-800 gal	0.27
Kettle, glass lined, jacketed	200-800 gal	0.31
Motor, squirrel cage, induction, 440 volts, explosion proof	5-20 hp	0.69
Motor, squirrel cage, induction, 440 volts, explosion proof	20-200 hp	0.99
Pump, reciprocating, horizontal cast iron (includes motor)	2-100 gpm	0.34
Pump, centrifugal, horizontal, cast steel (includes motor)	10^4-10^5 gpm × psi	0.33
Reactor, glass lined, jacketed (without drive)	50-600 gal	0.54
Reactor, S.S, 300 psi	10^2-10^3 gal	0.56
Separator, centrifugal, C.S.	50-250 ft^3	0.49
Tank, flat head, C.S.	10^2-10^4 gal	0.57
Tank, C.S., glass lined	10^2-10^3 gal	0.49
Tower, C.S.	10^3-2×10^6 lb	0.62
Tray, bubble cup, C.S.	3-10 ft diameter	1.20
Tray, sieve, C.S.	3-10 ft diameter	0.86

2.5 Project Feasibility (รองศาสตราจารย์ ดร.ประสิทธิ์ ตงยิ่งศิริ, 2527 : 126)

2.4.1 Net present value (NPV)

Net present value is the sum of the net present value of the project. It aims to measure the project being considered. If the NPV value is greater than 0 or positive, it is a good investment. If the NPV is negative or lower than 0, then the NPV is negative. That investment is not worth it. This criterion is used to help decide whether to accept or reject a project.

The calculation of net present value. There is two ways to do this. It starts with the adjustment of the time of cost and returns on a yearly basis throughout the life of the project. In order for the current value to be subtracted, the NPV of the project the cost of the project is deducted from the annual return. Then adjust the time value of the cash flow that occurs each year, which is multiplied by the PWF or annual cash. When combined, the net present value of the project, Method of measurement is called "Discounted cash flow method"

The formula is as follows:

$$NPV = \sum_{t=1}^{n} \frac{B_t}{(1+i)^t} - \sum_{t=1}^{n} \frac{C_t}{(1+i)^t} - \sum_{t=1}^{n} \frac{TAX}{(1+i)^t} \tag{2.1}$$

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t - TAX}{(1+i)^t}$$

When NPV = Net present value of the project.

B_t = The return in year 1, 2, ...n.

C_t = Cost in year 1, 2, ... n, which may be combined with K_0 or excluded, as the case may be.

TAX = Fee

i = Interest rate or opportunity cost of capital.

t = The time of cash flow

n =The time period of project.

2.4.2 Internal rate of return (IRR)

The internal rate of return (IRR) is the rate which makes the return and present cost is equal. The rate is the ability rate of the investment cost generate a return be worth investment. In other words, it is the rate that decreases the net present value equal zero. This is similar to how NPV is different. It changes from i or interest rate in NPV to r or discount rate in IRR.

IRR calculations start with a deduction of annual cost over the life of the project. To get a net return each year or cash flow. After that, the discount rate that gives the sum of the present value of the net return is zero. The method is called "Trial and error".

The formula is as follows:

IRR is the value of r (discount rate) to make.

$$\sum_{t=1}^{n} \frac{B_t - C_t - TAX}{(1+r)^t} = 0 \qquad 2.2$$

To help decide when an IRR comes out, it compares with the opportunity cost of capital. If the IRR is greater than the opportunity cost of capital It is a worthwhile investment but the IRR is lower than the opportunity cost of capital. It is not worth the investment.

2.4.3 Payback period

Payback period is the period when net return on operations is equal to project investment. This method considers the number of years to receive a return on investment. And used in the business. Especially in the case of high risks, such as the case of new yield. Or new methods that are not protected by law. New ideas may be stolen or imitated by competitors within a short time. After the new product is released to the market. In the event that the political situation is uncertain, then for sure not to underestimate. Investors must consider short-term return projects in the 3 to 5 years.

The payback period can be calculated as follows:

Payback period = Cost of investment / Average net return per year. 2.3

CHAPTER III

RESEARCH METHODOLOGY

The objective of this project was to simulate the White Spirit production process using the Aspen hysys program to determine equipment to improve in the Condensate Stabilizer unit. Prior to Simulation, the production process needed to know the components of the NGL that would produce the White spirit and the White Spirit specifications.

3.1 Procedures

3.1.1 Find NGL information of the gas separation plant.

1. Find out how to add value to NGL of gas separation plant.
2. Detect Composition NGL of the gas separation plant by sent to the Research Institute.

3.1.2 Find out about White spirit.

1. Find the type and grade of White spirit.
2. Find the price and quantity of import-export of White spirit.

3.1.3 Distillate NGL to White spirit sample which is divided into two types: 1. C_6-C_{12} and 2. C_7-C_{12} to take samples give customers to test and bring the sample to production.

1. Distillate NGL to the White spirit in the lab by simple distillation.
2. Deliver White Spirit samples to marketers for testing.

3.1.4 Take a sample of White spirit to detect for composition at the research institute.

3.1.5 Study equipment information of Condensate Stabilizer unit.

3.1.6 White spirit production process simulation is both examples using Aspen hysys program, to find the appropriate condition for White spirit production and equipment that must be improved in the Condensate Stabilizer unit.

1. Simulation using the Aspen hysys program and selecting the appropriate condition for the production of White spirit.
2. Check how to improve production equipment.

3.1.7 Estimate Cost Capital Expenditure (CAPEX) and Operating Expenses (OPEX) of both samples of White spirit.

1. Estimation of Condensate Stabilizer unit improvement costs for both White spirit samples.

Finding the improvement point of the Condensate stabilizer -unit by comparing the design of the device with the values obtained from the Simulation. Then, the price of the device in 2008 is estimated to be in 2017, which accounts for a 3.3% growth rate. Then use "Estimating Equipment Costs by Scaling" to evaluate the price of the device which different sizes.

The formula used to calculate inflation.

$$P_2 = P_1(1+i)^n \tag{3.1}$$

The formula used to calculate Estimating Equipment Costs by Scaling.

$$\text{Cost of Equipment A} = \text{Cost of Equipment B}\left(\frac{\text{Capacity of Equipment A}}{\text{Capacity of Equipment B}}\right)^{0.6} \tag{3.2}$$

2. Estimation of Capital Expenditure (CAPEX) from Condensate Stabilizer unit improvement.

3. Estimation of Operating Expenses (OPEX) of Condensate Stabilizer unit.

Find the amount of utility used in the equipment by using the Aspen Hysys program, then multiply the price of the utility.

3.1.8 Evaluate the feasibility of both White spirit samples by using internal rate of return (IRR), Net present value (NPV), and Payback period (PBP).

1. Calculate the Internal rate of return (IRR), Net present value (NPV), and Payback period (PBP) to evaluate both White spirit samples whether there is a probability of the project.

The formula used to calculate internal rate of return (IRR).

$$\sum_{t=1}^{n} \frac{B_t - C_t - TAX}{(1+r)^t} = 0 \tag{3.3}$$

The formula used to calculate net present value (NPV).

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t - TAX}{(1+i)^t}$$

3.4

The formula used to calculate Payback period (PBP).

Payback period = Cost of investment / Average net return per year. 3.5

CHAPTER IV

RESULTS AND DISCUSSION

4.1 The results from the simulation of each case by using Aspen hysys program

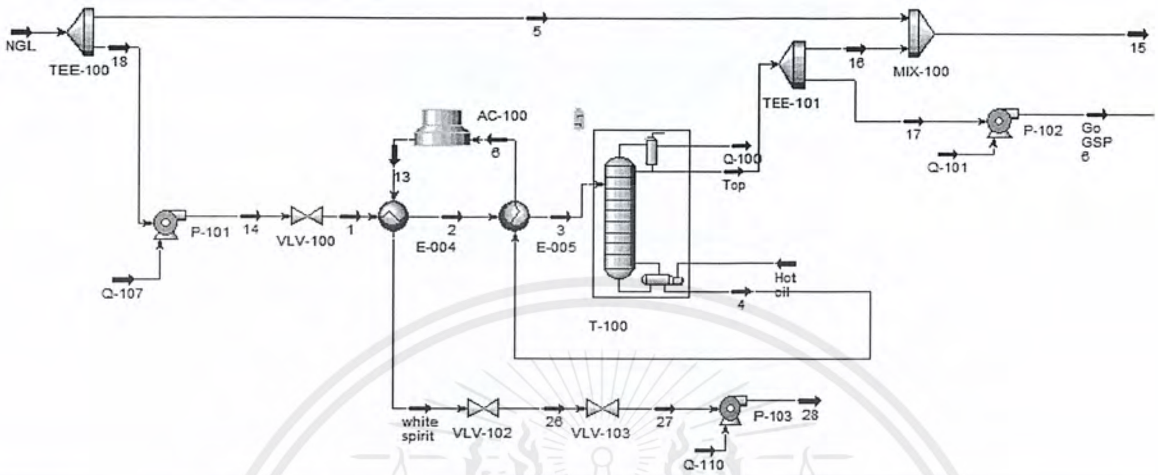

Figure 4.1 Process flowsheet for White spirit production in case C_6-C_{12} and C_7-C_{12}.

Figure 4.1 shows that the NGL feed in this process is limited by the capacity of the stabilizer column. If you do not split the NGL feed into the stabilizer column will cause flooding of the tower stabilizer column. Then split the line from the NGL to the pump (P-101) to increase the pressure to 5.8 bar to provide adequate pressure drop in the heat exchanger and stabilizer column. After the pump passes (P-101), it enters the control valve and enters the heat exchanger (E-004). The temperature increases to 56°C and the heat exchanger (E-005) increases to 90°C before entering the stabilizer column. Which enters the 7th floor. The tower has a number of 20 floors after passing through the Stabilizer column from the bottom of the tower is white spirit will lead to preheat NGL before entering the tower stabilizer column. The upper part of the column stabilizer tower is split with the NGL. NGL's RVP is 13.5psi and sent to Gas Separation Plant 6 unit for LPG and Isopentane to increase the value of NGL.

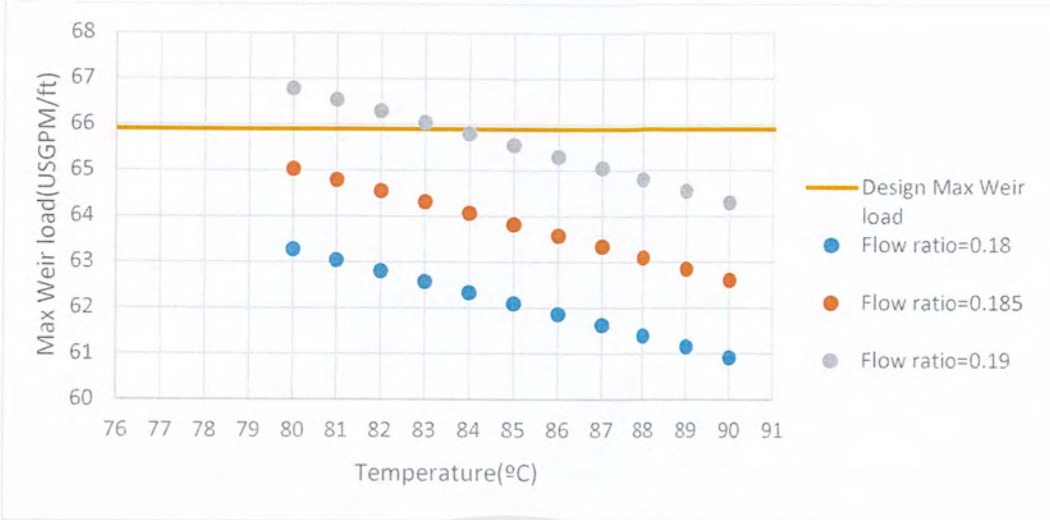

Figure 4.2 The relationship between the pre-feed temperature of the tower stabilizer tower, the maximum weir load of the tower stabilizer and the flow ratio of the TEE-100.

From Figure 4.2, when the flow ratio increases, it indicates the amount of NGL that feeds. The Stabilizer column It increases at the same temperature, which results in Max weir load. If we want to reduce Max weir load can be done by increasing the temperature of NGL before feeding into the Stabilizer column. The maximum increase in temperature is 90°C and the flow rate is 0.19.

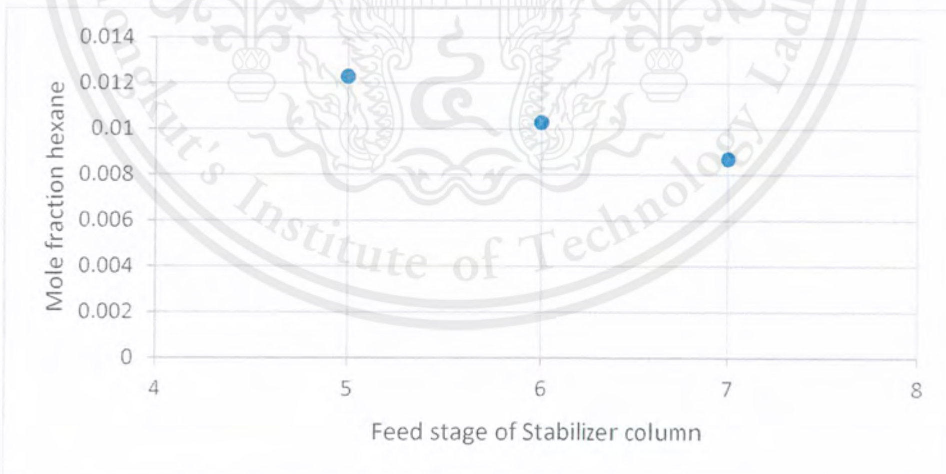

Figure 4.3 The relationship between the feed stage of the stabilizer column and the fractional hexane in the top line.

Figure 4.3 shows the appropriate feed stage for feeding into the stabilizer column to obtain the appropriate composition for the production of White spirit. The top of the tower stabilizer does not require a fraction of hexane to exceed 0.01.

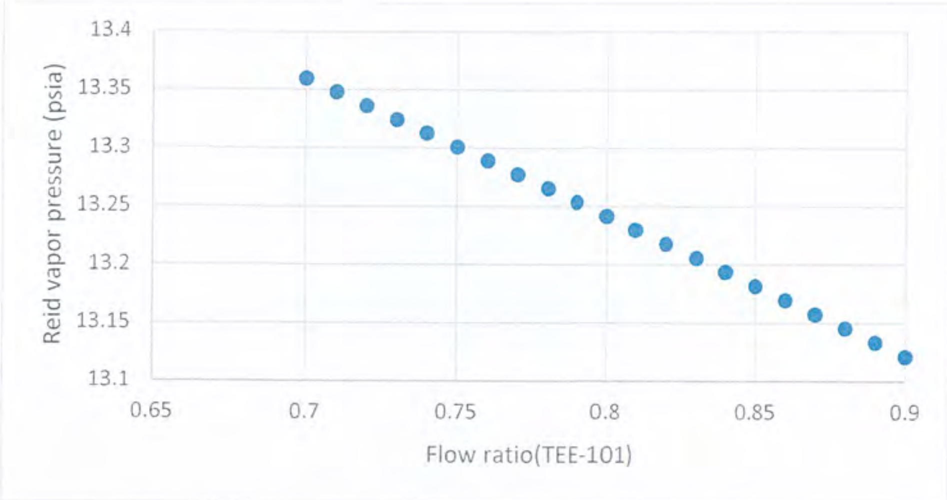

Figure 4.4 The relationship of flow ratio (TEE-101) to GSP6 with Reid vapor pressure at line 15.

Because the line coming out of the top of the Stabilizer Column are large, they can increase the value of the line by adding them to the NGL produced by Reid vapor pressure not exceeding 13.30 psi. Feed into GSP 6 to separate into LPG and ISO Pentane. The Ratio that does not make line 15 has a Reid vapor pressure not exceeding 13.30 psi is 0.75 in Figure 4.4.

4.1.2 White spirit C_7-C_{12} case

Figure 4.1 shows that the NGL feed in this process is limited by the capacity of the stabilizer column. If you do not split the NGL feed into the stabilizer column will cause flooding of the tower stabilizer column. Then split the line from the NGL to the pump (P-101) to increase the pressure to 5.8 bar to provide adequate pressure drop in the heat exchanger and stabilizer column. After the pump passes (P-101), it enters the control valve and enters the heat exchanger (E-004). The temperature increases to 40°C and the heat exchanger (E-005) increases to 71°C before entering the stabilizer column. Which enters the 7th floor. The tower has a number of 20 floors after passing through the Stabilizer column from the bottom of the tower is white spirit will lead to preheat NGL before entering the tower stabilizer column. The upper part of the column stabilizer tower is split with the NGL. NGL's RVP is 13.5psi and sent to Gas Separation Plant 6 unit for LPG and Isopentane to increase the value of NGL.

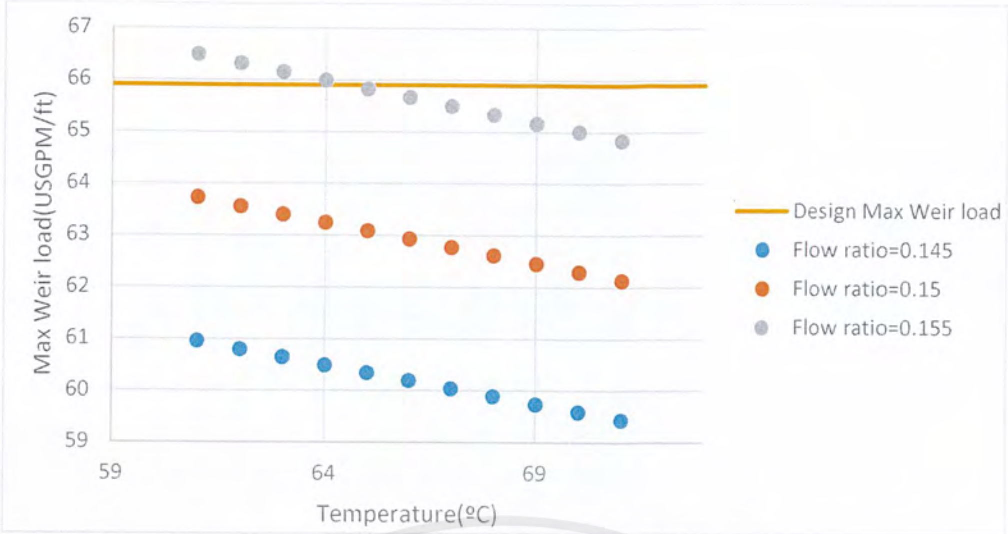

Figure 4.5 The relationship between the pre-feed temperature of the tower, the weir load of the tower stabilizer and the flow ratio of the TEE-100.

From Figure 4.5, when the flow ratio increases, it indicates the amount of NGL that feeds. The Stabilizer column It increases at the same temperature, which results in Max weir load. If we want to reduce Max weir load can be done by increasing the temperature of NGL before feeding into the Stabilizer column. The maximum increase in temperature is 71°C and the flow rate is 0.155.

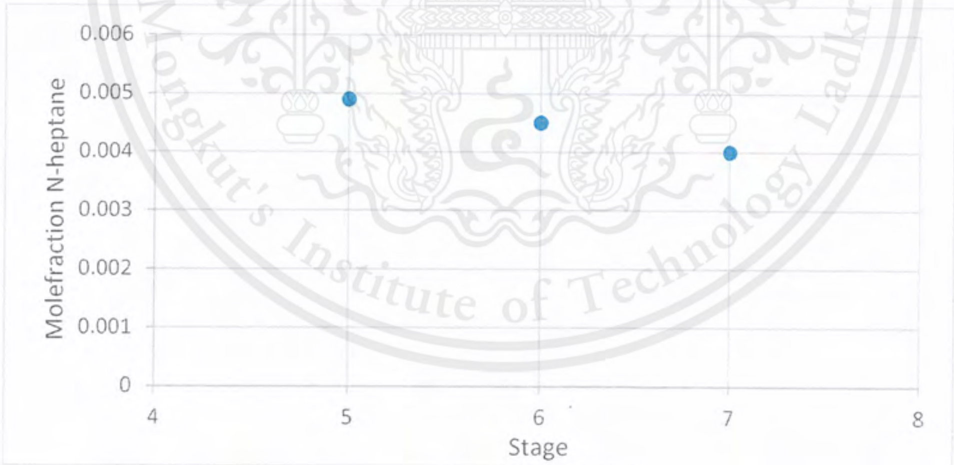

Figure 4.6 The relationship between the Feed stage of Stabilizer column and Mole fraction hexane in Top line.

Figure 4.6 shows the appropriate feed stage for feeding into the stabilizer column to obtain the appropriate composition for the production of White spirit. The top of the Tower Stabilizer does not require a fraction of hexane to exceed 0.004.

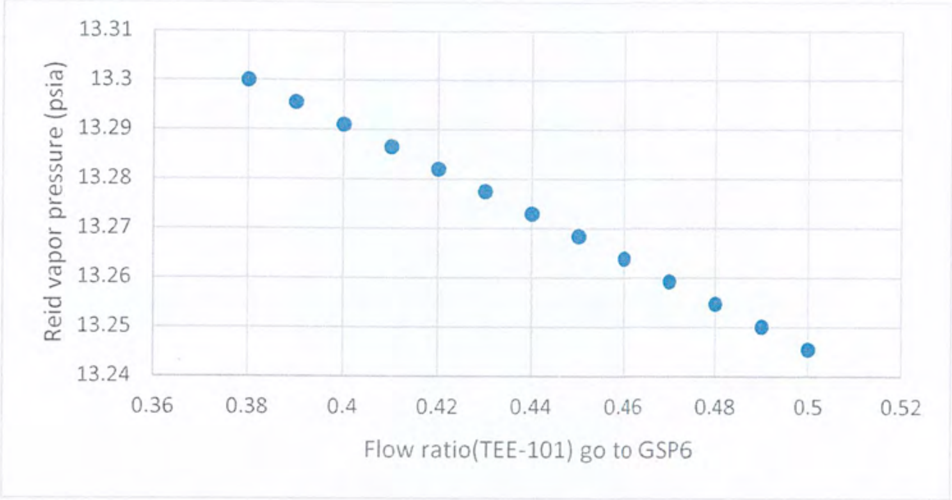

Figure 4.7 The relationship of flow ratio (TEE-101) to GSP6 with Reid vapor pressure at line 15.

Because the line coming out of the top of the Stabilizer Column are large, they can increase the value of the line by adding them to the NGL produced by Reid vapor pressure not exceeding 13.30 psi. Feed into GSP 6 to separate into LPG and ISO Pentane. The Ratio that does not make line 15 has a Reid vapor pressure not exceeding 13.30 psi is 0.38 in Figure 4.7.

4.1.3 White spirit C7-C12 case by adding heat exchanger before feed into tower stabilizer column.

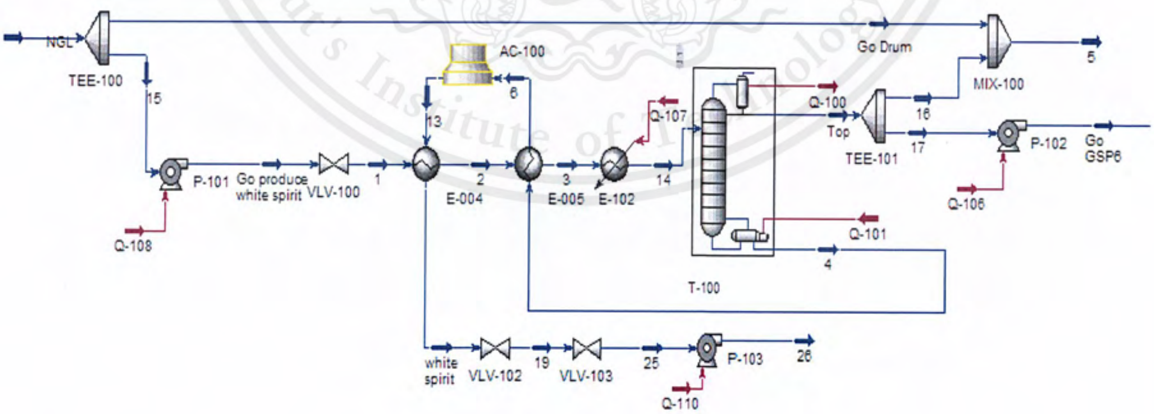

Figure 4.8 Process flowsheet for White spirit production in case C_7-C_{12}.

Figure 4.8 shows that the NGL fed into this process is limited by the capacity of the stabilizer column. If the NGL is not broken, the feed into the stabilizer column will cause a collapse of the tower stabilizer column. Then split the line from the NGL line into the pump (P-101) to increase the pressure to 5.8 bar to provide sufficient pressure drop in the heat exchanger and stabilizer column. After passing the pump (P-101), it will pass through the control valve and into the heat exchanger (E-004). Increase the temperature to 40°C and heat exchanger (E-005). Increase the temperature to 71°C. In this case, the Heat exchanger Shell & Tube is added to increase the temperature to 130°C before entering the Stabilizer column, which enters the 7th floor. The tower has 20 floors after passing through the Stabilizer column from the bottom of the tower is white spirit will lead to preheat NGL before entering the tower stabilizer column. The upper part of the column stabilizer tower is split with the NGL. NGL's RVP is 13.5psi and sent to Gas Separation Plant 6 unit for LPG and Isopentane to increase the value of NGL.

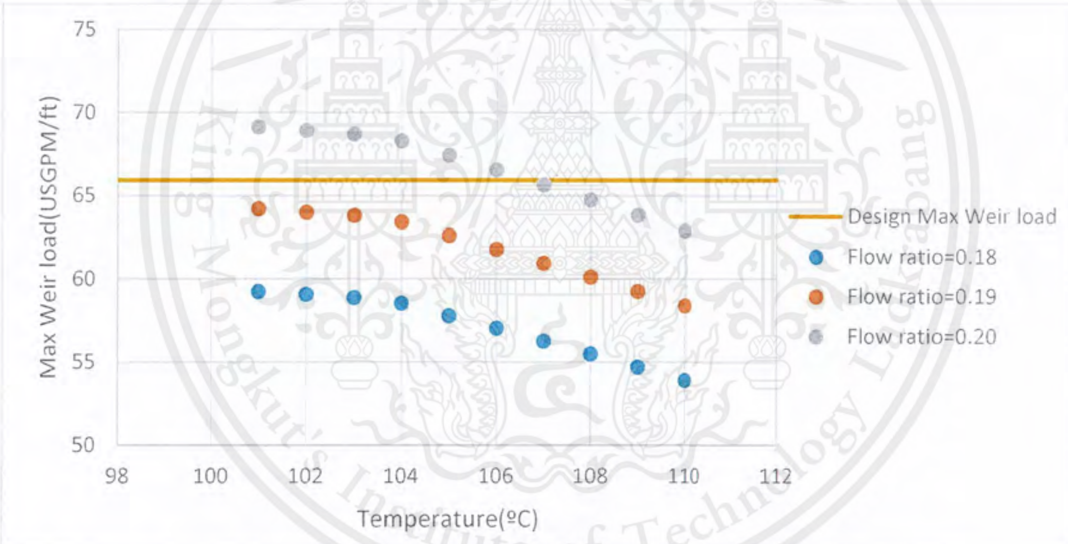

Figure 4.9 The relationship between the pre-feed temperature of the Stabilizer tower, the Max weir load of the Stabilizer tower, and the TEE-100's Flow ratio.

From Figure 4.9, when the flow ratio increases, it indicates the amount of NGL that feeds. The Stabilizer column It increases at the same temperature, which results in Max weir load. If we want to reduce Max weir load can be done by increasing the temperature of NGL before feeding into the Stabilizer column. The maximum increase in temperature is 110°C and the flow rate is 0.20.

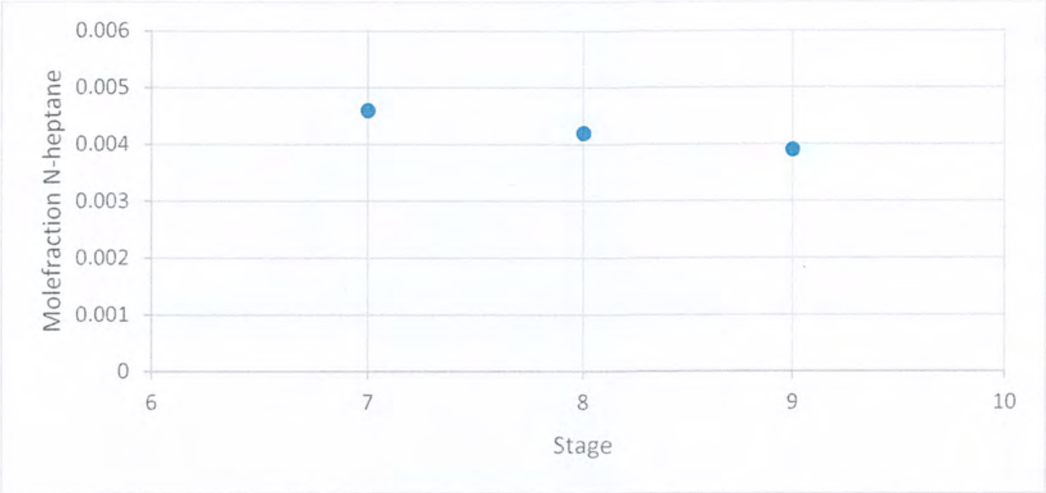

Figure 4.10 The relationship between the Feed stage of Stabilizer column and Mole fraction hexane in Top line.

Figure 4.10 shows the appropriate feed stage to feed into the stabilizer column to obtain the appropriate composition for the production of White. The top of the Tower Stabilizer does not require a fraction of hexane to exceed 0.004.

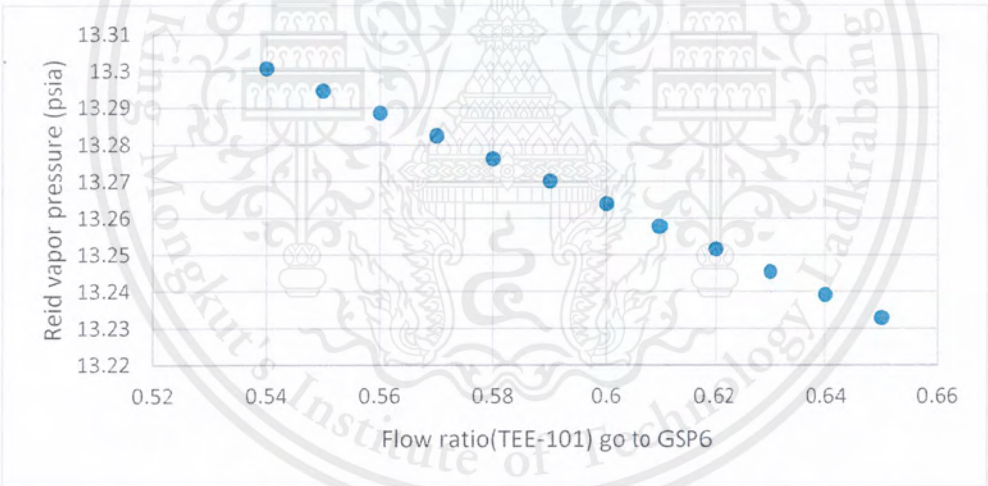

Figure 4.11 The relationship of flow ratio (TEE-101) to GSP6 with Reid vapor pressure at line 5.

Because the line coming out of the top of the Stabilizer Column are large, they can increase the value of the line by adding them to the NGL produced by Reid vapor pressure not exceeding 13.30 psi. Feed into GSP 6 to separate into LPG and ISO Pentane. The Ratio that does not make line 15 has a Reid vapor pressure not exceeding 13.30 psi is 0.54 in Figure 4.11.

4.2 Results of improvements and enhancements in Condensate Stabilizer unit

Table 4.1 Show devices that need to be updated and added to each case.

Section	Equipment	Case 1	Case 2	Case 3
Storage	Pump(P-101)			
Preheat	Fin fan heat exchanger(E-003)	-	-	-
	Shell & tube heat exchanger(E-004)			
	Shell & tube heat exchanger(E-005)			
	Shell & tube heat exchanger(E-102)	-	-	
Column	T-001			
Condenser	Fin fan heat exchanger(E-002)			
	Reflux Drum D-005			
	Reflux Pump P-002A/B			
Reboiler	Shell & tube heat exchanger(E-005)			
Go to GSP 6	Pump(P-102)			
White spirit tank	Tank			
	Pump(P-103)			

Table 4.1 shows the devices that need to be updated and added to each case. Green will replace the device that can be used without updating Blue represents the device that must be added to the Condensate Stabilizer unit. Red represents the device that needs to be updated or replaced, and the "-" sign replaces the idle device.

4.3 Feasibility of Project

4.3.1 Evaluate the device

1. Convert the price of known equipment there in 2008 to 2017, where inflation is equal. 3.3%, as shown in Table 4.2.

Table 4.2 shows the prices of equipment in 2008 converted into money in 2017.

Equipment	Cost of equipment in 2008(USD)	Cost of equipment in 2017(USD)
Shell & Tube Heat exchanger	110,157	147,542
Fin-fan Heat exchanger	17,770	23,801
Pump	9,163	12,273
Reflux drum	75,692	101,380
Tank	303,576	406,602

2. Prices of equipment of different sizes.

Table 4.3 Price of equipment to be added and changed in case 1.

Equipment	Exponent	Capacity of Equipment B	Capacity of Equipment A	Cost of Equipment B(USD)	Cost of Equipment A(USD)
Fin fan heat exchanger(E-002)	0.6	531 kW	1,413 kW	23,801	42,817
Pump(P-101)×2	0.6	60 m^3	22.6 m^3	12,273	13,664
Pump(P-102) ×2	0.6	60 m^3	9.08 m^3	12,273	7,906
Pump(P-103) ×2	0.6	60 m^3	14.77 m^3	12,273	10,586
Tank	0.6	4,020 m^3	5,314.5 m^3	406,602	480,699

Table 4.4 Price of equipment to be added and changed in case 2.

Equipment	Exponent	Capacity of Equipment A	Capacity of Equipment B	Cost of Equipment A(USD)	Cost of Equipment B(USD)
Fin fan heat exchanger(E-002)	0.6	531 kW	2,432 kW	23,801	59,307
Pump(P-101)	0.6	60 m^3	18.44 m^3	12,273	12,093
Pump(P-102)	0.6	60 m^3	2.35 m^3	12,273	3,513
Pump(P-103)	0.6	60 m^3	5.28 m^3	12,273	5,710
Reflux Drum	0.6	111.5 m^3	9.21 m^3	101,380	22,706
Tank	0.6	4,020 m^3	1,903.5 m^3	406,602	259,613

Table 4.5 Price of equipment to be added and changed in case 3.

Equipment	Exponent	Capacity of Equipment A	Capacity of Equipment B	Cost of Equipment A(USD)	Cost of Equipment B(USD)
Shell & tube heat exchanger(E-102)	0.6	16,482 kW	1793 kW	147,541	38,981
Fin fan heat exchanger(E-002)	0.6	531 kW	3343 kW	23,801	71,781
Pump(P-101)	0.6	60 m^3	24.68 m^3	12,273	14,404

Pump(P-102)	0.6	60 m^3	5.86 m^3	12,273	6,079
Pump(P-103)	0.6	60 m^3	6.91 m^3	12,273	6,711
Reflux Drum	0.6	111.5 m^3	12.61 m^3	101,380	27,416
Tank	0.6	4,020 m^3	1,903.5 m^3	406,602	304,900

3. The appraised value of the equipment to be installed.

It is an evaluation of the equipment and tools required to install the main equipment.

Table 4.6: Prices of equipment and tools required to install the case 1.

Description	Cost (Mil. USD)	% of FCI
Equipment & Machinery	555,671.13	35.66%
Civil Related and Structure Materials	77,908.96	5.00%
Piping Material	57,499.57	3.69%
Electrical Equipment and Material	16,360.70	1.05%
Instrument and Control Equipment and Materials	186,981.50	12.00%
Transportation	32,128.63	2.06%
Construction (Installed)	155,817.91	10.00%
Total Direct Cost	1,082,368.40	69.46%

Table 4.7: Prices of equipment and tools required to install the case 2.

Description	Cost (Mil. USD)	% of FCI
Equipment & Machinery	362,945.00	35.66%
Civil Related and Structure Materials	50,887.41	5.00%
Piping Material	37,556.72	3.69%
Electrical Equipment and Material	10,686.24	1.05%
Instrument and Control Equipment and Materials	122,129.79	12.00%
Transportation	20,985.30	2.06%
Construction (Installed)	101,774.83	10.00%
Total Direct Cost		

Table 4.8: Prices of equipment and tools required to install the case 3.

Description	Cost (Mil. USD)	% of FCI
Equipment & Machinery	470,275.93	35.66%
Civil Related and Structure Materials	65,935.96	5.00%
Piping Material	48,663.07	3.69%
Electrical Equipment and Material	13,846.40	1.05%
Instrument and Control Equipment and Materials	158,246.29	12.00%
Transportation	27,191.12	2.06%
Construction (Installed)	131,871.91	10.00%
Total Direct Cost	916,030.68	69.46%

4.3.2 Utility Price of the Process

Table 4.9 Price of Utility Case 1.

Equipment	Duty(kW)	Cost of Utility(THB/year)
Heat exchanger (E-002) Electricity	1413	60,121,131
Heat exchanger (E-008) Hot oil	1696	17,828,352
Pump(101)	1.12	47,654
Pump(102)	4.98	211,891
Reflux Pump P-002A/B	0.087	3,701

Table 4.10 Price of Utility Case 2.

Equipment	Duty(kW)	Cost of Utility(THB/year)
Heat exchanger (E-002) Electricity	2432	103,478,125
Heat exchanger (E-008) Hot oil	2853	29,801,520
Pump(P-101)	0.91	38,719
Pump(P-102)	1.29	54,887
Reflux Pump P-002A/B	0.1	4,254

Table 4.11 Price of Utility Case 3

Equipment	Duty(kW)	Cost of Utility(THB/year)
Heat exchanger (E-002) Electricity	3343	142,239,874
Heat exchanger (E-008) Hot oil	2083	21,896,496
Heat exchanger (E-102) Hot oil	1793	18,848,016
Pump(P-101)	1.23	52,334
Pump(P-102)	3.21	136,580
Reflux Pump P-002A/B	0.74	31,485

4.3.3 IRR, NPV, and PBP values depending on the capacity of the tower stabilizer column.

Table 4.12 shows the CAPEX, OPEX, IRR, NPV, and PBP.

Case	CAPEX	OPEX	IRR(%)	NPV(THB)	PBP
1	46,675,576	1,040,948,055	2,231.66	6,348,261,326	0.044
2	33,150,268	480,503,679	832.96	1,662,080,320	0.12
3	54,288,503	637,044,229	650.61	2,114,152,092	0.15

4.3.4 Production volume of the project, NPV, PBP and production time with an IRR of 14%

Table 4.13 shows the NPV, PBP, Quantity, and Operating time.

Case	NPV(THB)	PBP	Quantity (L/year)	Operating time(Day)
1	8,270,045	7.53	9,346,125	28
2	7,844,803	7.53	15,193,545	121
3	7,105,901	7.53	20,411,800	124

CHAPTER V

CONCLUSION

5.1 Conclusion

The solvent suitable for gas separation plants are the White spirit, which are C6 + and C7 + compounds. The marketing department will take those of products to costumers for choosing the valid type.

The value added of NGL can be refined into gasoline and a solvent, but the composition NGL of gas separation plant is more suitable solvent production.

Stabilizer column can be refined NGL to a solvent but additional equipment, such as Condenser, Reflux drum, Pump and Drum respectively, are needed. Moreover, a heat exchanger is needed to add before a stabilizer column for increasing white spirit production.

5.2 Suggestion

The suggestion in this project is to reduce the Reid Vapor Pressure of the NGL to a low value to mix with the substance from the top of the Stabilizer column so that it does not need to divide the substance out of the Stabilizer column to distill in GSP6 so it has not to pay for the pump and piping.

The CAPEX valuation of the project will require a more thorough evaluation, especially with regard to the price of the equipment to be inquired with the equipment vendor.

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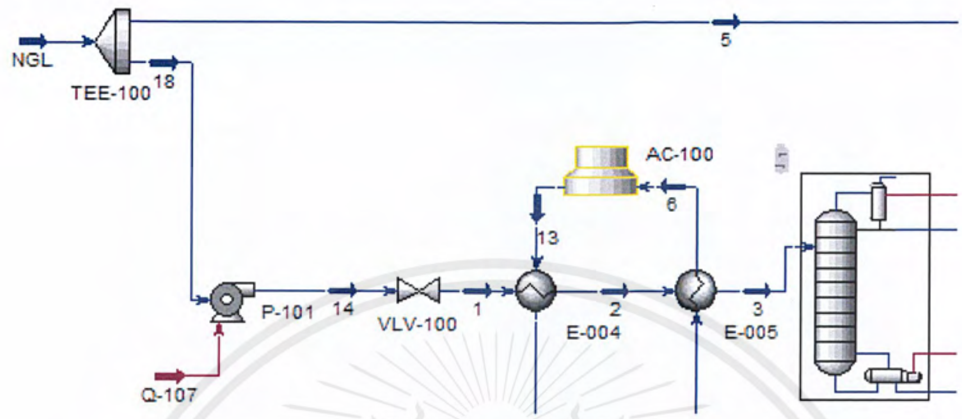
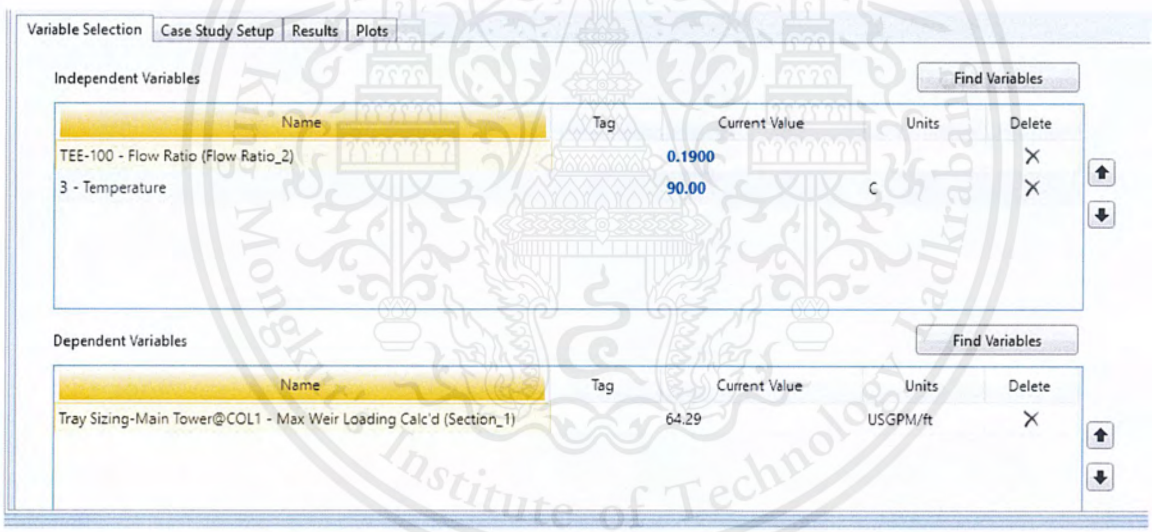
APPENDIX

APPENDIX A

ASPEN HYSYS SIMULATION (VERSION 9.0)

1. Flow ratio TEE-100 Calculation





Variable Selection | Case Study Setup | Results | Plots

Independent Variables — Find Variables

Name	Tag	Current Value	Units	Delete
TEE-100 - Flow Ratio (Flow Ratio_2)		0.1900		X
3 - Temperature		90.00	C	X

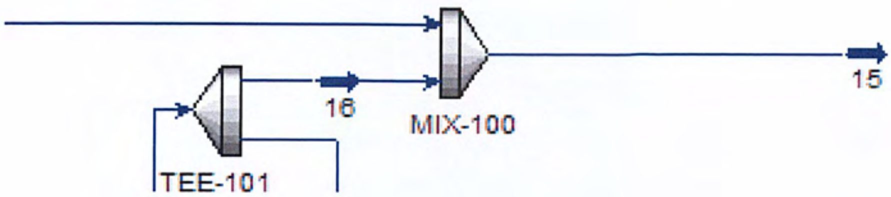
Dependent Variables — Find Variables

Name	Tag	Current Value	Units	Delete
Tray Sizing-Main Tower@COL1 - Max Weir Loading Calc'd (Section_1)		64.29	USGPM/ft	X

Figure A.1 Case study of Flow ratio TEE-100 Calculation

The independent variable and dependent variable are the temperature before entering the Stabilizer Column, Flow Ratio and Max Weir Loading respectively. The temperature before entering the Stabilizer Column has a maximum temperature of 90 °C. The flow ratio that can be used is the value that does not make the Max Weir Loading exceeds the design of the Stabilizer Column is 65.9 USGPM / ft.

2. Flow ratio TEE-101 Calculation



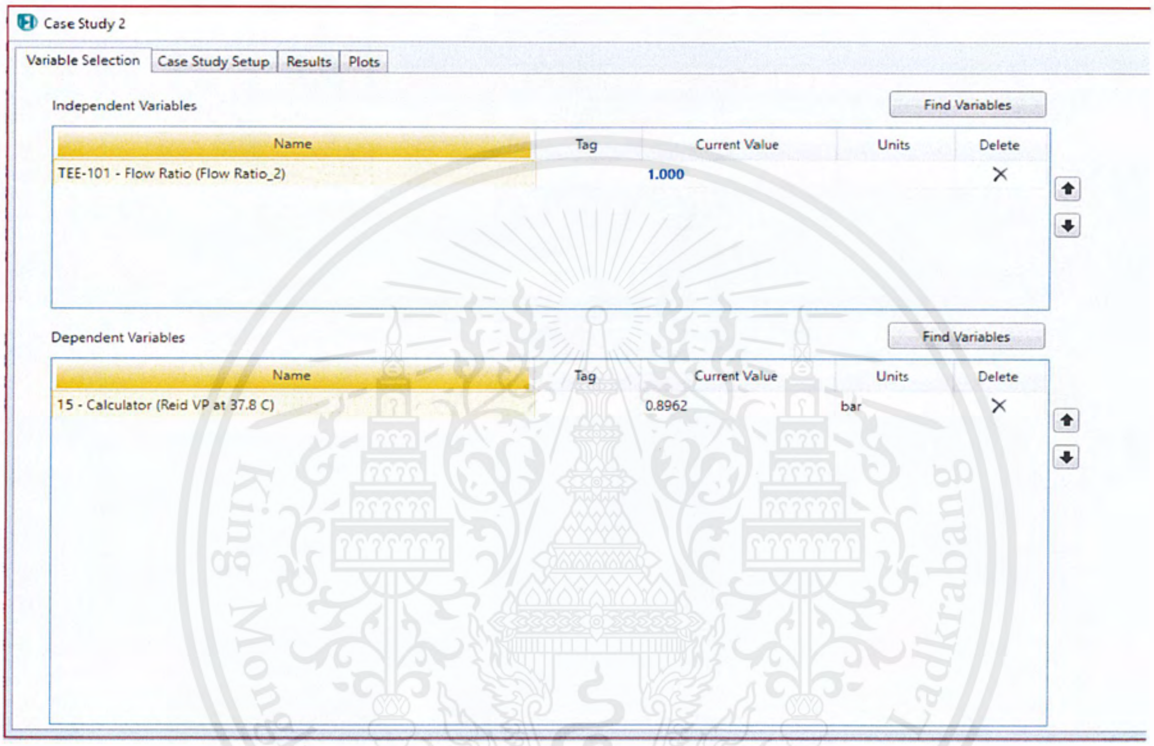


Figure A.2 Case study of Flow ratio TEE-101 Calculation

The independent variable and dependent variable are Flow Ratio and Reid Vapor Pressure respectively. The case study is to find the flow ratio suitable for removing substances from the Stabilizer Column mixed with NGL and Reid Vapor Pressure not exceeding 13.30 Psia.

APPENDIX B

EXAMPLE CALCULATION

1. Inflation Calculation of Equipment

$$P_2 = P_1(1+i)^n \tag{3.1}$$

$$P_2 = 110{,}157\,\mathrm{THB}\,(1+0.033)^{2017-2008}$$

$$P_2 = 147{,}542\,\mathrm{THB}$$

2. Cost of Equipment Calculation

$$\text{Cost of Equipment A} = \text{Cost of Equipment B}\left(\frac{\text{Capacity of Equipment A}}{\text{Capacity of Equipment B}}\right)^{0.6} \tag{3.2}$$

$$= 12{,}273\,\mathrm{USD}\left(\frac{22.6\,\mathrm{m}^3}{60\,\mathrm{m}^3}\right)^{0.6}$$

$$= 13{,}664\,\mathrm{USD}$$

3. Cost of Utility (Hot Oil) Calculation

$$\text{Cost of Utility (Hot Oil)} = \text{Duty kW/h} \times \text{Cost of Hot Oil THB/kW} \times 24\text{h/Day} \times 365\text{Day/Year}$$

$$= 1696(\mathrm{kW}) \times 1.2\,\mathrm{THB/kW} \times 24\,\mathrm{h/Day} \times 365\,\mathrm{Day/Year}$$

$$= 17{,}828{,}352\,\mathrm{THB/Year}$$

4. Cost of Utility (Electricity) Calculation

$$\text{Cost of Utility(Electricity)} = \text{Duty kW/h} \times \text{Cost of Hot Oil THB/kW} \times 24\text{h/Day} \times 365\text{Day/Year}$$

$$= 1413\text{kW/h} \times 4.85\text{THB/kW} \times 24\text{h/Day} \times 365\text{Day/Year}$$

$$= 17{,}828{,}352\text{THB/Year}$$

5. NPV Calculation

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t - TAX}{(1+i)^t} \qquad 3.4$$

B_t = The return in year 1, 2, ...n.

C_t = Cost in year 1, 2, ... n, which may be combined with K_0 or excluded, as the case may be.

TAX = Fee

i = Interest rate or opportunity cost of capital.

t = The time of cash flow

n =The time period of project.

5.1 B_t Calculation

B_t(THB)	=	(Productivity × Product Price) - Operating Expenses
	=	(129,282,835 L/Year × 17 THB/L) - 1,040,948,055THB
	=	1,156,860,140 THB

5.2 C_t Calculation

C_t(THB)	=	CAPEX ÷ The time period of project
	=	46,675,576 THB ÷ 10 Year
	=	4,667,558 THB

5.3 TAX Calculation

TAX(THB) = $(B_t - C_t) \times$ Fee

= (1,156,860,140 THB - 4,667,558 THB) × 10 %

= 115,219,258 THB

5.4 NPV Calculation

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t - TAX}{(1+i)^t} \tag{3.4}$$

$$= \sum_{t=1}^{n} \frac{1,156,860,140\,\text{THB} - 4,667,558\,\text{THB} - 115,219,258\,\text{THB}}{(1+10.02)^t}$$

$$= 6,348,261,326\,\text{THB}$$

6. IRR Calculation

$$\sum_{t=1}^{n} \frac{B_t - C_t - TAX}{(1+r)^t} = 0 \tag{3.3}$$

Find r by iteration

$$\sum_{t=1}^{n} \frac{1,156,860,140\,\text{THB} - 4,667,558\,\text{THB} - 115,219,258\,\text{THB}}{(1+r)^t} = 0$$

$r = 2,231.66\%$

7. PBP Calculation

Payback period = Cost of investment / Average net return per year.

3.5

= 46,675,576 / 1,041,640,882

= 0.044

BIOGRAHPY

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Acadamic Background

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