CHAPTER 1
INTRODUCTION

1.1 Background of the company

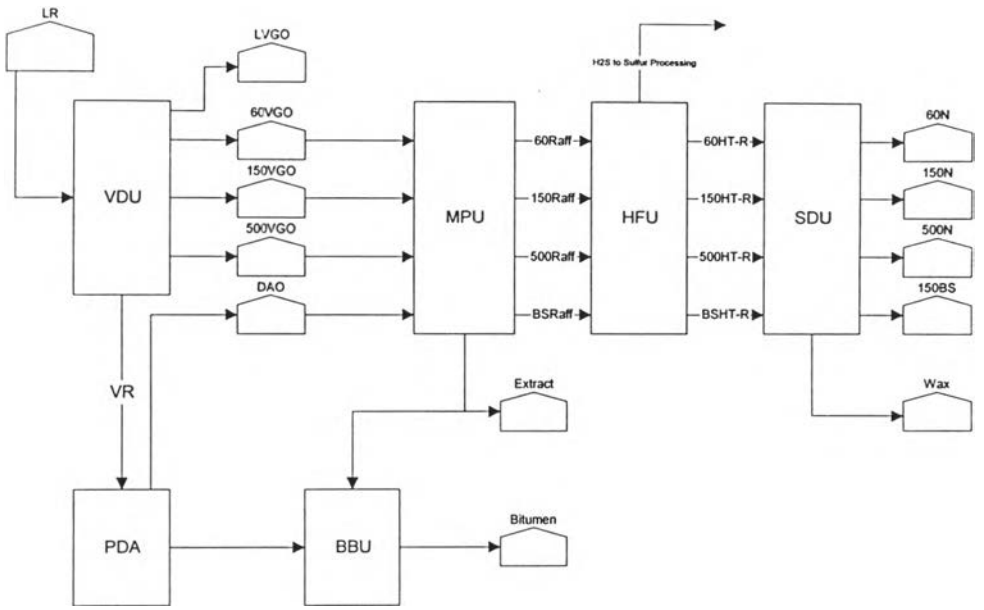
Company A is lube base oil (raw material of lubricant) refinery. The main products of the company are four grades of lube base oil categorized by the oil's viscosity. The by-products produced from the lube base oil process are bitumen, extract oil, slack wax and liquid sulfur. In lube base oil processing, the raw material called Long Residual (LR), the residual oil from fuel refining process, will be sent to the vacuum distillation column to be separated into the components according to the different viscosity by its product specification. After that, the separated oil will be sent to downstream units to improve other properties, namely viscosity index (VI), sulfur content, flash-point and pour-point. The detail of lube base oil processing may be found in the next section. In order to process the oil, large amount of energy in the form of steam and electricity must be input to the processing units. Finally, the product must be cold down and all energy input to the process must be removed. According to the existing practice, the company has to buy most of the energy it consumes from out site the company. There for, if the energy used in processing can be minimized without any effect on product's quality; the operating cost will be greatly.

1.2 Lube base oil processing

In order to process finished lube base oil from Long Residual, there are 5 processing units as shown in Figure 1.1 and the function of each unit is discussed as following.

1. *Vacuum distillation unit (VDU):* In this unit, Long Residual is fed from storage tank to a VDU, designed to produce three waxy distillate cuts suitable for processing into finished lube base oil called vacuum gas oil (VGO) and also the residual heavy product called vacuum residual (VR).

2. *Propane deasphalting unit (PDA):* The VR from VDU is fed to a PDA to produce a deasphalted oil (DAO) suitable for manufacturing of the heaviest grade of lube base oil called 150 Bright Stock (150BS).
3. *Bitumen blowing unit (BBU):* The asphalt from PDA is blended with extract oil to be bitumen feed and the bitumen feed is fed to BBU to produce bitumen product by using oxidation reaction.
4. *MP Refining unit (MPU):* The three waxy distillates (VGOs) from VDU and DAO from PDA are solvent extracted by NMP or n-Methyl-2-Pyrrolidone to selectively remove undesired aromatic compound which has poor lubricating characteristics and poor oxidation stability. The process improves the VI of the oil.
5. *Hydrogen finishing unit (HFU)*: The product from MPU is fed directly to the HFU, where it is treated with Hydrogen in the presence of catalyst. This remove sulfur compounds from the base oil, to achieve product specifications and improve the color and oxidation stability.
6. *Solvent dewaxing unit (SDU)*: The treated oil from HFU is fed directly to SDU, which removes naturally-occurring waxes from the base oil by precipitating out wax in crystalline form. The unit operates at a low temperature in order to produce base oil with a low pour point. There are 4 grades of lube base oil produced from SDU that are *60N, 150N, 500N and 150BS.*



Process units			***Feeds and products***		
VDU	=	*Vacuum distillation unit*	*LR*	=	*Long residual oil*
PDA	=	*Propane deasphalting unit*	*VR*	=	*Vacuum residual oil*
BBU	=	*Bitumen blowing unit*	*VGO*	=	*Vacuum gas oil*
MPU	=	*MP Refining unit*	*Raff*	=	*Raffinate oil*
HFU	=	*Hydrogen finishing unit*	*HT-R*	=	*Hydrotreated*
SDU	=	*Solvent dewaxing unit*			*raffinate oil*

Figure 1.1: Lube base oil processing units

From Figure 1.1, the VGOs from VDU will be stored in VGO tanks and fed to MPU to produce lube base oil in grade by grade. In each processing unit, the energy is consumed in different rate as shown in table 1.1.

Table 1.1: Energy consumption of each processing unit.

Unit	VDU	PDA	MPU	HFU	SDU
Energy					
Electricity (MWhr/month)	750	740	360	500	3,900
Steam (ton/month)	13,500	4,200	1,900	1,800	2,400

1.3 Statement of the problem

The most significant cost in lube base oil refining business is the feedstock price. Since 1999 the feedstock, Long Residual, price is increasing continuously until nearly twice when it is compared to 1998 due to the higher price of fuel oil in the world market (See Figure 1.2).

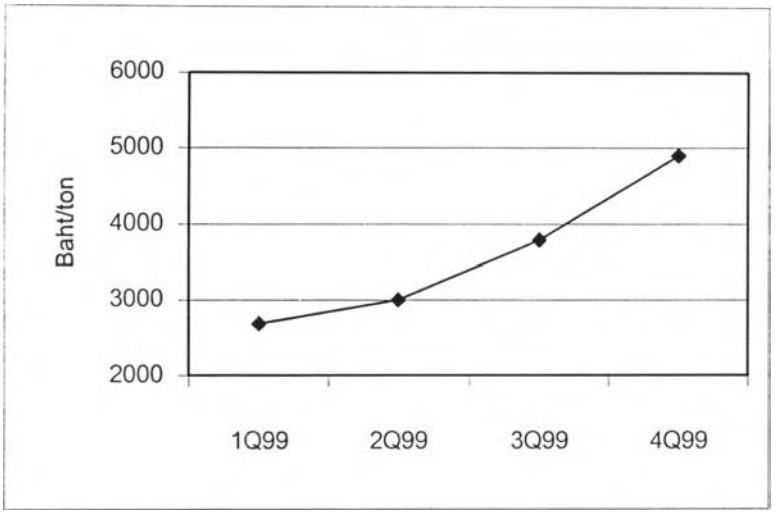


Figure 1.2: The increasing of Long Residual price in 1999

However, the price of lube base oil does not directly depend on the price of feedstock but on demand of lubricant. So, if the demand of lubricant decreases, the price of lube base oil also decreases although the feedstock price is high. Because the price of feedstock is an uncontrollable factor, in order to survive in the difficulty situation, operating cost must be minimized as much as possible to compensate with the higher price of feedstock. When we consider on energy consumption, the company has to pay for the energy cost around 30 million baht per month in average that is divided to be steam cost around 17 million baht, 13 million baht for electricity (See table 1.2). This consumption is generally known that it is not the optimization point and can be improved. So, to reduce the energy and utility consumption is another challenging area that can not be looked over.

Table 1.2: Utility and energy cost January to September 2000

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Electricity (million baht)	12.2	15.5	13.9	14.7	7.2	4.9	4.6	12.8	15.5
Steam (million baht)	8.8	15.9	15.5	15.9	3.2	1.6	2.2	9.5	17.0

Note: The refinery was shut down on January and May to July 2000

1.4 Objective of the research

The objective of the thesis is to reduce the energy consumption in order to reduce the operating cost in lube base oil processing by applying the principles a productivity technique that is a modified Failure Mode and Effect Analysis.

1.5 Scope of the research

The scope of the research is to study and improve the problem in energy consumption of 6 processing units that are VDU, PDA, BBU, MPU, HFU and SDU.

1.6 Expected results

In order to reduce energy consumption by using productivity techniques, the result expected from this research can be concluded as following:

1. Improve productivity by reducing operating cost from energy conservation.
2. Establish productivity systems to process the problem shooting and plant's efficiency monitoring.
3. Develop people's performance by training and implementing the productivity technique and also creating cost minimization awareness.

1.7 Research procedure

The procedure for conducting the research follows:

1. *Select cross-functional team members:* The cross-functional team's member will be composed of shift superintendent and technicians that are selected by process operation engineer (the author) acting as team leader who has authorize to process this activity from operation manager. In the team, the function of each team's member can be described as following.

   Process engineer: The process engineer (the author) act as the team leader whose responsibility is to select the team's members, plan for the activity schedule, set up and lead agenda for the meeting, analyze the result of the implementation and conclude the activity's result.

Shift superintendent: The shift superintendent is the person who has the responsibility to look after and control all activities in the whole plant during the shift. So, for the modified FMEA activity, shift superintendent can analyze the problems in plant overview level such as the relation of the problem between process units that the process unit technicians may not able to clearly understand.

Process unit technician: The process unit technicians are the people whose responsibility is to follow the activity and look after equipment in their process units. So, they will understand and can analyze the problems that occur in their process units very well. For the modified activities, the technician in each process area is selected to join the team to share their ideas in the energy conservation activity in their process area that the process engineer or shift superintendent may look after or has not much detail in that process unit.

After the team's members are selected, they will be trained about the principle and implementation of productivity techniques used in this research in order to proceed the activities. With the team members that come from the different process units and each member is the person who familiar with his process unit, the team leader does not have to be the most familiar person with the process units.

2. *Define the process boundaries for analysis:* In order to avoid the overlooking of some potential failure modes, the process boundaries for the analysis should be defined. In this research, the team may be separated into 3 groups to consider on the different groups of process units. In order to define the boundary of each process unit group, the process flow diagram (PFD) will be used. The boundaries of each group of process units is set as following:

Group 1: VDU, PDA, and BBU.

Group 2: MPU, HFU, and SDU

Group 3: Utility

3. *Modify evaluation criteria and ranking system for the Severity of Effects and Occurrence of Failure:* The evaluation criteria and ranking system of severity and occurrence will be modified to evaluate the energy consumption failure modes and effects.
4. *Brainstorm to analyze the failure modes:* The process technicians of operation department will be attended the energy conservation seminar to propose ideas about energy conservation. In this seminar, the attendants will be provided the knowledge about the significant of energy conservation and actions that have been done for this purpose to be example. After that, the technicians will be assigned to brainstorm to find out the points of the energy loss. The brainstorming will focus on the activities, machines or operating practices (potential failure mode) that will effect on the energy consumption rate on each group of process units. The brainstorming result will be organized onto FMEA data correction form (Appendix A) by modified FMEA cross-functional team. After that cause-and-effect diagram will be used to group the related failure modes.
    - *List and describe the potential effect form the failures.*
    - *List the potential causes of the failure*
    - *List the current control for each of potential causes.*
    - *Estimate the frequency or probability of occurrence of each cause.*
    - *Estimate the severity.*
    - *Estimate the detection ranking.*
    - *Calculate the Risk Priority Number (RPN).*
5. *Determine and implement the recommended actions:* After the causes of the failures have been prioritized, the suitable actions to reduce the risk of the cause of failure will be determined by following the priority. To reduce the risk, the team may focus on these following guidelines:
    - *Reduce the probability of occurrence.*
    - *Reduce the severity of the failure's effect.*
    - *Improve the detection method.*

After that, the recommended actions will be implemented to the process and the resulted will be monitored.

6. *Monitor the result of the action by using Energy Intensity Index (EII):* After the implementation of the recommended actions, the Energy Intensity Index (EII) will be used to monitor the improvement of the energy utilized in each process unit and compare with the utilization before the implementation of the actions. The EII can be calculated as following equation.

$$EII = \frac{\text{Re } ported \text{ Re } fineryEnergyConsumption}{\sum (Unit\ Utilized\ Capacity * Unit \text{ Re } ference\ Energy\ Coefficient + SensibleHeat)}$$

7. *Evaluate the result of the actions:* the team will analyze and conclude the result of EII. If the result is not satisfied or further improvement can be done, the step 2 to 4 will be reprocessed.
8. *Write the thesis form*
9. *Final examination*

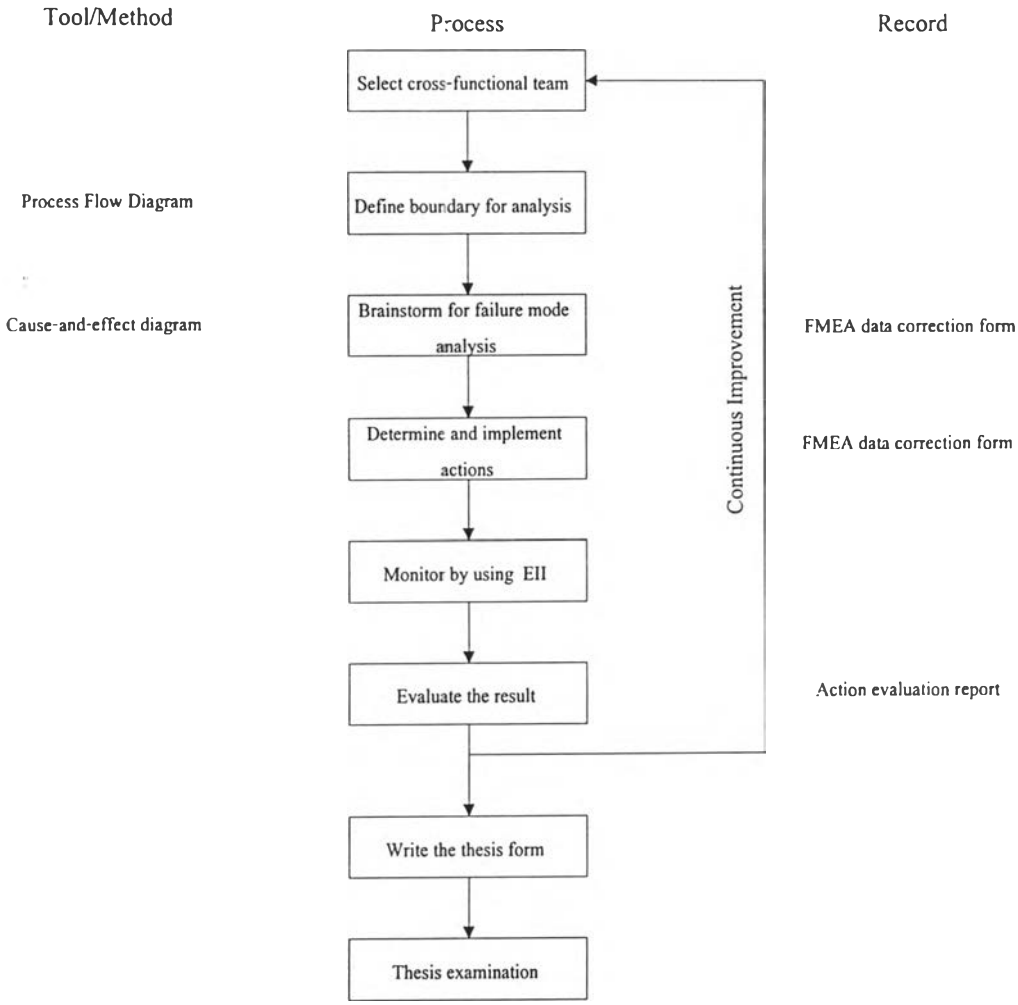


Figure 1.3: Process flow chart of the research procedure