CHAPTER I

Introduction

When two moving parts are in contact, friction occurs and causes surfaces of the moving parts to be worn out. Lubricants are applied between two surfaces to reduce friction. In moving parts systems of automobile engine such as pistons, bearing and floating axle lubricating oil, which uses as lubricant, is applied to reduce friction. In this study, the term "lubricating oil" refers to the lubricating oil used in automobile engine.

The lubricating oil is usually a mixture of base lube oil and additives. Details of the additives and their properties are described elsewhere (Eric, 1967; George, 1980; Szeri, 1980; Cameron, 1987). Lubricating oil is contaminated while in operation by dust, metal particles, oxidation products, unburned fuel and products and byproducts of combustion such as water, soot and acid. The amount of contaminants gradually increases and reduces the lubricating oil's abilities to protect and lubricate the engine. When the lubricating oil can no longer be used at desired conditions, it is drained to remove the contaminated oil and refilled with fresh and clean oil. The lubricating oil which is drained from the engine is called used lubricating oil or used oil.

After the used oil is drained from the engine, the used oil can either be reused or disposed. The used oil is disposed by landfill, incineration or discharge. All of disposal methods affect the environment such as groundwater supplies can be affected by penetration of used oil when it is landfilled.

Several operations are utilized to reuse the used oil industrially such as burning as fuel, road oiling, re-refined base oil, etc.. However, some methods of used oil utilization generate hazardous materials that contribute to environmental pollution. For example, when the used oil is burnt, metallic compounds from additives react with oxygen and generate metallic oxide, such as lead oxide, which is emitted to the environment.

Today, one of effective processes to reuse used lubricating oil is re-refining process. It is a process that removes contaminants from used oil and produces a oil product which has a quality similar to base lube oil. Several processes have been developed base on these concept. Most of the processes consist of three major steps: removal of water and light hydrocarbon compounds, removal of contaminants and additives and finishing or polishing the product.

Contaminated water is removed by flash distillation. Other contaminants and additives are removed by several methods such as reaction with chemicals, extraction, atmospheric distillation and vacuum distillation.

Both clay contacting and hydrofinishing (hydrotreating) have been used successfully in the finishing step to attain color and odor improvement. Many processes such as Kinetics Technology International

(KTI) process, Phillip Re-refined Oil (PROP) process and Bartiesvile Energy Technology Center Solvent Extraction (BETC) process, use hydrotreating as a final step.

Hydrotreating is a process commonly used in most modern oil refining operation. Nitrogen, sulfur, oxygen and metallic compounds from petroleum fractions are removed by catalytic reaction with hydrogen. Hydrotreating consists of several classes of reactions that occur simultaneously: hydrogenation, hydrodesulfurization (HDS), hydrodeoxygenation (HDO), hydrodenitrogenation (HDN) and hydrodemetallization. In re-refining process, results of hydrotreating are almost complete improvement in color and removal of trace of metals, carbonyl, sulfur, nitrogen, oxygen and chloro compounds.

The catalysts commonly used for hydrotreating process are Mo and W on alumina support. Ni and Co are also used as promoters to improve catalyst activities. The most common catalyst is CoMo oxides on alumina. Other catalysts, NiMo and NiW on alumina oxides, may also be used. CoMo catalyst is selective for sulfur removal and NiMo catalyst is selective for nitrogen removal although both catalysts remove both sulfur and nitrogen.

Researches have been conducted on hydrotreating of used lubricating oil. For example, Bethea et al. (1978) used CoMo catalyst in their study and found that hydrotreating of used lubricating oil gave an acceptable lube oil product. They also found that the hydrotreating activities of the catalyst increased with increasing temperatures. In their study, the used oil was collected from different areas of the United State. A viscosity at

38°C (100°F) of the used oil varied from 68.75 cSt. (319 SSU) to 118.45 cSt. (549 SSU) and sulfur contents varied from 0.26 to 0.32 wt%.

Similar result is obtained by Bahn et al. (1986) who used NiMo and CoMo catalysts in their study and found that the catalysts loss their activity very quickly. The feedstock in their study has the viscosity at 38°C (100°F) of 29.18 cSt. (137.5 SUS) and sulfur content of 0.3 wt%.

In this project, the used lubricating oil is the used oil from gasoline engine taken from service stations in Bangkok. The average viscosity at 38°C (100°F) of this feedstock is 56.19 cSt. (260.7 SUS) and the sulfur content is 1.04 wt%. The roles of operating conditions on catalytic hydrotreating of used lubricating oil were studied over commercial catalysts. The catalysts used in this study are NiMo, CoMo and NiW on alumina support. The experiments are conducted in a fixed-bed reactor system. Operating pressure is at 5.51 MPa (800 psig) and operating temperatures are varied from 320 to 380°C (608 to 716°F) at an increment of 30°C (54°F). Operating liquid hourly space velocities (LHSV) are varied from 0.5 to 1.5 hr^{-1} at an increment of 0.5 hr^{-1} and hydrogen gas:oil ratio is maintained at 600:1.