CHAPTER 3

RESEARCH METHODOLOGY

3.1 Data Collection

The study is conducted through the literature search to collect data and relevant information where sources of data can be categorized into:

3.1.1 Primary data: data from reliable commercial enterprises and government offices by interview.

3.1.2 Secondary data: data from organization environmental reports and documentation, research journals, theses, and other reference proceedings as well as data on related technologies from the Internet.

3.2 Data Classification

Data and information are classified according to the nature of the technology: these include regeneration, and recovery as fuel or petroleum products. There are five varieties of technologies for regeneration, four out of these five were sub-grouped as re-refining and the other one as a physical process. For the recovery as fuel, two technological options are available. This classification of technologies is illustrated below

3.2.1 Regeneration as new lubricating oil

A) Re-refining

- Acid clay treatment
- Chemical and clay treatment
- Solvent extraction and
- Distillation clay filtration process

B) Physical process

- Ultrafiltration membrane

3.2.2 Recovery as fuel

- Combustion ULO in boilers, space heater, waste oil furnace
- Direct burning in cement kiln

3.3 Evaluation of Data

Two criteria are proposed for the evaluation of ULO management technology, (i) environmental impact and (ii) cost effectiveness. Detail analysis of each of these criteria follows:

3.3.1 Environmental Impact Assessment

Environmental impacts for the proposed technology can be illustrated through appropriate indicators. The indicators can be acquired directly from the data obtained from literature search, or else material balances shall be conducted to estimate missing data. Where possible, emission factor (US.EPA, AP-42, 1995) will also be used to estimate the emission rate from various activities.

Information on each technology can be analyzed to cover principally the true impacts on the environment. These impacts can be grouped into

- Air pollution including particulate matter (PM), sulfur oxide (SO_2), oxides of nitrogen (NO_x), etc
- Waste streams generated from the process such as spent clay, solvent sludge, wastewater etc. This is often shown as the concentrations of contaminated heavy metals. The majority of heavy metals of concerns are Arsenic, Aluminum, Barium, Cadmium, Calcium, Chromium, Copper, Lead, Iron and Zinc

Accepted environmental standards (such as emission and effluent standards) are used as the criteria to determine the significant environmental impacts. In this study, the environmental standards for Thailand are used as a basis for comparison. However, in the case of unavailability, some other international standards are employed as substitutes. To complete the environmental impact assessment, the

corresponding mitigation measures for the identified significant environmental impacts are proposed.

Choices of these mitigation measures depend upon the nature of the impact itself, and can be classified as:

- Treatment technology
- Pollution control
- Process modification

3.3.2 Methodology foe economic analysis

In this study "cost effectiveness analysis" will be employed as an economically decision making tool for selecting the most appropriate alternative or in this case, the selection of the management technology for Used Lubricating Oil. When evaluating alternatives, it is necessary to combine capital investment and operating cost into a single estimate in order to determine which alternative is the best in terms of cost effectiveness.

This section describes techniques used to ensure that the most cost effectiveness solutions are identified and to quantify the cost of implementing these solutions. A capital investment is required for any industrial process, and determination of the necessary investment. The costs might not be highly accurate but the purpose is to express some idea of what is involved and whether the project looks as if it will be profitable. Making a rough estimate of total cost for proposed process consists of capital investment cost plus operating cost for raw materials and needed utilities.

The following calculation will be performed for each of the management technology in the cost effectiveness analysis

Total present cost of treatment ULO (C_t),

$$C_t = I + \Sigma O_t / (1+r)^t$$

Present quantity of input (q) = $\Sigma q / (1+r)^t$

Total present revenue of treatment ULO (B),

$$B = \Sigma\, vp/(1+r)^t$$

Average present cost of treatment one unit of ULO (a_c) is estimated by;

$$a_c = \frac{C_t/(1+r)^t}{\Sigma\, q_t/(1+r)^t} \qquad (3.1)$$

Average present revenue of treatment one unit of ULO (a_r) is estimated by:

$$a_r = \frac{B/(1+r)^t}{\Sigma\, q_t/(1+r)^t} \qquad (3.2)$$

Revenue per cost is estimated by:

Net Present Value (NPV)[1]

$$NPV = \sum_{t=0}^{t} \frac{(B_t - C_t)}{(1+r)^t} \qquad (3.3)$$

Feasibility of option is estimated by B/C ratio

$$\frac{\text{Average revenue of unit ULO}}{\text{Average cost of unit ULO}} = \frac{B/(1+r)^t}{\Sigma\, q_t/(1+r)^t} \Big/ \frac{C_t/(1+r)^t}{\Sigma\, q_t/(1+r)^t}$$

$$= \frac{B/(1+r)^t}{C_t/(1+r)^t} \qquad (3.4)$$

where

C_t	=	Total cost
I	=	Investment cost
O	=	Operating cost
B	=	Total revenue
v	=	price of product
a	=	Average Cost of input or out put
q	=	Quantity of ULO
r	=	rate of return / interest (0.1)

[1] Net present value (NPV) defined as the net benefit from the all of project [24].

[2] B/C ratio, when the two or more project alternatives are being compared using B/C ratio. Note that the exceeds 1.0 of B/C ratio is the preferable project [24].