CHAPTER IV

PROCEDURE AND ANALYSIS TECHNIQUES

4.1 The Apparatus

The experimental apparatus, as shown in Figure 4.1, consists of two major parts: mixing system and tracer measurement system.

4.1.1 Mixing system

The mixing system consists of the following :-

Standard mixing tanks: Three standard mixing tanks, having dimensions as shown in Table 4.1, were used in this study. Mild steel was selected as construction material. The mixing tank impeller's arrangement, tank diameter, liquid level and sampling point are illustrated in Figure 4.2 and summarized in Table 4.2.

Agitator: A US digital variable speed motor model ML-4RT equipped with a controller unit, attached with 6-bladed disc turbine as shown in Figure 4.3, was used in this study and Table 4.2 summarized configurations of mixing tanks.

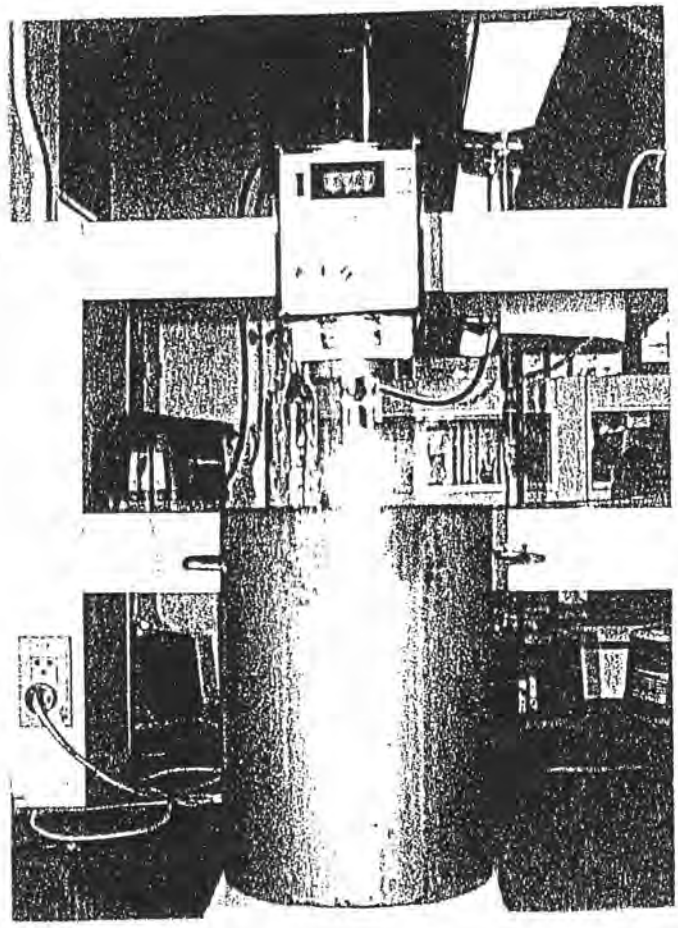

Figure 4.1 Standard 6-bladed disc turbine and vessel used in Experiment

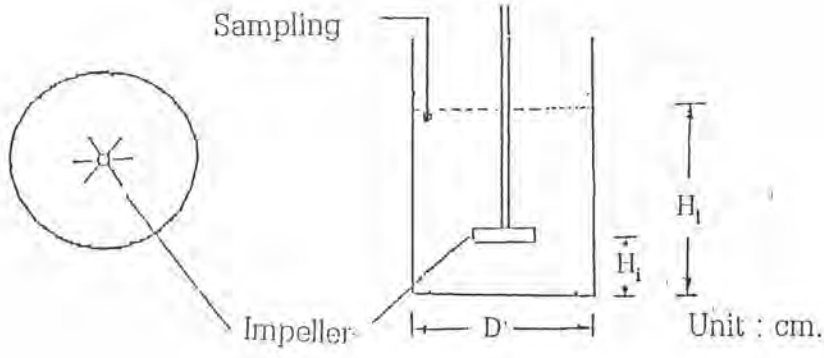

Figure 4.2 Setup of impeller, liquid level,
diameter of tank, and sampling point

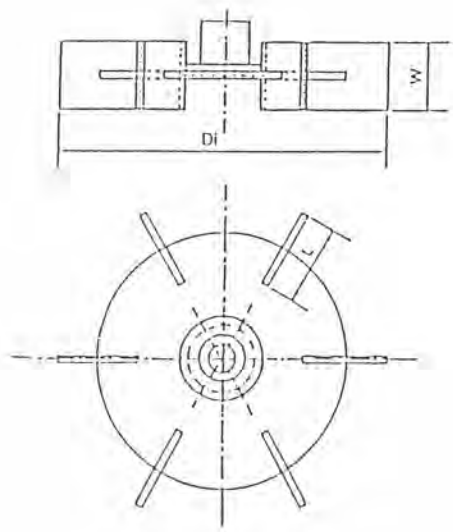

Figure 4.3 Impeller for experiment

Table 4.1 Dimension of three standard mixing tanks

Mixing tank	Diameter, cm	Height, cm
Tank 1	12	16
Tank 2	25	33
Tank 3	36	45

Table 4.2 Configurations of mixing tanks

Conditions	Diameter of tank, cm		
	12	25	36
Liquid level, H_l, cm	12	25	36
Impeller height from tank bottom, H_i, cm	4	8.3	12
Impeller diameter, D_i, cm	4	8.3	12
Impeller blade width, W, cm	0.8	1.6	2.4
Impeller blade length, L, cm	1	2.1	3
Volume of lubricating oils, lts.	1.35	12.27	36.66

4.1.2 Tracer measurement system

Inductive Coupled Plasma Optical Emission (ICP-OES) was used as tracer measurement to determine the required mixing time.

ICP-OES consists of the following:-

Type of spectrometer: Plasma 1000/2000 software Atomic Emission

Optional components: AS-51 Auto-sampler

Vacuum system

Myers-Tracy Signal Compensation

Figure 4.4 shows ICP-OES spectrometer setup.

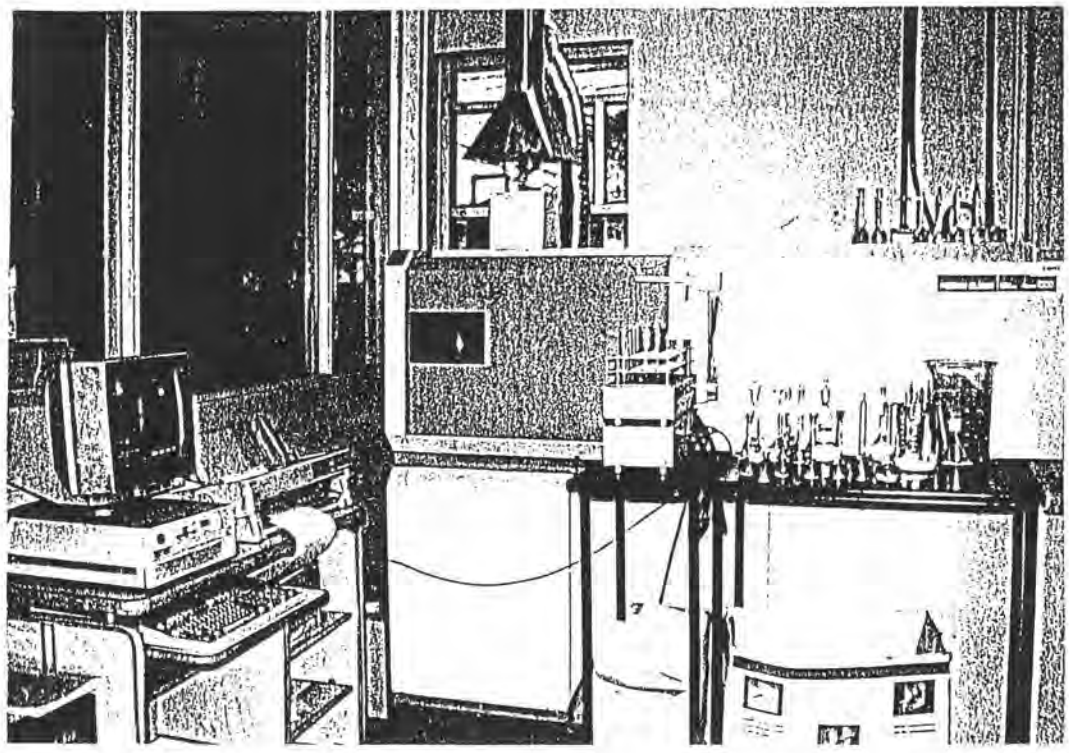

Figure 4.4 ICP-OES Spectrometer

4.2 Chemicals

Chemicals used in this experiment were:

Basic oil : Various basic oils supplied by The Shell Company of Thailand Limited and classified by viscosity @ 100 °C as 4, 4.5, 11, 32 and 55 cSt (approximately) were used.

Additives : Various additives supplied by The Shell Company of Thailand Limited and classified by their functions or applications as detergent, corrosion, anti-oxidant, pour point depressant, anti-rust demulsifier, anti-wear and anti-foam were used.

Typical properties of base oils and additives are shown in Appendix B and C respectively

4.2.1 Auxiliary equipment

Tachometer : A US made Lutron, digital tachometer model DT-2232

4.2.2 Digital multimeter

Model : KD-3200

Description : Digital multimeter 3 1/2 digits with bargraph

Measurement ranges :

ACA (50/60 Hz) : Range 300 μA, resolution 100 nA

Range 3000 μA, resolution 1 μA

Range 30 mA, resolution 10 μA

Range 300 mA, resolution 100 μA

Range 10 A, resolution 10 mA

4.3 Procedure

The objective of this experiment was to obtain the required mixing time by observing the degree of homogeneity of additive element in finished lubricating oils.

The procedure for experiments were summarized as follow:-

4.3.1 Experiment

The following is an outline of the procedure for each experiment. The mixing tank was mounted on a support. Half of all basic oils were charged into blending tank followed by all additives and topped up to the balance which is equal to the tank's diameter with basic oils. The agitator was mounted on a

support at the desired impeller level as shown in Figure 4.2. The heater was turned on and adjusted to the desired temperature. This temperature was controlled to be +/- 5°C from the set value. Impeller drive was supplied, and adjusted to the desired speed (digital variable speed). The speed was confirmed by a digital tachometer at top drive shaft. Fluctuations of speed were no greater than 5 rpm. from any set speed. Every 15 seconds, 0.5 ml. of sample was sampled at top level of the vessel for measurement of Ca-content by ICP-OES. The sampling process was continued every 15 seconds until the end of blending process. (at least one hour to ensure getting a homogeneous lubricating oil) The drawn samples were prepared into proper solution for measurement of Ca-content as described in the standard test method (Appendix A-3). The sampling times were plotted against the measured value, Ca-content, to determine the required mixing time.

A digital multimeter is used to measure electrical current of agitator during mixing process to derive the energy consumption.

Samples were taken after completion of each mixing process for analysis against the quality in specifications to ensure that the experiment resulted in a homogeneous lubricating oils. The tested items can be shown as follows:-

- Density (ASTM D-1298)
- Viscosity, kinematics (ASTM D-445)
- Pour point (ASTM D-97)

The detail of each method can be shown in Appendix A.

Samples were taken from top level of mixing tank as the preliminary study showed that the product was homogeneous throughout all positions of the vessel as shown in Appendix E. Therefore, for ease of access, top surface of mixing tank was selected as the sampling point.

The experiments were conducted in temperature at 60 °C. The interested parameters studied in this work were the effect by the speed of

agitator, viscosity of lubricating oils, and tank diameter on the required mixing time.

The range of parameter studied were the following:

Diameter of tank: 12, 25, 36 cm. respectively

Type of impeller: Six bladed disc turbine in which related with standard configuration tank as follows :-

4 cm. for 12 cm. of tank diameter

8.3 cm. for 25 cm. of tank diameter

12 cm. for 36 cm. of tank diameter

Position of impeller: 4, 8.3, 12 cm. from bottom of tank (1/3 diameter of tank)

Speed of impeller: 300, 400, 500 rpm.

Baffles: without baffles installation

Viscosity of lubricating oils @ 100 ^{o}C: 12, 14, 19 cSt.