Chapter IV

Experimentation

4.1 The Apparatus

The experimental apparatus as shown in Figure 4.1 can be separated into 4 parts, inlet and outlet system, motor adjustment system, mixing system and conductivity measurement system

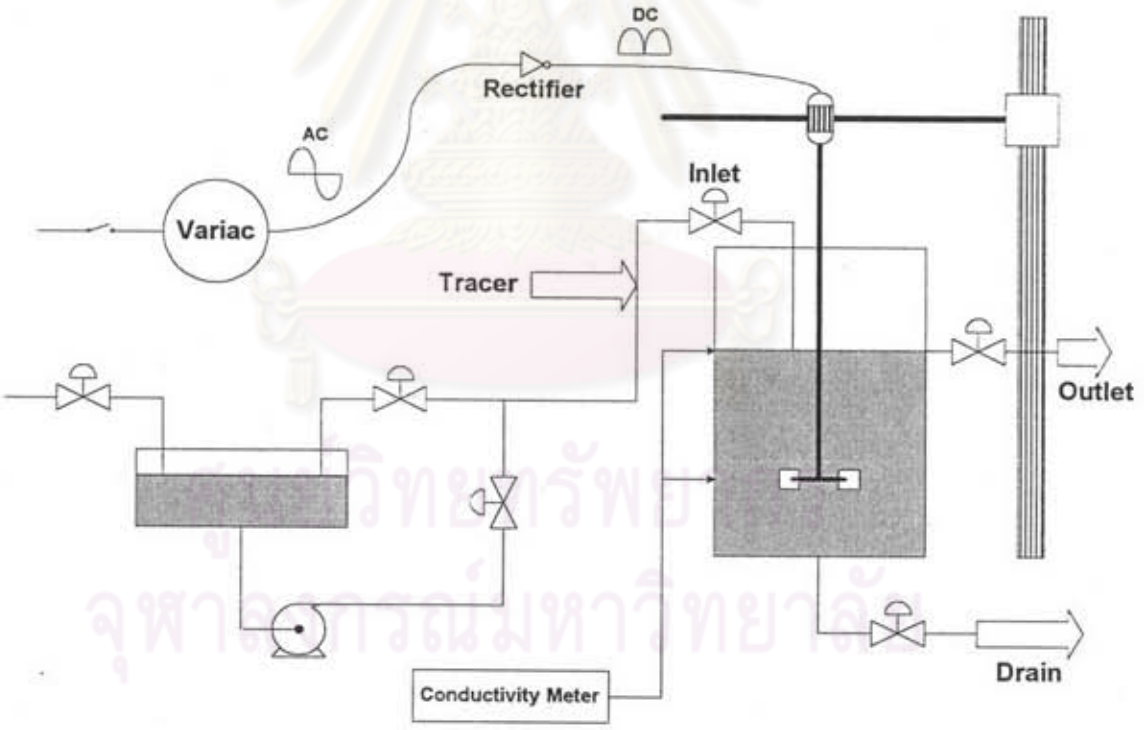

Figure 4.1 Experimental apparatus

4.1.1 Inlet and Outlet System

- Storage Tank : 27.14 liters tank was used to store feed liquid from a tap
- Pump : 1/4 Horse Power pump was installed for sucking feed liquid from storage tank to mixing system
- Valve : 1/4 inch ball valves installed in many parts of this system.

4.1.2 Motor Adjustment System

- Variac : Variac was used to regulate the electrical voltage from the wall jack (220 Volt). The range of voltage is between 20 and 140 Volt.
- Rectifier : Rectifier was installed to change from alternating current to direct current since the motor used was a direct current motor.
- Motor : 1/2 HP direct current motor that can rotate inversely when the electric poles were alternated.

4.1.3 Mixing System

The mixing system used consisted of the followings:

- Mixing Tank : Three sizes of tank were used, i.e. 20, 25, 30 in diameter and 30, 45, 45 high flat bottom cylindrical tank respectively equipped with 4 detachable baffles arranged as shown in Fig.4.1. The size of baffle used was ratio to the diameter of the tank as 1:10, so baffles used were 2.0, 2.5 and 3.0 cm. respectively. The materials used in the construction of all parts were Poly Vinyl Chloride (PVC) and Acrylic. For the conductivity measurement purpose, conductivity probe was installed at the exit.

- Agitator : Three types of agitators used as shown in Fig.4.2 were 6 bladed disc turbine, 6 bladed open turbine (Paddle) and 6 bladed 45 degree pitch turbine.

4.1.4 Conductivity Measurement System

Conductivity measurement system consists of the followings:

- Electrodes : 0.15 cm. in diameter and 19 cm. long probe with 3.0 cm. contacting length.
- Conductivity Meter : Extech that can detect the range between 0 to 2 S/m
- Injector : 20 ml. syringe.

4.2 Materials Used

The materials used in this experiment were:

Feed liquid : Tap water was used because of the great amount of continuous feed.

Tracer : The tracer used in this experiment was necessary to comply with the following requirements :

- It should be mixed easily with water
- It should be detectable and analyzed accurately at low concentration.
- It should be present in the water at a negligible or constant concentration.
- It should not react with the water or any other substance in such a way as to affect the measurement
- It should be cheap.

There are many chemical tracers that fit the above requirements as shown in Table 4.1. Concentrated nitric acid was selected because its properties fit the above requirements and the following reasons:

- Its conductivity is proportional to its concentration over this experiment range.
- It is commonly used in the laboratory.
- It can be detected in the range of conductivity meter used.

Substance	Solubility in 100 parts	
	0°c	100°c
HNO_3	∞	∞
HCl	82.3	56.1
H_2SO_4	∞	∞
NaCl	35.7	39.8

Table 4.1 The solubility of the tracer

The concentration of nitric acid used was 65%

4.3 The Procedure

The object of this experiment was to obtain tracer response after injection of the tracer and then observe the homogeneity of the tracer in order to understand the effect of conditions on mixing system.

The experiment used for studying the conditions affecting mixing in continuous stirred vessel can be summerized into two steps, calibration method and experimental procedure.

4.3.1 The Calibration

In this experiment, two calibrations are required, motor revolution calibration and concentration of tracer calibration.

4.3.1.1 Voltage Input and Motor Revolution Calibration

The line from wall jack was connected to the variac in order to adjust the voltage of the input electric current and then the line out of the variac was attached to the rectifier to change from the alternating current (AC) to direct current (DC), the motor used was the DC motor that can adjust the input voltage to the motor. The line from the rectifier was wired to the DC motor that is connected to the shaft with the impeller. At that time, a reflecting sticker was adhered to the shaft connected to the motor. The variac was adjusted to decrease the voltage output to 20 Volts (minimum voltage that can be tune). After that, the motor was operated in order to measure the revolutions using tachometer and the result was recorded. In the next step, the voltage output, from variac, was increased by 10 Volts in each step, and the result was recorded each step until 160 Volts. Subsequently, the voltage was tuned down 10 volts per times and the results were recorded in each step. The results were averaged and plotted. The relation of the revolution and the voltage input was developed by linear regression method as given in annexes.

4.3.1.2 Concentration and Conductivity Calibration

Various concentrations of nitric acid in water were prepared as follows: 0, 0.01, 0.02, 0.04, 0.06, 0.08, 0.10 and 0.12 mole/litre. Each prepared solution was measured using conductivity meter and the results were recorded. The data were averaged and plotted. The relation of the concentration and the conductivity was developed by linear regression method as given in annexes.

4.3.2 Experimental Procedure

1. The desired cylinder tank, installing baffles, was set up.
2. The conductivity probes were placed at the entrance and the exit of the mixing tank.

3. The voltage regulated system was connected to the DC motor, and the shaft with the desired impeller was attached to the axis of the motor.
4. The mixing tank was filled with water until the liquid level is equal to the diameter of mixing tank.
5. The pump was switched on to suck the feed from the storage tank to the mixing system while the storage tank was filled with the water from the tap.
6. The bypass line was fully opened in order to reduce pressure from the pump and then the flow rate of feed was adjusted to the appropriate value.
7. The motor was operated and adjusted to the desired revolution.
8. The flow rate of outlet was observed until it became constant.
9. Tracer was injected at the prior position to the entrance of the mixing system.
10. The results from both conductivity meters were recorded at various time until the entrance and the exit conductivity were equal. Then only exit conductivity was recorded the conductivity of outlet reduced to the initial value
11. The operation was shut down. The variables were changed to the next desired study and resume the experiment.

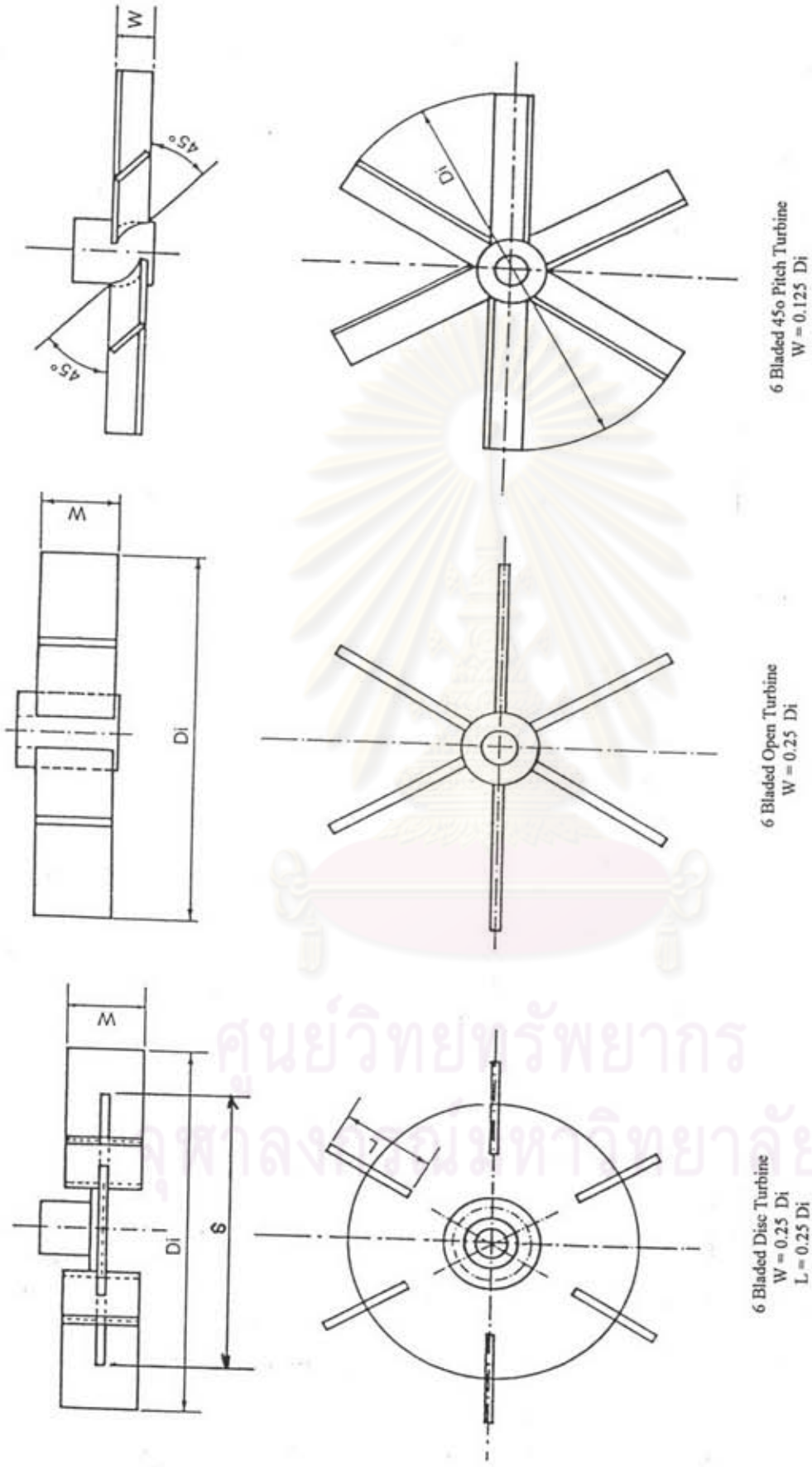

Figure 4.2 Diagram of three types of considered impeller