CHAPTER III
EXPERIMENTAL

3.1 Materials

- Simulated flue gas (15 % CO_2, 5 % O_2, and 80 % N_2)
- Monoethanolamine (MEA), 99 % purity
- 2-Amino-2-methyl-1-propanol (AMP), 99 % purity
- 2-Amino-2-methyl-1,3-propanediol (AMPD), 99 % purity
- 2-Amino-2-ethyl-1,3-propanediol (AEPD), 97 % purity
- Diethyldiamine or piperazine (PZ), 99 % purity

3.2 Equipments

- Gas chromatograph (GC 5890 seriesII, Hewlett Packard)
- Three-necked round-bottom Pyrex glass reactor
- Mass flow controller
- Stainless steel filter
- Temperature-controlling bath
- Cooling water bath
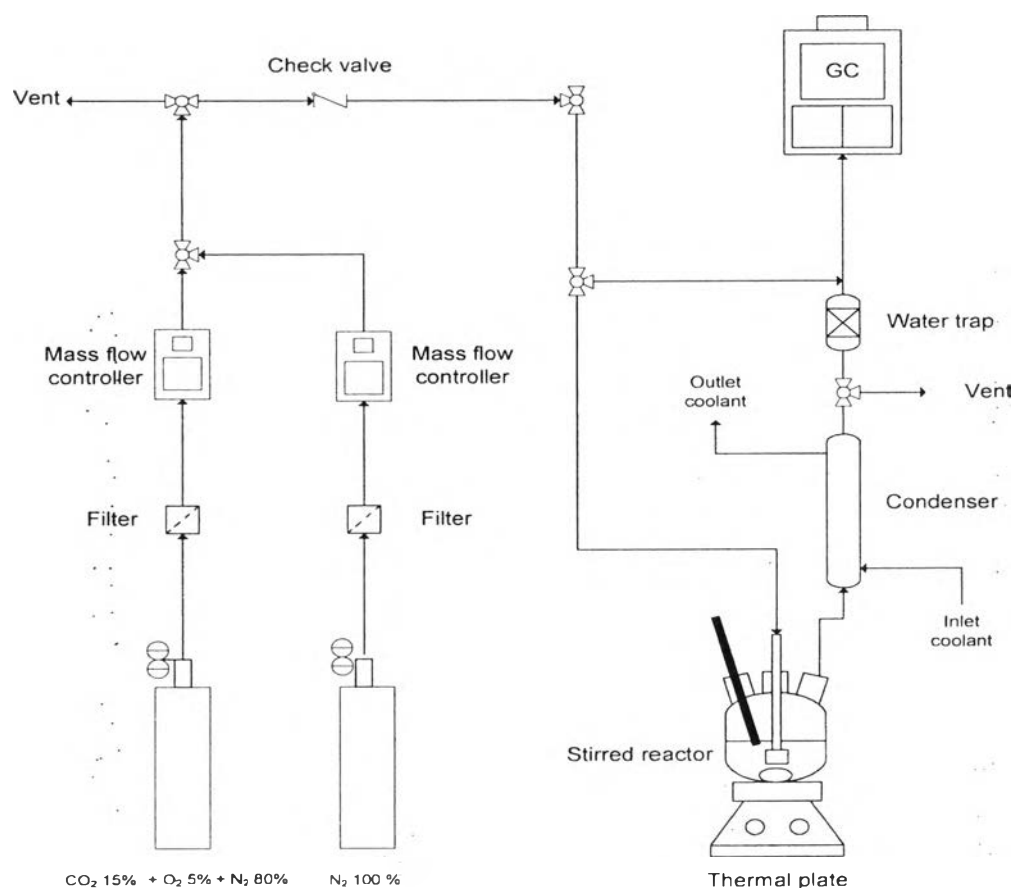- Magnetic stirrer

3.3 Methodology

Figure 3.1 Schematic of CO_2 absorption system.

The schematic of CO_2 absorption system used in this research is shown in Figure 3.1. There are 3 main sections in this system, including feed gas section, reactor section, and analytical section.

3.3.1 Feed Gas Section

The simulated flue gas, with compositions of 15 % CO_2, 5 % O_2, and 80 % N_2, was introduced into a stirred absorption reactor. The flow rate of the simulated flue gas passing through the reactor was regulated by a mass flow controller and a transducer. A stainless steel filter was placed upstream of the mass flow controller in order to trap any foreign solid particles impure in the simulated

flue gas. A check valve was also placed downstream of the mass flow controller to prevent any backflow. The pure N_2 gas was used to purge the reactor to remove air before the absorption experiments.

3.3.2 Reactor Section

For any studied conditions, the flue gas was introduced into the reactor through a gas dispenser connected to one neck of the reactor, where the reactor contained a studied liquid solvent: pure MEA, blended MEA-sterically hindered amines, and blended MEA-diamine. During the absorption experiments, the reactor was continuously stirred by a mechanical magnetic stirrer. The reactor was placed in a temperature-controlling bath in order to maintain the temperature of the system at a desired value. The temperature of the solvent inside the reactor was monitored using a thermometer inserted through one neck of the reactor. The gas exit at another neck of the reactor was connected to a condenser, which was connected to a cooling water bath, in order to return any vaporized solvent to the reactor for preventing the solvent loss.

The type and concentration of each studied solvent in an aqueous solution were comparatively investigated.

3.3.3 Analytical Section

The compositions of the feed flue gas and the outlet gas exiting the condenser were analyzed by a gas chromatograph (GC) equipped with a thermal conductivity detector (TCD). For any studied conditions, the system was operated under an atmospheric pressure. An analysis of the outlet gas compositions was performed every 10 min.

The GC was operated under the following conditions:

TCD injection temperature	60 °C
Oven temperature	60 °C
Carrier gas	High purity argon
Detector temperature	150 °C

The CO_2 removal efficiency was calculated by using the following equations:

$$CO_2 \text{ removal efficiency} = \frac{(\text{moles of } CO_2 \text{ in} - \text{moles of } CO_2 \text{ out}) \times 100\%}{(\text{moles of } CO_2 \text{ in})}$$

Moreover, the CO_2 absorption rate was calculated from the CO_2 absorption breakthrough curve (outlet CO_2 amount vs absorption time) in terms of slope value over the range of 10 to 90 % outlet CO_2 amount (Singh *et al.*, 2009). And, the CO_2 loading capacity was estimated from the total absorbed CO_2 amount up to 50 % of the breakthrough curve per total mole of amine used.

3.4 Studied Conditions

The conditions for all studied parameters (MEA concentration, total feed flow rate, and sterically hindered amine and diamine concentrations) are shown as follows:

MEA concentration	20–40 wt.%
Total feed flow rate	50–180 cm^3/min
Sterically hindered amine and diamine concentration	1–8 wt.% of total amine