CHAPTER 3

CONSTRUCTION AND LEAK-TESTING OF REACTOR SET

The two feed streams of water and propylene enter the reactor inlet tee from opposite sides, get mixed in the center, and pass onto the reactor through a feed preheater section where the reaction mixture is pre heated. A stainless steel cone, is placed in each of the feed lines at the entrance of the inlet tee. The feed streams are thus jetted into the tee to produce good mixing of the two fluids. After leaving the preheater,the two-phase mixture passed through the catalyst bed which surrounds a thermowell containing two thermocouples. A pressure regulator at the bed inlet is used to maintain the desired reaction pressure. The reaction products then flows into a products condenser, from which the unreacted propylene gas flows through a water bubbler and a wet test meter before being vented to the atmosphere. (21)

3.1 Construction and Leak Testing of Reactor Set

A reactor set for isopropanol synthesis was constructed in the laboratory at the Department of Chemical Engineering, Chulalongkorn University. The maximum design pressure and temperature were 100 atg and 400°C, respectively (1 atg = 1 kg/cm^2 gauge). The materials of construction were all stainless steel. Swagelok unions, joints, and reducers, etc., were used because of their high reliability.

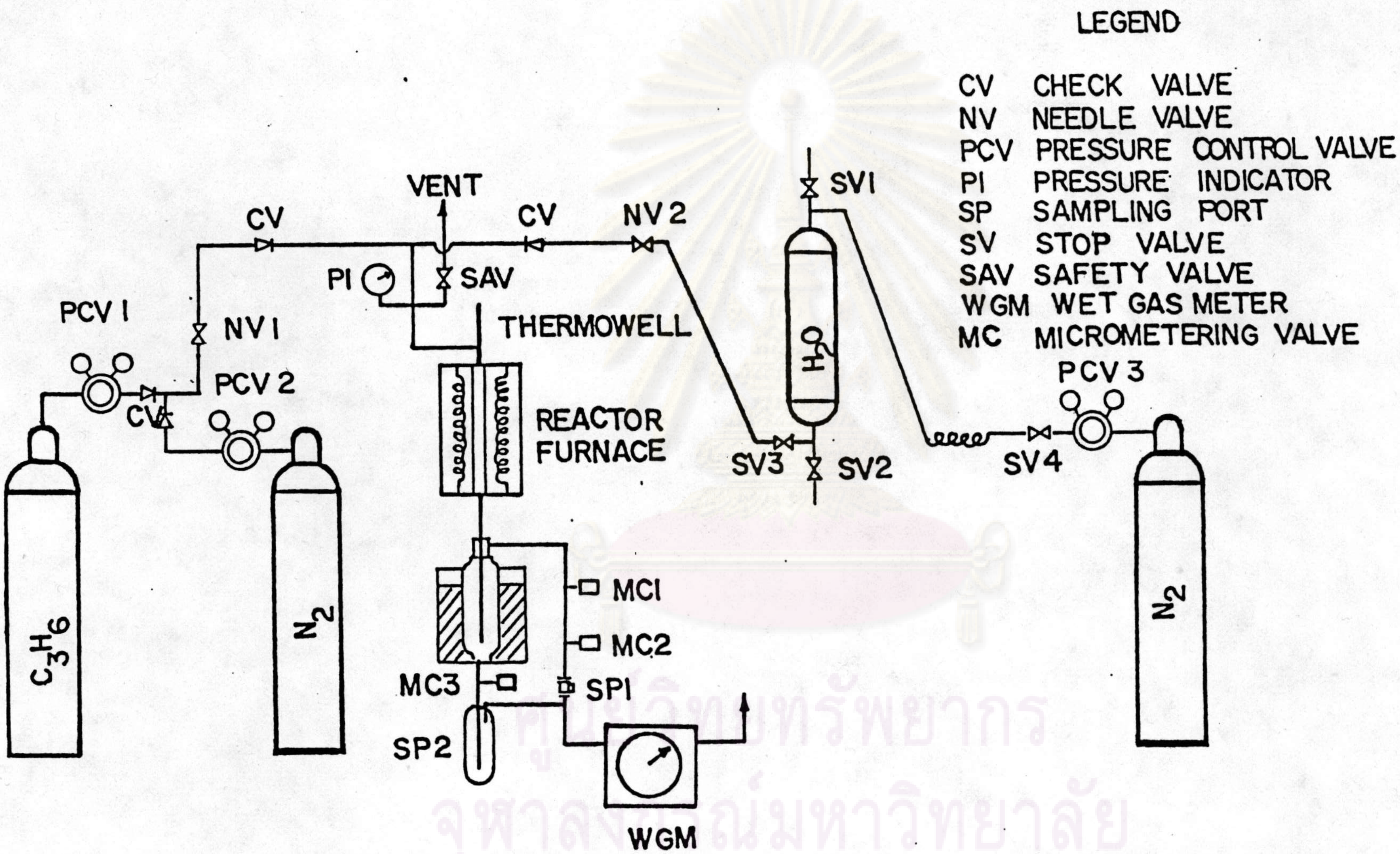

Figure 3.1 Schematic diagram of the constructed tubular reactor.

Fig.3.1 shows a schematic diagram of the constructed tubular reactor for isopropanol synthesis. Propylene and water were the starting materials for the synthesis.

$$C_3H_6 + H_2O \longrightarrow i\text{-}C_3H_7OH$$

N_2 was used to purge the system before and after each experiment. A pressure control valve, PCV was used to regulate and maintain the pressure in this system at the desired value. Pressure indicators indicated the inlet and outlet pressures of the PCV. Two needle valves NV-1 and NV-2 served to roughly adjust the flow rate of water and propylene whereas two micrometering valves were used to fine adjust the flow rate through the wet-test meter (flow meter) and to reduce the outlet pressure to nearly atmospheric. A safety valve was provided to release any accidental buildup of pressure that might result in an explosion. The reactor tube (1/2"O.D.) was installed inside a uniformly heating furnace. Three sets of thermocouple were used to measure the temperature at the inlet, the mid section and the outlet of the catalyst bed in the reactor tube. SP-1, SP-2 were sampling ports. The condenser unit CU used ice to condense isopropanol, heavy hydrocarbons, and H_2O. The condensate was separated and accumulated in a receiving pot. Gaseous samples withdrawn at SP-1 were "dry", that is, without isopropanol, H_2O or any condensible compounds. The wet-test meter measured the actual flow before and during an experiment.

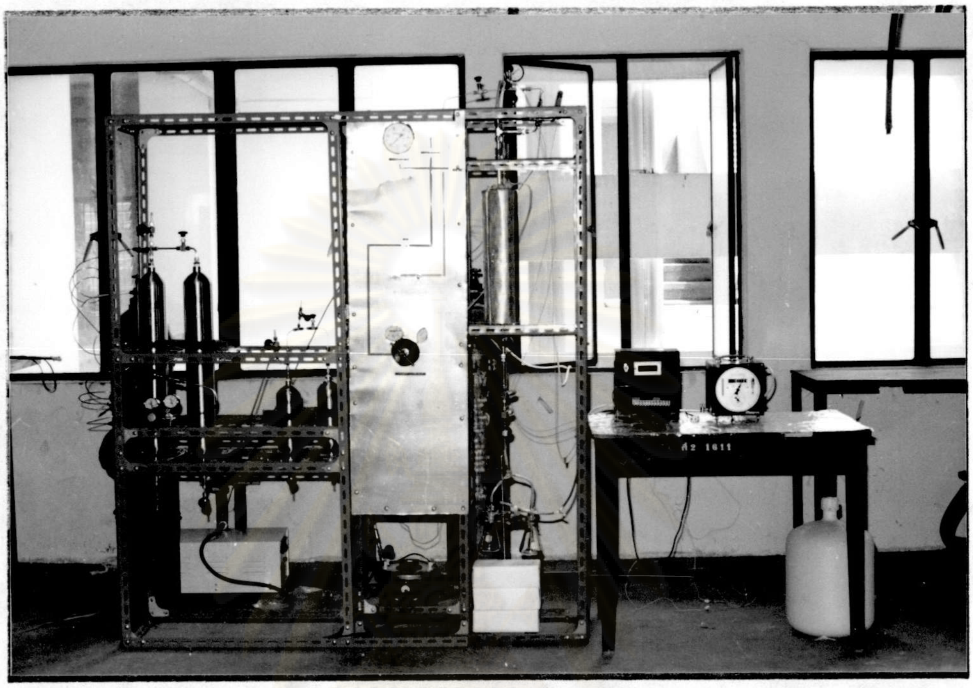

Fig. 3.2 A Reactor Set for Isopropanol Synthesis

The reactor set was supported on an angular steel framework (see Fig.3.2). Because of the high inflammability of propylene, test for leakage was first carried out using N_2 at 5 atg, 10 atg, 15 atg, 20 atg, 30 atg, 40 atg, and 100 atg, respectively. In each test, a soapy solution was squirted onto all areas susceptible to leakage, such as unions, joints, valve handles, etc. Appropriate measures were then taken to correct all detected leaks. In constructing the high-pressure reactor set and in correcting leaks, it was important not to turn any joint tighter than necessary, since that might lead to irreparable damage.

3.2 Construction of Electric Furnace and Measurement of its Axial Temperature Distributions

The furnace for the isopropanol synthesis reactor was constructed from refractory brick blocks. The furnace was made by carving out 4 refractory brick blocks, inserting electrical heating wires inside the grooves, and wrapping all four semicircular sections of the furnace in an aluminium-tin sheet. To control the heating temperature, the electric voltage supplied to the wires was adjusted via a slidac. (Fig. 3.3)

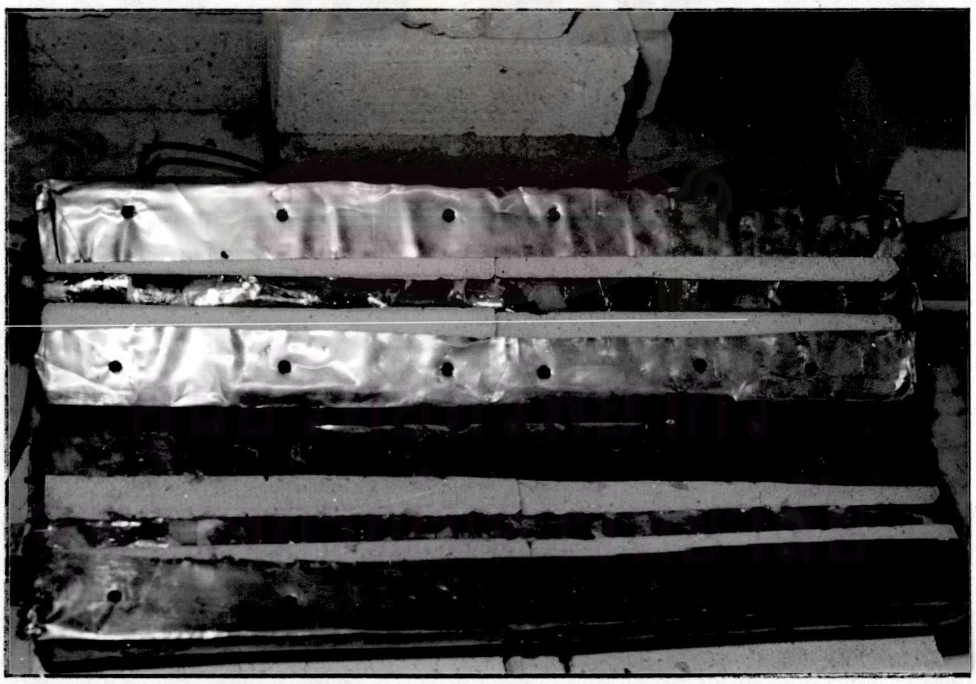

Fig. 3.3 The Inside of the Reactor Furnace

To ensure a uniform axial temperature distribution along the middle section of the constructed furnace, we measured the axial temperature distribution inside a stainless tube placed inside the furnace and adjusted the electric wires, so that an axial temperature variation within $\pm$ 3 °C was achieved over the entire middle section of the furnace (see Fig. 3.4)

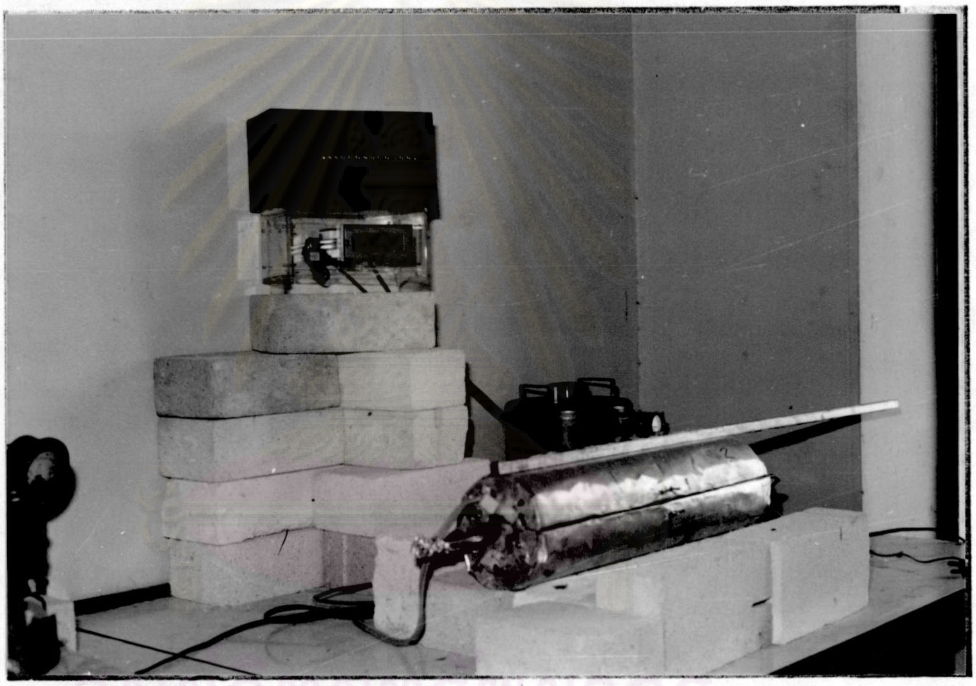

Fig. 3.4 Set of Measuring the Axial Temperature Distribution

Measurement of axial temperature distribution was made by inserting a thermocouple into the stainless tube within the furnace after setting the desired temperature by adjusting the slidac. When the whole furnace had reached a steady state, the axial temperature distribution was measured with a sheathed CA (chromel-alumel) thermocouple. Base on the observed temperature distribution, specific portions of the electrical wires were stretched or compressed accordingly by trial and error until the maximum axial temperature variation within the middle 20 cm region of the furnace was less than ± 3 °C. The same procedure was repeated at various temperature distributions under these circumstances. Fig.3.5 shows the observed axial temperature distributions for the above furnace under no gas flow conditions.

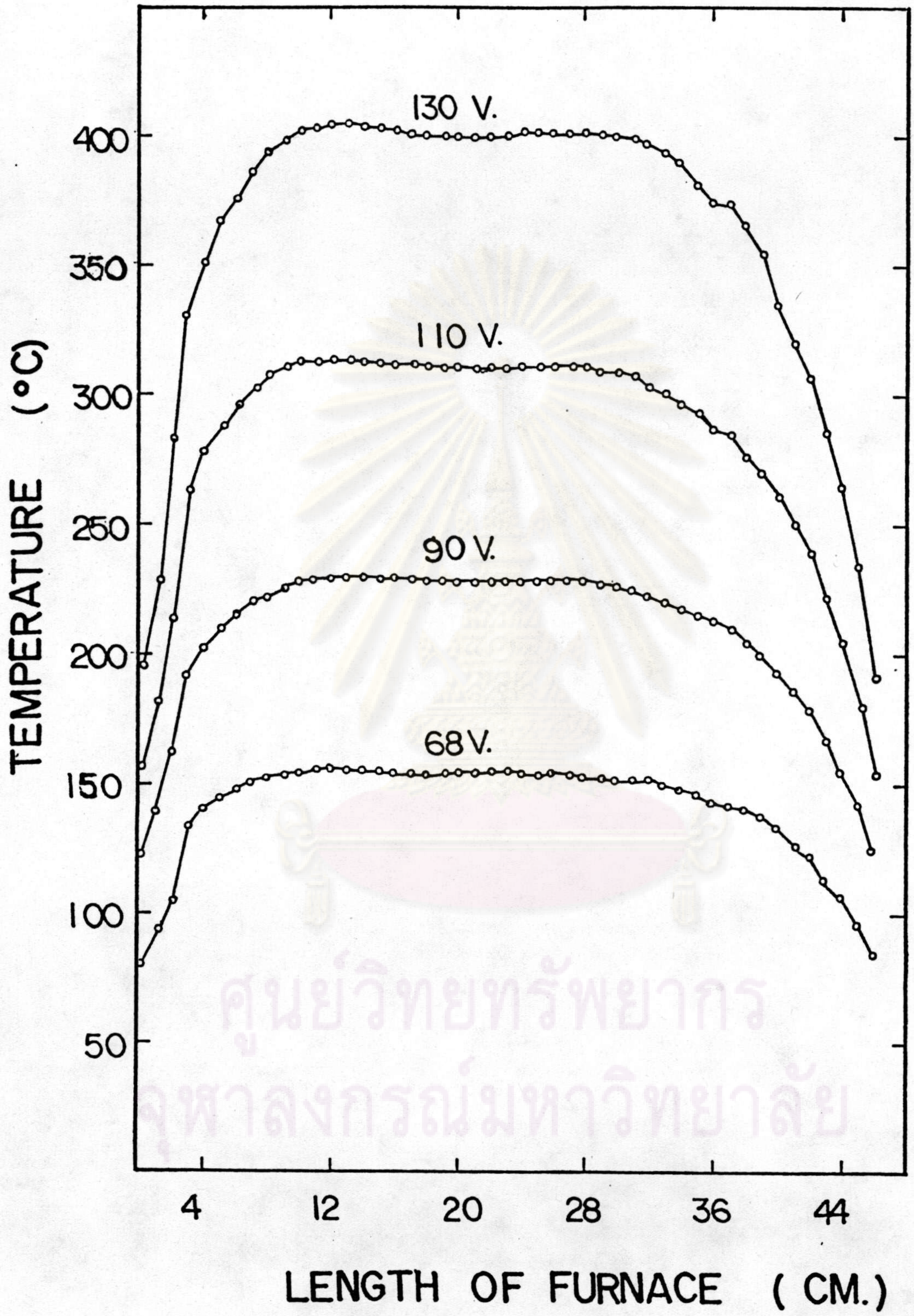

Figure 3.5 Axial Temperature Distribution within the Reactor Tube Inside the Electric Furnace.