III. EXPERIMENTAL APPARATUS

Two over-riding considerations dictated the choice of reactors for the catalyst test runs. Firstly, because Fischer-Tropsch reactions are highly exothermic, a reliable and precise means of controlling the reaction temperature was required. Secondly, because techno-economic evaluations would eventually be required, run data had to be correlatable for use in a computer simulation of a large commercial reactor.

The Berty reactor was selected as the best means to meet both requirements. Its high internal recirculation rate provides an accurate control of the reaction temperature. In addition, since the discharge conditions are nearly the same as those of an ideal, perfectly mixed Continuous-Flow Stirred Tank Reactor, the data can be easily correlated into rate expressions for the computer simulation.

Over 200 Berty reactors have been used in the chemical industry for routine catalyst testing and kinetic modeling since their introduction in the middle of the 1960's. Union Carbide's experience with over 40 Berty reactors has shown them to be relatively free of technical problems, to give reliable rate data, and to have small internal temperature gradients with even highly exothermic reactions.

The Berty Reactor

The reactor proper (Figure 1) is a stainless steel cylinder nominally five inches high and five inches in diameter. The internal chamber is 4 1/2 inches high and 4 7/8 inches in diameter, with a convex domed upper surface. In the center of the chamber is a solid, doughnut shaped, stainless steel toroid, 3 1/4 inches high, with a 2 inch inside diameter and a 4 3/8 inch outside diameter. With the toroid in place the void volume of the chamber is about 750 cc.

In the center of the toroid is placed a stainless steel open mesh basket, 3 inches high and 2 inches in diameter. This holds the catalyst that is being tested. Vertical draft tubes between the basket and the inside of the toroid keep the basket centered.

Below the basket is a horizontally rotating down-draft impeller, mounted on a shaft which extends down to the base of the reactor, where it is magnetically driven by a variable speed motor.

Liquid feed is introduced through a horizontal channel in the side of the vessel, at the level of the impeller. Gas feed is introduced up through the magnetic drive shaft. Both liquid and gaseous products are withdrawn through a channel at the bottom of the vessel.

The impeller draws gases down through the catalyst bed and propels them centrifugally outward. The shape of the chamber forces them around the toroid to recirculate through the basket before discharge. The recirculation ratio, which is controlled by the impeller speed, can be set to an experimentally determined level at which catalyst performance becomes insensitive to small changes, closely approaching a gradientless reactor.

Two thermowells provide for continuous monitoring of the reaction temperature. One is positioned just below the catalyst bed, and the other just above it.

The catalyst basket described above held 80 cc of undiluted catalyst, the amount that was used for most of the Task 1 and Task 2 runs. A larger basket, with a correspondingly smaller toroid, held 250 cc of undiluted catalyst and was used for the other runs.

The Complete System

Figure 2 presents a schematic diagram of the complete system. The system has the capability to deliver either liquid or gaseous feed stocks to the reactor.

Liquid feed, such as methanol or propylene, is drawn from a tank reservoir equipped with a graduated level gauge. A positive displacement pump introduces the liquid into the reactor where it is vaporized.

The CO and H2 feed gases are drawn from their own high pressure feed line or storage cylinder. The flow rate of each gas is controlled by a Linde mass-flow controller, which is stable and reliable. The gases mix and enter the reactor through the magnetic drive shaft of the reactor.

The desired temperature is obtained by the use of electrical resistance heating elements, which are mounted above and around the sides of the reactor and are controlled by two independent temperature controllers.

The product leaving the reactor passes through a pressure control valve which is operated by a pneumatic pressure controller with a Bourdon tube sensing element. The now depressurized and cooled product enters a 500 cc. glass receiver where the condensable fraction separates out. The non-condensable fraction passes out of the receiver to an on-line chromatograph, then to a back-up separator, a dry gas meter, and finally to the vent.

The reactor was also fitted with a by-pass line and a 1000 psig relief valve.

Three complete systems were installed, each in an individual bay, in a manner that allowed easy servicing of the reactors.