VII. CORRELATIONS

B. Effect of Operating Variables

Effect of Recycle Ratio:

It is evident from an inspection of the data that the degree of conversion; that is, the % Contraction, H_2 disappearance or CO disappearance, can be materially increased by simply changing the composition of the fresh feed or the recycle ratio, both of which influence the composition of the total feed. This in turn also profoundly effects the distribution of product for a given conversion.

Fig. XV is a plot of H_2 Conversion vs. R/FF for the HRI H Series data and the Beacon data obtained with CM&S Reduced Catalyst. It will be evident that increasing recycle ratio increases conversion. As a matter of fact recycling is essential if the H_2 Conversion is to be increased above 60-65% which is the conversion consistently obtained when operating with 2/1 H_2/CO feed once through.

On the other hand recycling is apparently not the only means to increase conversion. Fig. XVA shows some of the HRI 14 Series data taken directly from their summaries. These data show that under some conditions it is necessary to recycle more than in the H Series runs in order to obtain the same degree of conversion. It should be noted from Fig. IVA that in most of these 14 Series high recycle runs, the yield of C_{3+} for a given conversion was low and the CO Conversion was low (Fig. IIA) indicating perhaps that high recycle ratios have a detrimental effect and that to obtain maximum yields one should operate with conditions and catalysts which will produce a high H_2 Conversion at a recycle ratio of no more than 1 or 1.5.

The reasons why high recycle ratios were necessary in most of the 14 Series runs is not clearly evident because we do not have available to us all details on the type of catalyst that was used. The catalysts may be partly responsible but in some cases notably 14-9 and 14-11 lower temperatures were used than in the H Series runs and this alone may have been enough to cause the deviation.

The 14-10 Series data which were obtained with diluted catalyst did not correlate at all against recycle ratio. They did however correlate

well against temperature, as will be seen later, indicating that in the cases of low catalyst activity, temperature instead of total feed composition becomes the dominating factor.

Fig XVB is a similar plot of H_2 Conversion vs. R/FF of all the Stanolind and Laboratory A and Laboratory B data.

The Stanolind, with H_2/CO in FF varying from 3.4 to 5.1, all correlate very well on a single line which has a shape similar to that of the HRI 2/1 data. The temperature in the Stanolind runs ranged from 580 to 600° and the pressure was about 160#. The low temperature and low pressure may account for the higher recycle ratios required for a given H_2 Conversion. It will be recalled that the Stanolind fresh feed always contained a high CO_2 content and therefore although the H_2/CO ratio was high, the H_2 Conversion was apparently at the same rate as though it was 2/1. In other words, CO_2 in the feed had about the same effect as CO so far as H_2 Conversion is concerned.

The significance of the high recycle ratios used in the Laboratory A and B low H_2/CO runs will be discussed later.

R/FF vs. Total Feed Composition

The effect of recycling on total feed composition for the good HRI and Beacon runs with 2/1 feed is shown on Fig. XVI.

H_2 Conversion vs. Total Feed Composition

Figs. XVII, XVIIA and XVIIB were prepared to obtain some idea of the effect of total feed composition on H_2 Conversion.

Effect of Temperature

Fig. XVIII is a plot of all the HRI and Beacon data that can be used to establish the effect of temperature.

The line labeled HRI 14-10 shows all the data of the series that was made at high space velocity with diluted catalyst. It will be recalled that these data did not plot at all against R/FF ratio. It is indicated that temperature is the dominating factor when catalyst activity is low or space velocity is high.

Run H-14 which was also made at a high space velocity, checks well with this curve.

The Beacon data indicate that even with an active catalyst and low space velocity, temperature has an effect when the recycle ratio is low, about 0.5 to 1.0, but when the recycle rate is increased and conversions are high, the HRI and Beacon data together indicate that the temperature effect is small.

Fig. XVIIIA shows the effect of temperature on H_2 Conversion for the Stanolind high H_2/CO ratio data and the low H_2/CO ratio data of Laboratories A and B. The former show no relation with temperature. The latter indicate that temperature is important both in Runs 11 and 12 with 2/1 ratio fresh feed and in the 1/1 ratio runs. It also indicates that lower pressure tends to reduce conversion.

Effect of Pressure

Inspection of the data indicates that pressure has an effect on degree of conversion. Low pressures give lower conversions. However, the range of pressures covered by the data was relatively small and the obscuring effect of other variables was so great that the magnitude of the pressure effect could not be established.

Effect of Space Velocity

As in the case of pressure, inspection of the data shows that space velocity has a definite effect on conversion, particularly at the low conversion levels; but the effect was so obscured by changes in other variables that its magnitude could not be established.

Effect of Catalyst

These will be considered under "Discussion".