

product. This type of reaction may also be responsible partly for the carbon or coke found in catalyst deposit but no consideration has been given to such secondary or trace reactions in this report.

#### "Catalyst Equilibrium"

The above completes the description of our interpretation of the various steps involved in the entire process.

Unfortunately the reactions do not proceed through these various steps without interruption. The catalyst is apparently a definite intermediate for the primary reactions and it seems to remain active only so long as the oxidizing tendency of the surrounding medium does not equal some function of the carbiding and reducing tendency of the same medium. When these two are equal, or perhaps when one exceeds the other by too much, all primary reactions cease. What relationship of the components in the reactor are responsible for this "catalyst equilibrium" has not been established. It may occur during any of the phases of the process described above, depending upon the initial composition of the feed to the reactor. It may be affected by the amount of undesorbed product on the catalyst but it appears quite likely that the relative concentration of oxidizing, reducing and carbiding components at that instant is the most important factor.

The fact remains, that once this "catalyst equilibrium" condition is reached, further disappearance of  $H_2$  or CO can only be accomplished by upsetting that equilibrium by recycling or by otherwise changing the composition of the reactor feed.

#### Effect of Operating Variables:

The degree of conversion that can be attained before "catalyst equilibrium" is reached may be influenced by many factors but the most important appears to be composition of reactor feed. This in turn, determines product distribution so it can be seen that both conversion and product distribution can be controlled to a large extent by simply controlling feed composition, that is, fresh feed quality and recycle ratio.

The type and activity of catalyst obviously has a profound effect. Space velocity, temperature and pressure are important particularly with respect to the secondary reactions.

When with a given bed of catalyst, conditions are such that primary reactions are fast and "catalyst equilibrium" is reached and the primary reactions stop early in the bed, then there is more time in the remainder of the bed for secondary reactions to occur. If the basic synthesis reaction and the gas-shift are slow so that "catalyst equilibrium" is not reached until late in the bed or not reached at all, then a higher average concentration of CO is available a longer period of time for the slower reactions and product distribution is affected correspondingly.

A discussion of the effect of some of the variables is included in the report. It is pointed out that when considering the effect of recycle ratio it should be remembered that the effect of recycling will be different with a fresh feed that would have reached "catalyst equilibrium" when running once through than it will be when conditions are such that equilibrium would not be reached in once through operations.

Conclusion:

The study of the effect of operating variables and the full significance and application of this hypothesis is by no means complete and further time and thought on the subject are well warranted. It was felt advisable to present results to date however so that others might benefit from the developments made so far.



### FOREWORD

Because of the large number of graphs involved in this report, they have all been arranged in the order discussed and have been bound together. It is suggested that they be removed from the report for ease in reference as the report is read.