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SUMMARY

The present work discusses ways of saving energy in the different stages of gas-to- liquids, GTL, as well as modeling of the Fischer- Tropsch slurry reactor.

In the synthesis gas production stage, the concept of autothermal reforming process which combines both steam reforming and partial oxidation is a milestone towards energy conservation in this stage. This process takes the advantage of the exothermal reaction taking place in the partial oxidation process to supply the heat required by the endothermal steam reforming reaction and in the same time produces synthesis gas with the H_2/CO ratio required by the Fischer-Tropsch reaction chemistry.

Process integration between the three-steps GTL process can save the natural gas feed stock and improve its utilization efficiency.

Once-through process rather than recycle can provide a combined cycle power generation plant with its needs of high, medium and low pressure steam, so produced as byproducts. Additionally unconverted and produced gas can be used to generate electricity using gas turbines. The co-produced electricity saleable byproduct improves the economics of GTL process.

Energy conservation in the pilot scale slurry-phase FT AFDU demonstration plant at Laporte Texas USA has been attempted in this work. The transshipment model for minimum energy utilization developed at the Egyptian Petroleum Research Institute has been utilized together with LINDO linear programming solver to establish minimum energy utilization. Five assigned minimum temperature differences, ΔT_{min} namely; 10, 20, 30, 40 and 50 ^{o}C were utilized. The results indicated that hot utility was not needed until ΔT_{min} = 30 ^{o}C. The heat content of the hot streams was enough to heat the cold streams to their target temperatures, only cold utility was required. Thus a total saving of the hot utility was possible. The minimum cost heat exchanger network was chosen among the designed networks at different minimum temperature differences. That corresponded to, ΔT_{min} = 10 ^{o}C showed the minimum annualized cost.

Bubble column slurry reactors are the choice of almost all new GTL Fischer-Tropsch based processes and of the largest two technology providers; Sasol and ExxonMobil companies.

Modeling of the slurry bubble column FT reactor is complicated by the presence of the three phases. The Synthesis gas phase, the wax liquid phase and the solid catalyst phase. In order to build a reactor model, knowledge of the reaction kinetics and hydrodynamics of such reactors has to be understood. Kinetics and selectivity models as well as the hydrodynamic ones have been reviewed. The two-bubble class model presented by Shah et al. (1985) and modified by Van der Laan et al. (1999) was chosen for further manipulation.

The model assumes that, in the churn turbulent regime, the most interesting from industrial point of view, the gas phase travels up the bed in two bubble classes; small bubbles and large bubbles. The small bubbles are completely mixed while the large bubbles travel in plug flow. The slurry phase, consisting of the molten wax and fine suspended catalyst particles, is assumed completely mixed. The model equations were solved analytically. An overall executive program that calls different subroutines at request to calculate the hydrodynamic and kinetic parameters and at the same time performs the necessary calculations needed for model solution was developed.

The software developed was used to reproduce the performance study of an industrial scale slurry F-T bubble column which was undertaken by **Van der Laan et al. (1999).** The industrial reactor uses iron based catalyst. The operating conditions were varied so as to study the effect of superficial gas velocity, solids holdup and H_2/ CO feed ratio on synthesis gas conversion and reactor productivity. It was found that synthesis gas conversion decreases with increasing superficial gas velocity, decreasing solids holdup and decreasing H_2/ CO feed ratio. On the other hand reactor productivity increases with increasing all three variables. The reference authors obtained similar results.

Product selectivity was estimated using the Olefin Readsorption Product Distribution Model**, ORPDM**, of **Van der Laan et al. (1999)** with changing the $H_2\backslash CO$ ratio. Again the estimations were in agreement with the reference authors.

The same model but with cobalt catalyst based kinetics was used to simulate the performance of the pilot scale slurry reactor of the **Laporte AFDU.** Cobalt was the catalyst used in the F-T slurry reactor. Simulation studies were performed under different operating conditions. The parameters of the **ORPDM of Van der Laan et al. (1999)** were modified so as to suit selectivity obtained from the cobalt catalyst. The model results are in excellent agreement with the reported experimental results for gas holdup and reactor productivity and in fair agreement with the reported conversion and selectivity for light hydrocarbons.