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Controlled Variables Selection for a Gas-to-Liquids Process

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GTL (Gas To Liquid) is an important technology for converting natural gas to economical, clean and high quality liquid fuels. A GTL plant has 3 main parts (i) production of synthesis gas (syngas), (ii) Fischer-Tropsch (FT) reactor and (iii) upgrading units. Various technologies for producing synthesis gas and different types of FT reactor, catalyst and kinetics are available in literature.

In particular, Auto-Thermal Reforming (ATR) is claimed to be the best option for synthesis gas production [1]. In our work, we study in a detail; design, optimization and controlled variables selection for a GTL process based on ATR for synthesis gas production and a FT reactor with Cobalt catalyst in a Slurry Bubble Column Reactor (SBCR). The well-known kinetics of Iglesia [2] is used for the FT reactor; the remaining reactions are simulated assuming thermodynamic equilibrium. Selectivity to different hydrocarbons in FT reactions is described by ASF ideal model with a chain growth probability of hydrocarbons as function of the hydrogen to carbon monoxide ratio [3].

The UniSim process simulator is used to simulate and optimize one train of a GTL plant with capacity of around 34000 bbl/day, which is a current industrial scale capacity, similar to that of the Oryx (Qatar) and Nigeria plants.

The process includes heat integration, CO₂ removal, recycles and purge. Important process parameters, which are subject to optimization, include feed rates of water, oxygen, reactor temperatures, CO₂ removal percent and recycle flows. Nominally, the optimal ratios of oxygen and water to hydrocarbons (fresh natural gas and recycle hydrocarbons from FT reactor) were H₂O/hydrocarbons=0.6 and O₂/hydrocarbons=0.52, and the optimal ratio of H₂ to CO in fresh syngas is 2.1. Optimization is used to find bottlenecks of the process while flowrate of natural gas is also a degree of freedom and it is tried to maximize the variable income of the plant respect to these bottlenecks.

In addition to determining the process and equipment design and finding the bottlenecks, optimization is used to find optimal operation (control) policies where an important issue is: what should we control? To answer this in a systematic manner we first need to define operational objective (which in this case is to maximize the variable income) and operational constraints. Next, we optimize the operation for various disturbances (such as feed composition and flowrate, pressure and temperature, constraint values, etc.). The first thing we need to control is the active constraints, for example, the outlet temperatures of the fired heater and ATR in syngas unit. Next, we look for "self-optimizing variables" [4], which are controlled variables which indirectly give close-to-optimal operation when held at constant setpoints, in spite of changes in the disturbances. Selection of the single and combinatorial measurements and its effect on the economy of the plant both in the nominal case and in the mode of maximizing throughput is discussed.

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References

- [1] Bakkerud, P. K. (2005). "Update on synthesis gas production for GTL", *Catalysis Today* 106(1-4): 30-33.
- [2] Iglesia, E., S. C. Reyes, et al. (1993). "Reaction-Transport selectivity models and the design of fischer-tropsch catalysts. Computer-aided design of catalysts", P. C. J. Becker E. Robert 199-257
- [3] Song, H.-S., D. Ramkrishna, et al. (2004). "Operating strategies for Fischer-Tropsch reactors: A model-directed study", *Korean Journal of Chemical Engineering* 21(2): 308-317
- [4] Skogestad, S. (2004). "Control Structure Design for Complete Chemical Plants", *Computers and Chemical Engineering*, 28, 219-234

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