Project Title: Maximizing the Effectiveness of Fischer-Tropsch Fixed-bed Reactor: Tailoring Reaction Media, Catalyst Geometry and Pore Structure

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Project/Technology Description

This project aims to develop a novel catalyst material, and reactor technology for the Fischer Tropsch (FT) process that could facilitate improvement in thermal properties compared to the conventional gas phase catalyst. The holistic aim is to provide improvement in thermal conductivity, hotspot elevation and provide improvement in process selectivity that could enable selective control on the hydrocarbon product distribution. Additionally, a high fidelity model is developed using principles of Process Systems Engineering supported by CFD studies to evaluate scale-up potential of the developed process that could enable process intensification.

Key Results:

- The combination of the MEFCC and the supercritical phase produce the highest stable activity performance for relatively long time-on-stream.
- Sintering of catalyst in MFECC structure under the SCF environment is significantly less compared to a conventional packed bed.
- MFECC reactor scale-up from 0.015 m ID to 0.1016 m ID demonstrated 20 times reduction in hotspot formation corresponding to a 64-fold reduction in number of fixed-bed tubes required to meet targeted capacity.

Technical Approach and Solution:

Major Challenges addressed:

Hotspot formation in fixed bed reactor is a major hurdle for scale-up of FTS reactors. We have successfully demonstrated scale-up of the FTS reactor from 0.015 m to 0.106 m ID through our modeling and experimental efforts.

Approach/Solution:

- A multi-scale 1-D model was devolved for FTS fixed-bed reactor to predict the CO conversion and methane selectivity. Further, 2-D pseudo-homogeneous FTS fixed-bed reactor was simulated using COMSOL Multiphysics to visualize the radial heat transfer capability of the MFECC bed.
- An alternate separation sequence was designed for SCF-FTS aimed at reducing the energy requirement/duty of the downstream separation utilities.
- Finally, a techno-economic analysis was conducted and different scenarios were studied to find the least energy requirement and highest product recovery.

Benefits/Potential Applications/Customers/Markets

Benefit:

- Improved catalyst activities achieved by the utilization of the novel MFECC and the supercritical media provides the following benefits:
  - Reduction in reactor downtime.
  - Improvement in sustained catalyst cycles that reduces resources required for regeneration.
  - Saves OPEX as less number of reactor tubes can be utilized with almost same productivity.
  - Improved product selectivity due to better thermal control of the reactor bed.

Application:

- Existing reactors could be scaled-up after implementing the novel systems developed in this project.

Potential Customers/Market:

- Local Energy Corporation that are focused on the advancements of the GTL technology and the products from the same (e.g., Qatargas, ORYX GTL, Shell, WOQOD, etc.).
- Global Energy Corporation that work in fuels and chemicals markets (e.g.,, Qatar Petroleum, Shell, Waqood,, ORYX GTL, etc.).

Key Outcomes:

- An hybrid process combining MFECC bed and SCF-FTS, which provides high throughput with improved product selectivity.
- Increased loading of catalyst in the FTS fixed bed reactor without affecting product profile.
- Sustained catalyst lifetime with the hybrid process.
- 2-D Model prediction for CO conversion and CH_4 selectivity completed successfully.
- A novel separation sequence with optimized design for the SCF-FTS process has been developed and verified.
- A Techno-Economic analysis data using ASPEN was developed for the SCF-FTS process.
- Scale-up of the fixed-bed FTS reactor from 0.015 m ID to 0.1016 m ID.

Major Impacts: FTS rector scale-up from 0.015 m ID to 0.1016 m ID demonstrated 20 times reduction in hotspot formation corresponding to a 64-fold reduction in number of fixed-bed tubes required to meet targeted capacity