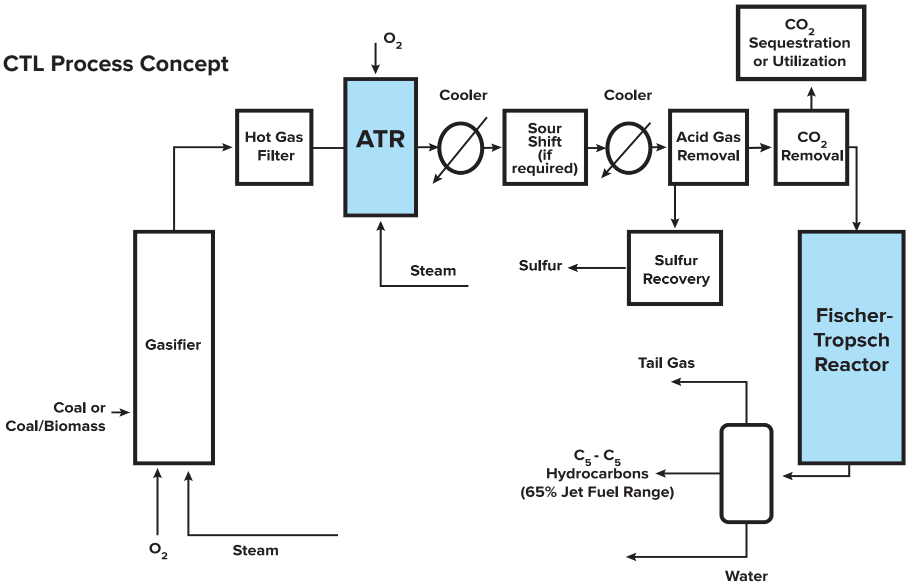
Indirect Liquefaction of Coal-Biomass Mixtures for Production of Jet Fuel with High Productivity and Selectivity

Background

Southern Research and its team members are conducting research and development to provide innovative improvements to indirect coal liquefaction for conversion of coal or coal/biomass mixtures to jet fuel with high productivity and selectivity. The proposed innovations are use of autothermal reforming (ATR) to reduce syngas cleaning and water gas shift requirements and application of a jet fuel-selective Co-zeolite hybrid Fischer-Tropsch (FT) catalyst in a novel high heat transfer reactor to eliminate wax production .

These improvements directly reduce capital costs of indirect CTL processes, resulting in significantly improved economics and cost competitiveness of CTL when compared to petroleum refining. This approach not only allows for CTL to be cost competitive at typical large scales, but also opens up opportunities for CTL to be economically viable in smaller modular scales. In addition, the improvements in system energy efficiency and the addition of biomass result in lower lifecycle greenhouse gas (GHG) emissions for CTL-based jet fuel production.

CTL Process Concept



Project Description

Autothermal reforming catalysts have been developed and will be demonstrated in a compact, high-pressure, high temperature skid-mounted reformer system and tested for their ability to reform tar and light hydrocarbons and decompose ammonia in simulated gasifier syngas. A final demonstration using the best performing catalyst will be conducted at the National Carbon Capture Center (NCCC) using actual syngas from the Transport Reactor Integrated Gasifer (TRIG) operating on Powder River Basin (PRB) sub-bituminous coal/wood pellet blends containing 75%-100% coal on a BTU basis.

SOUTHERN RESEARCH

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PROJECT DURATION
Start Date
10/1/2014

End Date
3/30/2017

COST
Total Project Value
$3,786,008

DOE Share
$3,028,807

Cost Share
$757,201

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The second portion of the experimental program will optimize catalyst formulation and process conditions to demonstrate a highly active and jet fuel-range hydrocarbon selective hybrid FT catalyst. Several catalyst formulations have been tested in microreactors for jet fuel productivity and selectivity. The most promising formulations will be incorporated into a novel heat-exchange reactor system for parametric testing to optimize operating conditions for maximizing jet fuel productivity and selectivity. Extended tests will evaluate potential catalyst deactivation. Reactor modeling will compare predicted productivity and thermal performance to experimental results. Several samples of fuels produced in this effort will be evaluated against MIL-DTL-83133. Appropriate blendstock type and quantity will be identified to meet JP-8 specifications. Aspen simulation will be carried out initially to prepare a process model and guide the experimental program. The data obtained during the research will be used to refine the model and develop a techno-economic analysis and life cycle analysis of the integrated process for comparison to petroleum-based jet fuel.

Goals and Objectives

Specific objectives of the 30 month project are:

- Improve a compact, pressurized, high temperature reformer to convert tar and light hydrocarbons to syngas, and deliver the required hydrogen (H_2) to carbon monoxide (CO) ratio for Fischer-Tropsch (FT) synthesis;
- Develop a second generation hybrid FT catalyst and a novel heat exchange reactor that will produce liquid hydrocarbon product with high productivity and jet fuel selectivity;
- Examine the resulting product fuels according to JP-8 specifications (MIL-DTL-83133) and determine blending stock and ratio of petroleum jet fuel to FT-jet fuel needed to meet specifications;
- Compare the performance of the integrated process to petroleum-based jet fuel with a techno-economic analysis (TEA) and life cycle analysis (LCA)

Accomplishments

The primary reforming catalyst was tested in the laboratory-scale microreactor for over 700 hours and showed high conversion of methane in the presence of H_2S. Tests of additional catalysts are planned. The design was completed for the bench-scale reactor system and fabrication will begin fall 2015. The ATR system will be tested at NCCC Fall of 2016.

Four hybrid jet fuel catalysts provided by Chevron were tested in Southern Research's laboratory-scale FT reactor process in experiments totaling approximately 3000 hours. Based on the results of those experiments, a 300 hour test was conducted in Southern Research's bench-scale FT skid using a 2-inch diameter heat-exchange reactor installed at NCCC. Results from the bench-scale system confirmed production of targets for jet fuel productivity. The heat exchange reactor being up to 4 inch diameter and will be tested again in Fall 2016.