ENGINEERING DEVELOPMENT OF CERAMIC MEMBRANE REACTORSYSTEM CONVERTING NATURAL GAS TO HYDROGEN AND SYNTHESIS GAS FOR LIQUID TRANSPORTION FUELS

Monthly Status Report Period Ending: 07/31/1998

DOE Award NO.: DE-FC26-97FT96052--10

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Contract Objectives

The objective of this contract is to research, develop and demonstrate a novel ceramic membrane reactor system for the low-cost conversion of natural gas to synthesis gas and hydrogen for liquid transportation fuels: the ITM Syngas process. Through an eight-year, three-phase program, the technology will be developed and scaled up to obtain the technical, engineering, operating and economic data necessary for the final step to full commercialization of the Gas-to-Liquids (GTL) conversion technology.

Summary of Activity

Task 1.1 Process Design and Engineering

Task 1.1.1 Process Design and Engineering

Process engineers from Chevron and Air Products met to review the process design work carried out to date. Chevron will simulate the baseline ITM Syngas process to ensure consistency of the respective data bases and will gave initial input into the GTL integration process design.

Task 1.2 Materials and Seals Development

Task 1.2.1 Materials Development

An initial assessment was made of the thermodynamics of the stability of various ITM Syngas materials in the partial pressures of CO_2 and H_2O expected under process conditions. Initial experimental tests of stability were carried out by exposing samples to 100 psig of CO_2 at 850°C for seven days. SEM and XRD analysis indicated a variation in reactivity, with some materials remaining inert. Static atmosphere tests will be continued and the results correlated with thermodynamic predictions to select ITM Syngas materials that are stable at operating conditions.

Subtask 1.2.1.1 Materials Characterization and Assessment

At Eltron Research, construction of the six atmospheric pressure quartz test reactors continued. The first four reactors have been completed. The gas manifolds are currently being installed and the GCs are being set up. All the reactors and analytical equipment are expected to be completed within the next month. The atmospheric pressure reactor constructed at Air Products is also near completion.

Subtask 1.2.1.2 Powder Production and Test Sample Fabrication

Preparation of the tubular test samples continued at Ceramatec. A total of 24 tubes were iso-pressed during July. Twelve tubes were fired successfully and eight were He leak tight at room temperature after firing. Four tubes were finished successfully to specification in the seal region.

Subtask 1.2.1.3 Low DP (<300 psig) Testing

Construction of the hot-wall, 300-psig test reactors continued at Eltron. Specific components and states of completion are as follows:

1. Gas supply manifolds are now complete and ready for leak checking.
2. Surface mount panels are complete and ready for leak checking.
3. Solenoid panels are 85% complete, with some wiring remaining.
4. Furnaces and controllers have been mounted, wired and tested.
5. PLCs have been mounted and tested. The software is completed and ready for I/O wiring.
6. The air compressor has been installed, and filters and lines are 80% complete.
7. Water supply and condensate tanks are 80% complete and are ready for mounting.
8. Preheater coils, mantle and controllers are complete and ready for mounting.
9. The reactor vessels are 95% complete and ready for mounting.

Subtask 1.2.1.4 High DP (<500 psig) Testing

Construction of the gas handling system for the high-pressure reactor continued at Air Products. The end fittings and internals of the high-pressure reactor were redesigned to accommodate a catalyst container.

Task 1.2.2 Seals Development

Iso-pressed tubes were fitted with ceramic/metal seals at Ceramatec. Prior to insertion into the seals, an internal coating of catalyst was applied as a wash coat, and the outer surfaces of the tubes were coated with a catalyst by dip coating. Two of the completed tube/seal assemblies were delivered to Eltron Research on 31 July for use when the 300-psig reactors are finished. Next month, Air Products will provide Eltron with metallic sample blanks to use in 'shaking down' the two reactors before the ceramic samples are employed.

Task 1.3 ITM Syngas Reactor Design and Fabrication

Task 1.3.1 ITM Syngas Reactor Design and Engineering

Subtask 1.3.1.2 Reaction Engineering and Kinetic Modeling

Background literature for the reaction engineering and kinetic modeling task was supplied to Chevron.

Subtask 1.3.2.1 Powder Production, Process Development and Scale-up

Work continued at Ceramatec on scaling up the first of two powder compositions selected for powder production development. Calcined powder was found to react with water during the preparation of

batches for spray drying. The use of additives to control the pH was investigated, and a method of minimizing the reaction was demonstrated.