FY06-LV(55)-144

"Gasification of Lignites to Produce Liquid Fuels, Hydrogen, and Power"

Contractor: Energy & Environmental Research Center;
Principal Investigator: Steven A. Benson

PARTICIPANTS

Sponsor	Cost Share
TXU	$ 90,000
Great River Energy	$ 90,000
Rio Tinto Technical Services	90,000
DOE - NETL	$ 959,990
NDIC	$ 99,717
Total Cost	$ 1,059,977

Project Schedule - 2 Years

Contract Date – 1/4/06
Start Date – 1/4/06
Completion Date – ~~10/31/07~~
Extended to – 12/21/07

Project Deliverables

Contract Signed: 1/4/06
Quarterly Reports:
4/30/06(✓); 11/30/06(✓);
5/31/07(✓);
Final Report: ~~10/31/07 ( )~~
12/31/07 (✓)

OBJECTIVE / STATEMENT OF WORK:

Provide essential information on the impacts of moisture and inorganic impurities on gasifier and gas cleanup technology performance to support power generation and coal-to-liquid processes, addressing key technical challenges facing lignite by conducting small pilot-scale tests to determine cleanup issues of lignite derived syngas for particulate, trace elements, mercury, and sulfur removal as well as carbon dioxide and hydrogen separation for selected lignite(s). A larger-scale pilot transport reactor will be used to determine the impacts of impurities and moisture on advanced sulfur removal, hydrogen purification, and carbon dioxide separation processes.

STATUS

January 1 – June 30, 2006. A kickoff meeting was held on February 15, 2006 in which the project sponsors provided input as to the direction of the project and the specific coals to be characterized. Acquisition of sulfur catalyst/sorbent material was achieved and the conceptual design of the continuous fluidized-bed contactor for sulfur removal and hot-gas filter vessel was accomplished.

July 1 – September 30, 2006. Testing of acquired sorbents has begun using Fourier transform infrared analysis. Work progressed with evaluating ZnO and CuZnO sorbents for their ability to remove sulfur from a flue gas stream at temperatures between 32 and 400 degrees Centigrade. Attempts at acquiring other metal oxide-based materials are continuing. Construction of the sulfur removal reactor is progressing and testing is anticipated next quarter.

December 1 – May 31, 2007. Five of seven sponsor coals were received and characterized. Those five coals were also gasified in the continuous fluidized -bed reactor (CFBR) last quarter. Agglomeration issues were noted on three of the five coals. The remaining two coals were received

and characterized at the end of the reporting period. The gasification testing on those coals will occur in June. The transport reactor for sulfur removal was completed and put in place with the CFBR. Initial testing occurred on the transport reactor using two coals and two materials for sulfur sorbents. Additional testing will occur with commercial sorbents next reporting period. Funding for the entrained-flow gasifier was secured, and the first components have been ordered.

Final Report. The project team developed a concept for warm-gas cleanup and applied it to the EERC's 4-lb/hr continuous fluidized-bed gasifier (CFBR). A sulfur removal reactor was built that was based on a transport-style reactor concept. Seven coals were identified for testing in the gasifier based on sponsor input, including North Dakota fuels from the Freedom and Falkirk mines. Each of the fuels was characterized in detail, including proximate, ultimate, heating value, x-ray fluorescence, computer-controlled scanning electron microscopy, chemical fractionation, and trace metal analysis. Each of the seven fuels was first gasified in the CFBR with a focus on front-end gasification characteristics, including carbon conversion, syngas quality, and agglomeration potential. Detailed testing was then conducted on the sulfur removal process with each fuel. Final testing focused on mercury control, water-gas shift, and hydrogen separation.

The results of the lignite gasification testing indicated that high carbon conversion efficiencies can be achieved for lignite coals at low gasification temperatures. Most of the fuels would have benefited from a solids recirculation loop from the primary cyclone. Agglomeration is a problem for some coals under either oxygen-blown or air-blown conditions. Agglomeration issues can be mitigated by the use of alternative bed materials such as bauxite or gettering agents such as kaolin. For some fuels, dolomite addition can increase the potential for agglomerates to form, so care must be taken when dolomite is considered for use as an in-bed sulfur sorbent. The effect of sodium on agglomeration potential is very significant when temperature–viscosity curves between the fuels are compared. Both the Spring Creek and Freedom coals exhibited a much higher potential for agglomeration because of their high sodium content. Greater than 99.9% sulfur capture at warm-gas temperatures is achievable using a combination of a transport reactor sorbent followed by a pack bed polishing sorbent. Both the high-temperature shift and low-temperature shift catalyst beds were successful at increasing the H_2 to CO ratio. The high-temperature shift increased the ratio to as high as 5.5. Addition of the low-temperature shift downstream of the high-temperature shift increased the H_2 to CO ratio to as high as 23, with CO concentration as low as 0.8%. Hydrogen separation at elevated temperatures was tested using an experimental hydrogen separation membrane. The membrane had a significant leak and, therefore, did not produce a high-purity hydrogen in the permeate stream. Mercury control at 400°F was tested using three sorbents. The two carbon-based sorbents did not perform well, whereas a metal-based sorbent was shown to remove 95% of the mercury from the syngas at elevated temperatures.

The results of this project provide the base-level research needed to develop commercial lignite gasification projects in the state of North Dakota. As a result of the project, coal mines and users have increased potential to develop gasification projects using North Dakota lignite.