DOE/PC/91034--T19

The Economical Production of Alcohol Fuels from Coal-Derived Synthesis Gas

Case Studies, Design, and Economics

Contract # DE-AC22-91PC91034

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October 1995

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Executive Summary

This project is a combination of process simulation and catalyst development aimed at identifying the most economical method for converting coal to syngas to linear higher alcohols to be used as oxygenated fuel additives. There are two tasks. The goal of Task 1 is to discover, study, and evaluate novel heterogeneous catalytic systems for the production of oxygenated fuel enhancers from synthesis gas, and to explore, analytically and on the bench scale, novel reactor and process concepts for use in converting syngas to liquid fuel products. The goal of Task 2 is to simulate, by computer, energy efficient and economically efficient processes for converting coal to energy (fuel alcohols and/or power). This report contains results from Task 2.

The first step for Task 2 was to develop computer simulations of alternative coal to syngas to linear higher alcohol processes, to evaluate and compare the economics and energy efficiency of these alternative processes, and to make a preliminary determination as to the most attractive process configuration. Seven cases were developed using different gasifier technologies, different methods for altering the H_2/CO ratio of the syngas to the desired 1.1/1, and with the higher alcohols as the primary product and as a by-product of a power generation facility. Texaco, Shell, and Lurgi gasifiers were used as to gasify coal, and steam reforming of natural gas, sour gas shift conversion, or pressure swing adsorption was used to alter the H_2/CO ratio of the syngas. In addition, a case using only natural gas was prepared in order to facilitate comparison between coal and natural gas as a source of syngas.

There are significant differences among the production costs for processes converting coal to syngas to higher alcohol fuel additives for cases involving Texaco, Lurgi, and Shell gasifiers, between cases involving natural gas reforming or sour gas shift conversion to alter the H_2/CO ratio, and for different plant capacities. The best case, on the basis of manufacturing cost, is one of the hybrids, a Shell gasifier with natural gas.

Production of 5.1 billion liters/yr (32 MM bbl/yr) of alcohol fuels from coal is considered the maximum feasible process scale. As expected, there are economies of scale favoring larger-scale over smaller-scale processes. However, resource and marketing constraints limit the maximum scale at which a plant could be constructed.

Production of higher alcohol fuel additives from natural gas is more economical, for the next 20 years, than production from coal at any scale at current or predicted (by DOE) natural gas prices. Production of higher alcohol fuel additives from coal and natural gas hybrids is more economical than production from natural gas at West Virginia natural gas prices ($3.00/MM BTU). The break even natural gas price for production of higher alcohols by natural gas versus the Shell gasifier/natural gas hybrid is $2.45/MM BTU. Furthermore, if a plant life of 10 years were used, which is more typical in the chemical process industry, then all of the manufacturing costs for the cases using coal gasification will increase, making natural gas the clearly superior option.

Capital and operating costs are estimated on the basis of conventional technology, equipment, processes, and environmental controls. Thus, it is possible that future emission control requirements could significantly increase capital and operating costs of all coal-based processes described.

The manufacturing cost of the alcohol derived from natural gas is highly dependent on the natural gas price. Capital costs are lower for natural gas cases than for coal-based cases. Therefore, raw material costs for the natural gas cases are a larger portion of the total annualized cost.

If the cost of natural gas exceeds $2.45/MM BTU, the coal/natural gas hybrid (Shell gasifier) is more economical than the natural gas only design. If the cost of natural gas exceeds $4.94/MM BTU, the all coal design (Shell gasifier) is more economical than the hybrid. This is primarily a result of the high capital investment for the gasifier and accompanying cryogenic oxygen plant. This higher investment outweighs the benefit of using coal, which is a cheaper raw material. The only way for coal based processes to be more competitive than natural gas under all conditions is either for the relative price of coal and natural gas to change or for a major development to occur in coal gasification technology. Price variations would have greater impact on the natural gas reference cases, since raw material costs for these cases are a larger portion of the total annualized cost. Therefore, the competitiveness of the coal-based cases would be enhanced more by increases in the price of natural gas than by decreases in coal cost.

The most energy efficient design, by wide margin, uses only natural gas. If pollution credits based on CO_2 or other combustion products are obtainable in the future, this process will benefit relative to the coal cases. The major question is whether an increase in natural gas prices would be completely offset by any potential gains realized by pollution credits.

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