EPRI PERSPECTIVE

PROJECT DESCRIPTION

Several processing schemes for the production of fuel-grade methanol from coal have been evaluated for EPRI. The ongoing engineering evaluation effort is being conducted in the following directions:

1. Evaluation of methanol production schemes incorporating only commercially proven, first-generation processes

2. Evaluation of methanol production schemes incorporating new, second-generation processes under development

An analysis of distillate fuel market trends led to the conclusion that the first large-scale coal-derived methanol plants will be based on first-generation processes; this was concluded because the market conditions for fuel-grade methanol will probably become favorable prior to second-generation processes becoming ready for commercialization.

An earlier study (RP832-3), therefore, focused on the evaluation of producing methanol as the sole product from lignite, incorporating only commercially proven processes: the Winkler technology for gasification and the Imperial Chemical Industries, Ltd., (ICI) process for methanol synthesis. It is also possible to utilize the Winkler and ICI technologies in a methanol and electric power cogeneration scheme with lignite; this scheme may be the subject of future evaluation. Lignite was the feedstock for these studies for two reasons: (1) the higher oxygen content of lignite makes it a more suitable feedstock for gasification and less attractive for liquefaction by direct hydrogenation and (2) the lower selling price of lignite partially compensates for the lower thermal efficiency of the first-generation Winkler gasification process.

The only other commercially available scheme to produce methanol from lignite utilizes Lurgi technology, incorporating their dry-bottom gasification process and the isothermal methanol synthesis. Because of the high methane content in the synthesis gas generated in the Lurgi gasifier, it is evident that the most attractive use of this route will occur when methanol is coproduced with substitute natural gas or electric power. An all-methanol production scheme via the Lurgi route is also feasible, but it will be far more complex and will require steam-methane reforming of the purge gas to convert the methane into synthesis gas. Such a processing scheme would also be worthy of consideration.

There are several second-generation coal gasification processes at various stages of a development. The four most advanced and promising coal gasification processes are (1) the Texaco entrained-bed gasifier, (2) the Shell-Koppers entrained-bed gasifier, (3) the British Gas Corporation (BGC)-Lurgi moving-bed slagging gasifier, and (4) the high-temperature Winkler fluidized-bed gasifiers. There is also an ongoing development on a new methanol-synthesis process, the Liquid-Phase Methanol synthesis. Although in an earlier stage of development, the latter process coupled with the Texaco gasification process constituted the backbone of two processing schemes that were investigated earlier for the conversion of bituminous coal (1) in an all-methanol production scheme (RP832-1) and (2) in a methanol and electric power cogeneration scheme (RP239, Task 15). In addition, the coproduction of methanol and distillate fuel oil from subbituminous coal was also investigated (RP832-1) via the Clean Distillate Fuels route incorporating new processes under development: (1) coal skimming in a solvent-refined coal (SRC-I) type of thermal liquefaction step coproducing distillate fuels with liquefaction residue, (2) gasification of liquefaction residue in the Texaco residue gasification process, and (3) conversion of the synthesis gas to methanol in the Liquid-Phase Methanol-synthesis process. The results of these studies confirmed that the successful development of a pressurized gasification process will have a substantial, positive impact on the overall efficiency of the coal-to-methanol processing routes. The development of the Liquid-Phase Methanol-synthesis process will have a positive impact on the methanol and electric power cogeneration schemes because the special features (higher synthesis gas conversion per pass and the ability to process gases with low H_2/CO ratio) claimed for this process make it especially attractive for the cogeneration scheme.

The present study (RP832-4) focuses on an all-methanol production scheme from coal, incorporating the second-generation Texaco water-slurry gasification process and the commercially available ICI methanol synthesis and using Illinois No. 6 coal.

PROJECT OBJECTIVES

Two principal objectives have been pursued in this project:

1. To develop a conceptual design, capital requirements, and product costs for a grass roots coal-to-methanol complex in an all-methanol

production scheme, incorporating the best gasification process under development

2. To provide the information required to adequately compare the coal-to-methanol route at its best performance with the emerging direct liquefaction routes, in particular, the H-Coal process which was comparably evaluated in RP411-4

Among the promising second-generation gasification processes under development, the water-slurry-fed, entrained-bed Texaco coal gasification process was chosen. This process is the most attractive for the production of synthesis gas from low-equilibrium-moisture bituminous coal because of the following three special features:

1. The operating pressure is high enough to provide the makeup synthesis gas at the methanol-synthesis loop pressure (750 psig), thereby eliminating the need for a makeup gas compressor.

2. The methane content in the synthesis gas is low, thereby reducing the amount of purge gas required to control the inert gas buildup in the synthesis loop.

3. The H_2/CO ratio in the gasifier effluent is relatively high, thereby reducing the amount of additional shift.

The ICI methanol synthesis, one of the two leading commercial methanol-synthesis processes, was arbitrarily chosen for this study for convenience. Therefore, any selection of a specific methanol-synthesis process for a commercial venture should be based on a comparative evaluation of both the ICI and Lurgi methanol-synthesis processes.

PROJECT RESULTS

The study confirmed that the thermal efficiency of the coal-to-methanol route will improve dramatically as the result of the successful development of the Texaco water-slurry gasification process and its incorporation into an all-methanol production scheme from bituminous coal. To achieve high thermal efficiencies, it is essential that a high-temperature heat recovery system also be successfully developed. For lower rank coals (subbituminous and lignites) having a high-equilibrium moisture content, the water-slurry-fed Texaco coal gasification process would be less attractive because of the additional thermal penalty associated with the lower solids concentration in the water slurries prepared from these feedstocks. It appears, therefore, that the other second-generation processes being developed with a solid feed system would be more appropriate for the gasification of lignites and subbituminous coals, despite their lower operating pressure.

The following are the major technical and economic results derived from this study:

- Thermal efficiency, % higher heating value (HHV) — 57.8
- Methanol produced
  - --Tons per day — 10,927
  - --Fuel oil equivalent barrels per day (FOE BPD) — 33,860
- Specific investment $/FOE BPD — 42,793
- Product cost, $/MM Btu (HHV)
  - --Levelized for 30-year operation including 6% annual rate of inflation on operation and maintenance cost items — 8.88
  - --First year of operation — 4.71

These product costs were calculated utilizing EPRI's Economic Premises for Fuel Conversion Plants (June 1978).

In addition, the required selling price of methanol was also calculated by EPRI's Engineering and Economic Evaluation Program using discounted cash flow methodology. The detailed calculations, together with the economic premises, are presented in the Appendix attached to this report. The two venture cases considered are (1) non-regulated producer with 100% common-equity capital and (2) regulated utility producer with 50% debt capital and a 12.25%-per-year interest on debt.

The required selling prices (RSP) of methanol, expressed in levelized mid-1980 dollars, are given below:

		RSP in Mid-1980 ($/MM Btu [HHV])
1.	For a nonregulated producer	7.51
2.	For a regulated utility producer	4.87

For comparison, the price of petroleum-derived fuels from an imported crude oil priced in mid-1980 at $38/barrel would be 8.17 $/MM Btu. Thus, methanol from coal has an excellent potential for becoming competitive with the petroleum-derived distillate fuels.

This study, together with the results from the previous studies published under RP832-3 and RP411-4, also provides the opportunity to compare the indirect liquefaction route of producing fuel-grade methanol with the direct liquefaction route of producing distillate fuels via the H-Coal process.

COMPARISON OF DIRECT AND INDIRECT LIQUEFACTION ROUTES

	Fuel Grade Methanol by Indirect Liquefaction		Distillate Fuels by Direct Liquefaction via H-Coal	
1 Coal feedstock	Lignite North Dakota	Bituminous Illinois No. 6	Bituminous Illinois No. 6	Subbituminous Wyodak
Moisture content as received (wt%)	35.20	11.07	11.05	[illegible]
Oxygen in MF coal (wt%)	17.34	6.86	[illegible]	[illegible]
Ash in MF coal (wt%)	9.87	[illegible]	[illegible]	7.88
Feed rate as received (TPD)	47,777	18,234	[illegible]	20,940
Priced at $/MM Btu (HHV)	0.5	[illegible]	[illegible]	[illegible]
2 Products (FOE BPD)	46,490	33,667	[illegible]	[illegible]
including LPG (TPD)			[illegible]	
Raw naphtha (TPD)			[illegible]	[illegible]
S (wt%)			[illegible]	[illegible]
N (wt%)			[illegible]	[illegible]
O (wt%)			[illegible]	[illegible]
Middle distillate (TPD)			2,676	1,922
S (wt%)			[illegible]	0.03
N (wt%)			0.52	0.22
O (wt%)			[illegible]	[illegible]
Boiler fuel (TPD)			1,590	[illegible]
S (wt%)			[illegible]	[illegible]
N (wt%)			[illegible]	[illegible]
O (wt%)			[illegible]	[illegible]
Methanol (TPD)	15,[illegible]	10,927		
S (wt%)				
N (wt%)				
O (wt%)	50	50		
3 Thermal efficiency, % HHV	47.4	57.8	70.7	62.0
4 Specific investment (1979) $/FOE BPD	41,127	42,79[illegible]	32,53[illegible]	46,509
5 Product upgrading	Not required	Not required	Required	Required
6 Product cost $/MM Btu (HHV) calculated for utility financing using EPRI's economic premises				
Levelized for 30 years of operation, including a 6% annual rate of inflation on operation and maintenance cost items	7.72	8.88	7.66	8.33
First year of operation	4.10	4.71	4.06	4.42

The comparative information is provided above. In the case of bituminous coals, the comparative evaluation indicates a definite advantage for the direct liquefaction route. For lower rank coals (subbituminous or lignites), the competitive edge of the direct liquefaction route is greatly reduced, and the incentives would disappear if severe product upgrading were required for the direct liquefaction products.

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