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# Wet Methanation Evaluation

## Final Report

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# WET METHANATION EVALUATION

October 9, 1973

SUMMARY Part of the evaluation work on methanation processes is to identify those processes that show commercial promise and to recommend further development work where justified. The evaluation report on wet methanation is as follows.

In an initial review of methanation, the economics of three fixed bed processes were compared. These were the recycle, the cold quench and the combined recycle and cold quench. It was concluded that the recycle is the least attractive. The cold quench is about a stand-off with the combined process.

In the present study, the economics of the combined process have been updated for use as a reference for comparison against wet methanation. The study shows that for an 80 MMSCFD gasification plant, wet methanation requires about $3,600,000 more capital investment and $620,000 per year more operating costs than the combined process. It was concluded that the addition of wet methanation to the research program is not justified at this time. It will be reconsidered if some particular circumstance develops which indicates an advantage for wet methanation which is not apparent at this stage of process development.

PROCESS DESCRIPTION The basis for the comparison of wet methanation with the combined recycle and cold quench methanation is an 80 MMSCFD plant.

Simplified process flow diagrams for both processes are attached for reference. For this discussion, wet methanation is considered as any process where steam is used to limit the temperature rise across the methanator.

The potential advantages of wet methanation over combined recycle and cold quench are that it is simpler to operate and less likely to deposit carbon. The operation of wet methanation is simpler because feed distribution between reactors is not required. Carbon deposition is less likely to occur in the presence of large quantity of steam. A brief description of both processes is given below.

The wet methanation process consists of two fixed beds in series, with associated heat recovery equipment.

High pressure steam (1250 psig) is used to dilute the fresh feed carbon oxides to the first reactor to about 5.3 volume percent to control the temperature rise. Most of the water leaving the first reactor is condensed. Recycled product gas is used for dilution to control the temperature rise in the second reactor. If steam were used in place of the recycled gas for temperature rise control, then a third reactor would be required in order to meet the product specifications. This is because steam makes the equilibrium less favorable for methanation.

The combined process consists of four reactors in series plus the tail end heat recovery equipment. Temperature rise control is by recycled product gas and feed distribution.

BASIS AND ASSUMPTIONS This study is based on a capacity of 80 MMSCFD product gas. The same feed rate, feed conditions, equipment sizing methods and data, utility data and cost estimating techniques have been used for both processes. The reactor space velocity is assumed to be the same for both processes. The feed is at 100° F, 1055 psia and contains about 16 volume percent carbon oxides. The pipeline quality product gas is delivered at 100° F and 1055 psia.

OPERATING REQUIREMENT The utility requirements for the wet methanation process have been estimated based on the equipment shown in the process flow diagram. Utility requirement for the combined process was taken from the initial review.

| | | COMBINED PROCESS | WET METHANATION |
|---|---|---|---|
| Steam use | | | |
| 1250 psig sat'd | lb/hr | - | 449,100 |
| 250 psig 456° F | lb/hr | 50,600 | 47,100 |
| Steam make | | | |
| 250 psig sat'd | lb/hr | 151,000 | 398,300 |
| 50 psig sat'd | lb/hr | 83,300 | 240,600 |
| BFW | gpm | 400 | 1,220 |
| Electric power | Kw | 180 | 130 |
| Cooling water | gpm | 400 | 720 |
| Process condensate make | gpm | 100 | 1,000 |

COST COMPARISON The total value of capital equipment is based on today's installed cost. Factors are applied to engineered equipment costs to arrive at the total installed costs. The utility unit costs are as follows.

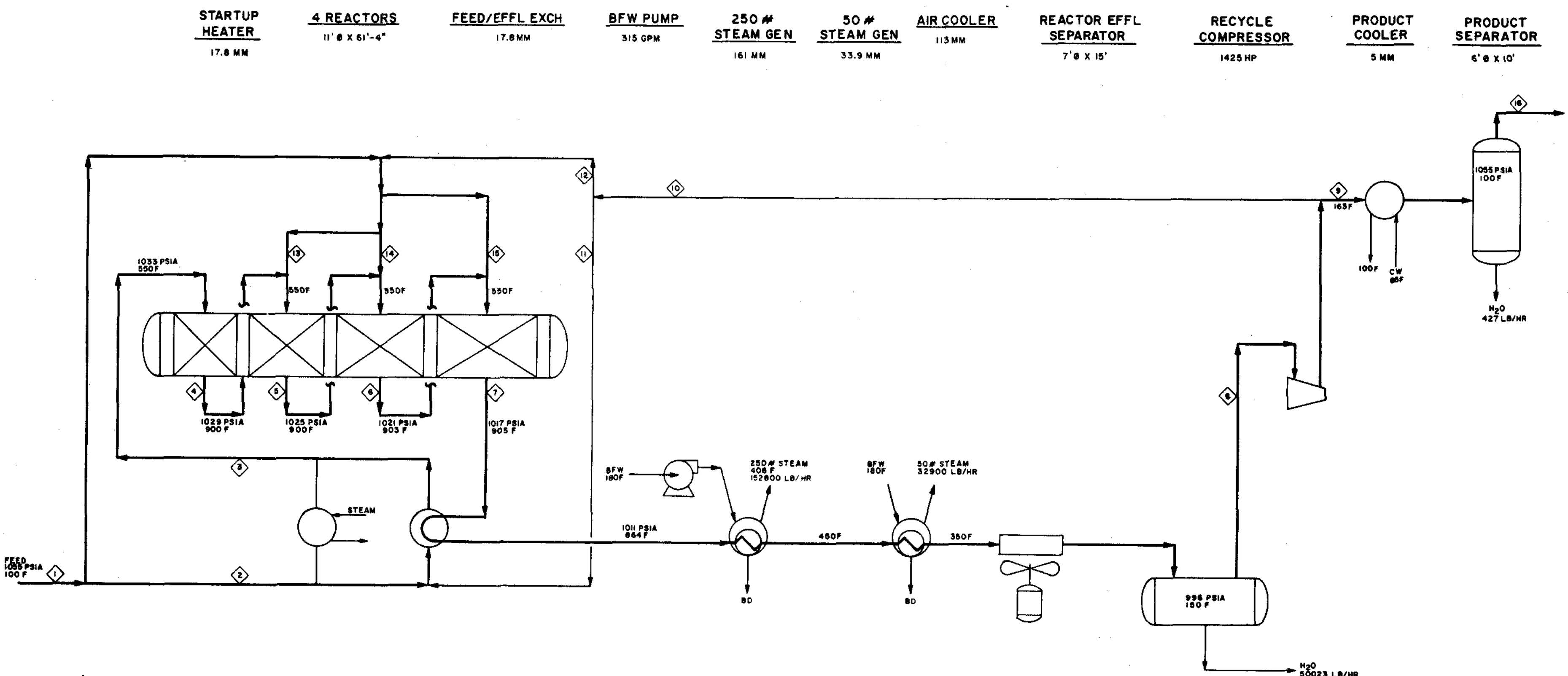
| | |
|---|---|
| Steam, 1250 psig sat'd | \$0.65 per 1000 pounds |
| 250 psig 465° F | \$0.55 per 1000 pounds |
| 250 psig sat'd | \$0.52 per 1000 pounds |
| 50 psig sat'd | \$0.50 per 1000 pounds |
| Boiler feedwater | \$0.55 per 1000 gallons |
| Process condensate | \$0.60 per 1000 gallons |
| Cooling water | \$0.015 per 1000 gallons |
| Electric power | \$0.008 per kilowatt-hour |

The relative rough capital and yearly operating costs are summarized below.

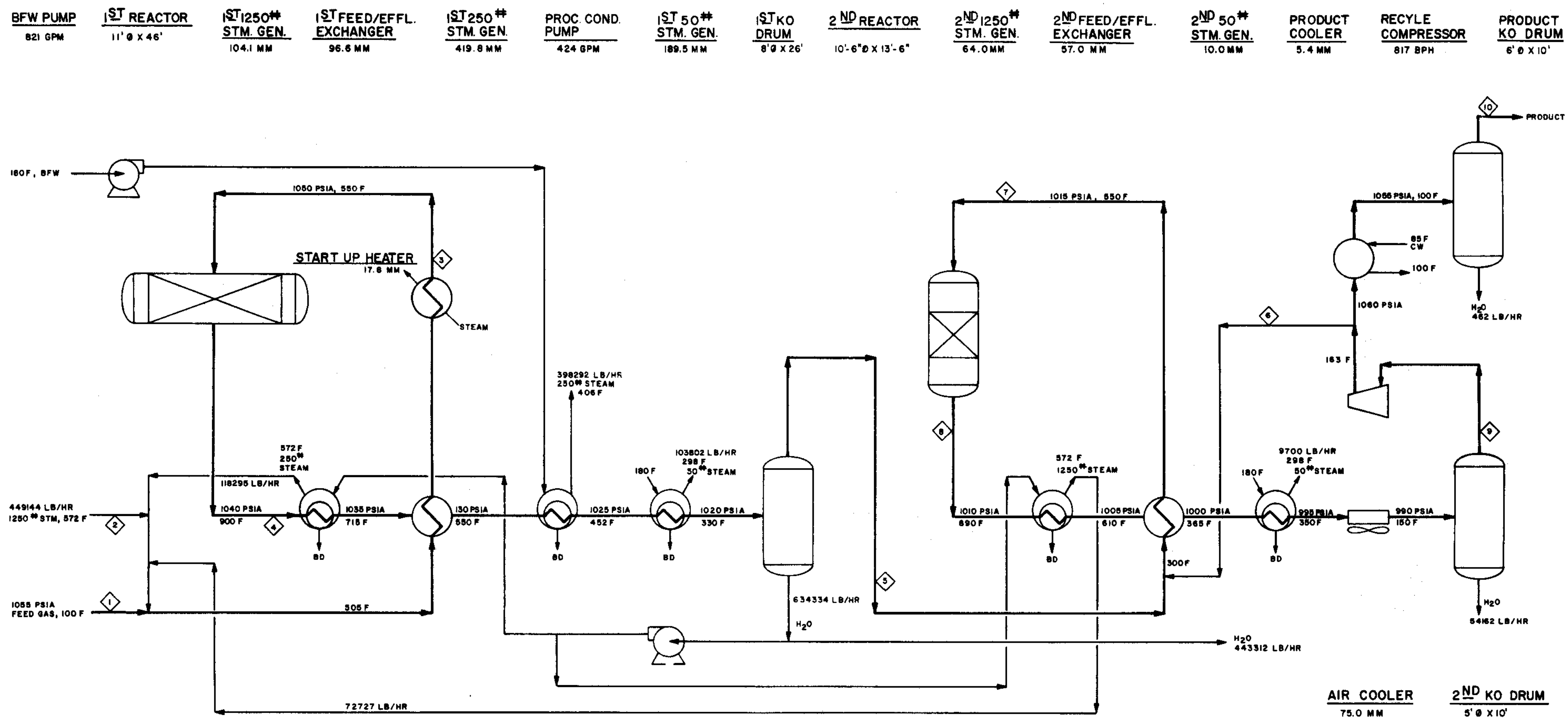
| | COMBINED PROCESS | WET METHANATION |
|---|---|---|
| Capital | Base | + \$3,600,000 |
| Operating costs per year | Base | + 620,000 |

The higher capital and operating costs of the wet methanation process are attributed to the addition of steam to the first reactor. The savings in compressor costs do not offset the incremental costs of steam addition.

RECOMMENDATION Based on the results of this study, it is recommended that no further investigation of the wet methanation process be done as part of the research program. It is believed that research and development will not improve the economics sufficiently to make it competitive. Should operational problems, such as carbon deposition, develop with the more attractive methanation schemes being studied during the testing program, consideration of wet methanation may again be undertaken.




| DESCRIPTION / STREAMS | (1) TOTAL FRESH FEED | (2) FRESH FEED TO 1ST REACT | (3) 1ST REACTOR FEED | (4) 1ST REACTOR EFFL | (5) 2ND REACT. EFFL | (6) 3RD REACT. EFFL | (7) 4TH REACT EFFL | (8) SEPARATOR OFF GAS | (9) PROD. FROM COMPRESS | (10) RECYCLE | (11) 1ST REACT. RECYCLE | (12) OTHER REACT RECYCLE | (13) FEED+RECY. TO 2ND REACT | (14) FEED+RECY TO 3RD REACT | (15) FEED+RECY TO 4TH REACT | (16) PRODUCT GAS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COMPONENTS MPH | | | | | | | | | | | | | | | | |
| MW | | | | | | | | | | | | | | | | |
| $C_2H_6$ 30 | 32.4 | 2.2 | 2.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4.3 | 8.6 | 17.3 | 0 |
| $CH_3OH$ 32 | 0.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.2 | 0.3 | 0 |
| $CO_2$ 44 | 25.6 | 1.7 | 5.4 | 1.3 | 5.4 | 14.4 | 32.5 | 325 | 95 | 23.0 | 3.7 | 19.3 | 6.2 | 12.3 | 24.7 | 9.5 |
| CO 28 | 2776.8 | 186.1 | 185.7 | 0.4 | 1.0 | 2.3 | 4.8 | 4.8 | 1.4 | 3.4 | 0.6 | 2.8 | 370.6 | 741.3 | 1482.6 | 1.4 |
| $H_2$ 2 | 9123.4 | 606.2 | 869.7 | 295.2 | 582.0 | 1159.2 | 2313.3 | 2313.3 | 699.8 | 1613.5 | 261.5 | 1352.0 | 1409.6 | 2819.2 | 5638.4 | 699.8 |
| $CH_4$ 16 | 5195.4 | 346.4 | 3346.4 | 3540.2 | 6828.0 | 13402.7 | 26552.3 | 26549.3 | 8049.3 | 18500.0 | 3000.0 | 15500.0 | 2907.0 | 5814.0 | 11628.0 | 8049.3 |
| $H_2O$ 18 | - | - | 12.1 | 205.8 | 588.9 | 1353.6 | 2883.0 | 109.1 | 34.3 | 74.8 | 12.1 | 62.7 | 9.0 | 17.9 | 35.8 | 10.6 |
| TOTAL MPH | 17154.2 | 1143.6 | 4421.5 | 4042.7 | 8005.3 | 15932.2 | 31785.9 | 29009.0 | 8794.3 | 20214.7 | 3277.9 | 16936.8 | 4706.8 | 9413.5 | 18827.1 | 8770.6 |
| TOTAL LB/HR | 161636 | 12109 | 61160 | 61160 | 121584 | 242428 | 484121 | 434098 | 131613 | 302485 | 49051 | 253434 | 60424 | 120844 | 241693 | 131186 |
| MMSCFD | 158.2 | 10.4 | 40.3 | 36.8 | 72.9 | 145.1 | 289.5 | 264.2 | 80.1 | 184.1 | 29.9 | 154.3 | 42.9 | 85.7 | 171.6 | 79.9 |




| DESCRIPTION / STREAMS | | 1 FEED GAS | 2 1250# STEAM | 3 1ST REACTOR FEED | 4 1ST REACTOR EFFLUENT | 5 1ST KO DRUM EFFLUENT | 6 RECYCLE | 7 2ND REACTOR FEED | 8 2ND REACTOR EFFLUENT | 9 2ND KO DRUM EFFLUENT | 10 PRODUCT GAS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COMPONENTS | MPH | | | | | | | | | | |
| | MW | | | | | | | | | | |
| $C_2H_6$ | 30 | 32.4 | – | 32.4 | – | – | – | – | – | – | – |
| $CH_3OH$ | 32 | 0.6 | – | 0.6 | – | – | – | – | – | – | – |
| $CO_2$ | 44 | 25.6 | – | 25.6 | 874.9 | 874.9 | 41.5 | 916.4 | 93.2 | 93.2 | 51.7 |
| CO | 28 | 2776.8 | – | 2776.8 | 22.1 | 22.1 | 4.5 | 26.6 | 10.2 | 10.2 | 5.7 |
| $H_2$ | 2 | 9123.4 | – | 9123.4 | 4224.1 | 4224.1 | 707.5 | 4931.6 | 1590.6 | 1590.6 | 883.1 |
| $CH_4$ | 16 | 5195.4 | – | 5195.4 | 7165.6 | 7165.6 | 6412.8 | 13578.0 | 14418.0 | 14418.0 | 8005.2 |
| $H_2O$ | 18 | – | 24952.4 | 36564.8 | 36620.9 | 1380.0 | 27 | 1407.0 | 3069.9 | 60.7 | 8.1 |
| | | | | | | | | | | | |
| TOTAL | MPH | 17154.2 | 24952.4 | 52719.0 | 48907.6 | 13666.7 | 7193.3 | 20860.0 | 19181.9 | 16172.7 | 8953.8 |
| | | | | | | | | | | | |
| TOTAL | LB/HR | 181221 | 449144 | 821387 | 821387 | 187053 | 106457 | 293510 | 293510 | 239348 | 132429 |
| | | | | | | | | | | | |
| MMSCFD | | 156.2 | 227.3 | 475.1 | 445.5 | 124.5 | 65.5 | 190.0 | 174.7 | 147.3 | 81.6 |