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Status of the 100 B/D Fluid-Bed Methanol-to Gasoline (MTG) Project

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by

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Summary

This paper briefly reviews the status of the fluid-bed MTG project which is jointly undertaken by URBK and Uhde, both of Germany, and Mobil. US DOE and German BMFT (our DOE equivalent) provide financial support.

Introduction

The discovery of a new class of shape selective zeolite catalyst, namely ZSM-5, has provided the basis for an efficient process for converting methanol to high octane gasoline. Recognizing that methanol can be produced from coal and natural gas using well established commercial technology, Mobil undertook the development of the Methanol-to-Gasoline (MTG) Process. It provides the first new route in 40 years for the production of premium transportation fuel from non-petroleum sources (Figure 1). Synthesis gas (CO and H_2) derived from coal by gasification, or from natural gas by steam reforming, is readily synthesized into methanol, which is then converted to mostly gasoline by the MTG Process.

A schematic drawing of the ZSM-5 channel structure is shown in Figure 2. There are two types of channels which intersect each other: elliptical 10-membered ring straight channels and sinusoidal, tortuous channels. The size of these channels permits only molecules of certain sizes to penetrate or exit. Consequently, the reaction products exhibit a high selectivity of gasoline; virtually no molecules with a carbon number higher than ten are produced.

MTG reactions are highly exothermic. The heat of reaction is estimated to be about 740 Btu per pound of methanol converted (Figure 3). Unless this heat is promptly removed, the catalyst temperature could rise by as much as 1100°F. Therefore, heat removal was one of the major considerations in the process design. Two modes of operation have been developed: fixed-bed process and fluid-bed process. In the fixed-bed process, the reaction heat is removed by recycle of light gas product, whereas cooling tubes are used in the fluid-bed system (Figure 4).

Status of Fixed-Bed MTG (Figure 5)

The Fixed-Bed MTG Process is ready for commercial application. A commercial size plant capable of producing 13,000 BPD of gasoline is

under design for construction in New Zealand. This venture is a joint effort by the New Zealand Government and Mobil. When completed the plant will supply one-third of New Zealand's gasoline needs from its indigenous natural gas resource (Maui Field). The plant will be a grass-root, totally integrated facility projected to start up in 1984-1985.

Fluid vs Fixed

Potential advantages of the fluid-bed process are (Figure 6):

- Higher gasoline yield from steady state operation
- Easy temperature control and heat removal
- Minimal recycle required and hence lower operating cost.

To fully exploit the merits of the fluid-bed process, it was decided to scale-up to a 100 BPD semi-works plant. Our strategy in the past few years has been to pursue both routes: conducting further R&D on the fluid-bed while at the same time proceeding with commercialization of the fixed-bed process.

Status of Fluid-Bed MTG (Figure 7)

The Fluid-Bed MTG process is currently in its final stage of engineering development. A program is underway to design, construct, and operate a 100 BPD pilot plant (Figure 8). This $35 million, 5-1/2 year program is an international venture jointly supported by the Bundesminister fur Forschung und Technologie (BMFT) of the Federal Republic of Germany (FRG) and the U.S. Department of Energy (DOE). The cost-sharing industrial participants are Union Rheinische Braunkohlen Kraftstoff AG (URBK), Uhde GmbH, both of FRG, and Mobil. The pilot plant will be located on a site provided by URBK in Wesseling, FRG. URBK is acting as the Operating Agent for the program. Uhde is responsible for engineering design. Mobil contributes the process technology, catalyst, and guidance in all aspects of the program.

The major technical tasks of this program are:

- Cold Flow Model (CFM) Studies
- Pilot Plant Design and Construction
- Pilot Plant Operation
- Product Evaluation
- Conceptual Design of a Commercial Fluid-Bed MTG Plant

Figure 9 shows the program schedule. The CFM studies are well underway and the pilot plant design is complete. Construction will begin in mid-1981 and startup is targeted for late 1982. A 21-month operating period is planned. The product testing will be carried out both in Germany and the U.S. The program will culminate in a conceptual design of a commercial size fluid-bed MTG plant.

A simplified flow diagram of the German plant is shown in Figure 10. The reactor, cooler, and regenerator section is exactly the same as the cold flow model. Commercial grade methanol from the Wesseling plant is mixed with boiler feed water to simulate crude methanol. The reactor effluent is further cleaned up in a wet scrubber, and then condensed and separated. The hydrocarbons are sent to a debutanizer to produce stabilized gasoline. The waste water is sent to the existing treatment facilities.

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Figure 1

MOBIL METHANOL-TO-GASOLINE (MTG) PROCESS

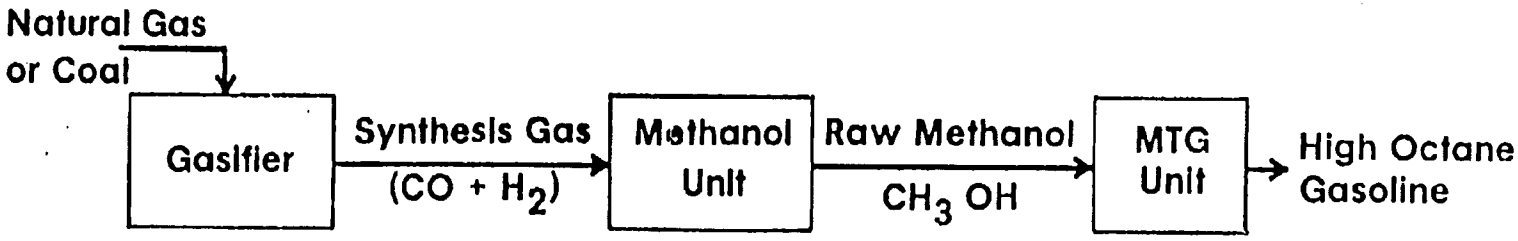
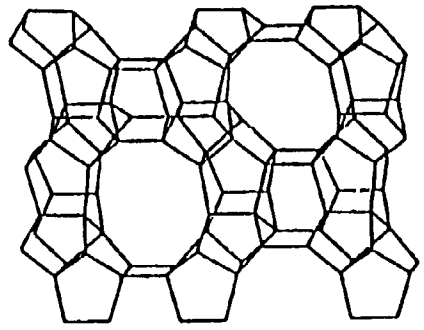


Figure 2

ZSM-5 STRUCTURE



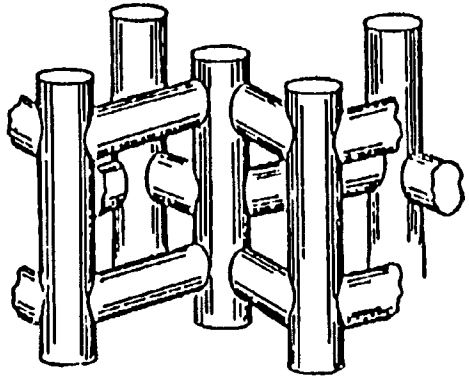


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Figure 3

METHANOL TO GASOLINE REACTION IS EXOTHERMIC

- Reaction Heat is About 750 Btu/Lb Methanol (1.74 MJ/Kg)
- Adiabatic Temperature Rise is About 1100°F (590°C)

Figure 4

VARIANTS OF MOBIL PROCESS

- Fixed Bed Reactor

  Temperature Control by
  Recycle of Light Product Gas

- Fluid Bed Reactor

  Heat Removal by Internal or
  External Cooling Tubes

Figure 5

STATUS OF FIXED-BED PROCESS

- Completed Development in Bench-scale Unit
- Completed Long-Term Catalyst Aging Tests
- Demonstrated in 4 B/D Plant
- Commercial Applications Underway
  (e.g., New Zealand, Grace)

Figure 6

WHY FLUID-BED MTG TECHNOLOGY?

- Potentially Higher Gasoline Yield (85% vs. 89%)
- Better Thermal Efficiency
- No Recycle
- Better Suited for Very Large Plants (>50,000 B/D)

- Needs Extensive Scale-Up Studies
- Requires Catalyst Development

Figure 7

STATUS OF FLUID-BED MTG

- Developed in Bench-Scale Unit
- Demonstrated in 4 B/D Unit
- 100 B/D Semi-Works Plant Being Built in Germany

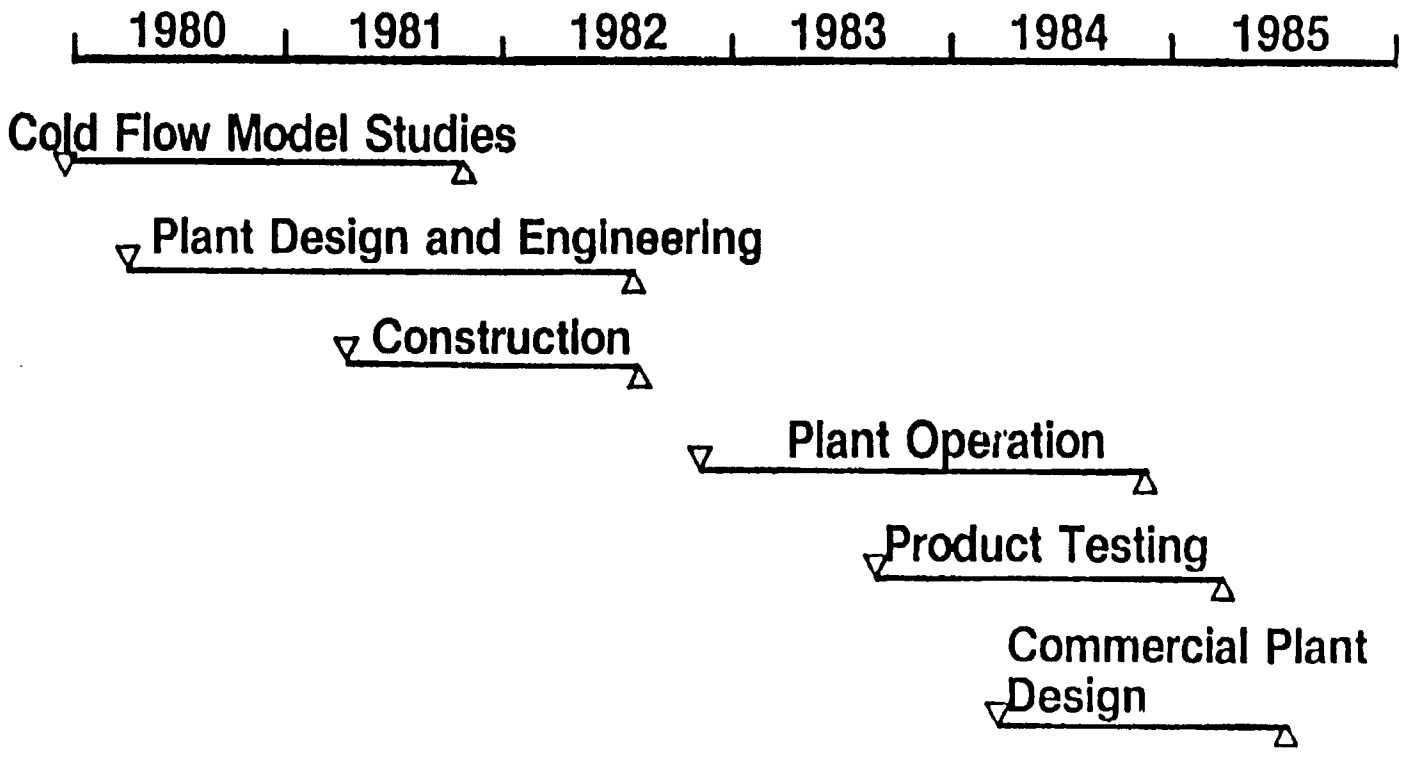
Figure 8

100 B/D FLUID-BED MTG PROJECT

- Demonstrate Commercial Feasibility of Fluid-Bed MTG
- Build a 2′ ID x 40′ High Reactor in Germany and Operate for 2 years
- Five Year (1980-1985), 63 Million DM Program
- US DOE, German DOE, URBK, Uhde, Mobil

Figure 9

100 B/D FLUID-BED MTG PROGRAM



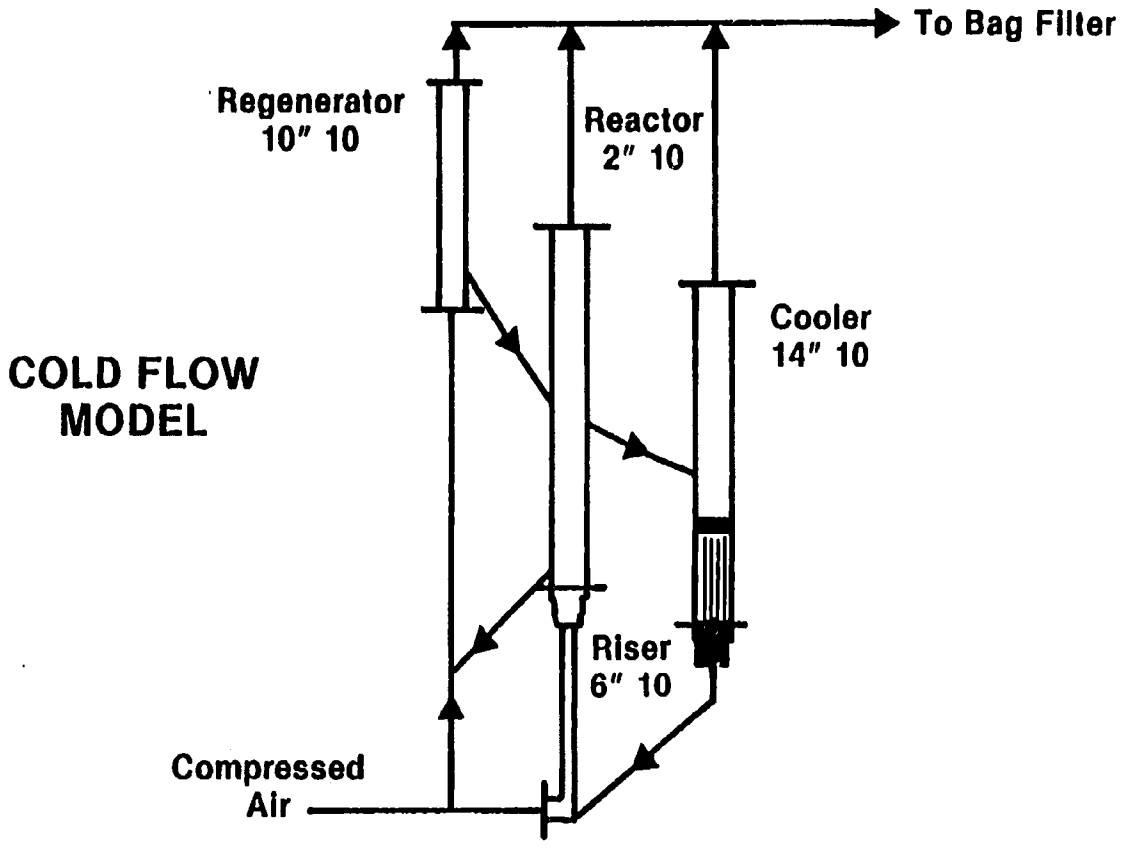

To Bag Filter
Regenerator
10" 10
Reactor
2" 10
Cooler
14" 10
COLD FLOW
MODEL
Riser
6" 10
Compressed
Air

Figure 10

100 B/D FLUID-BED MTG PLANT

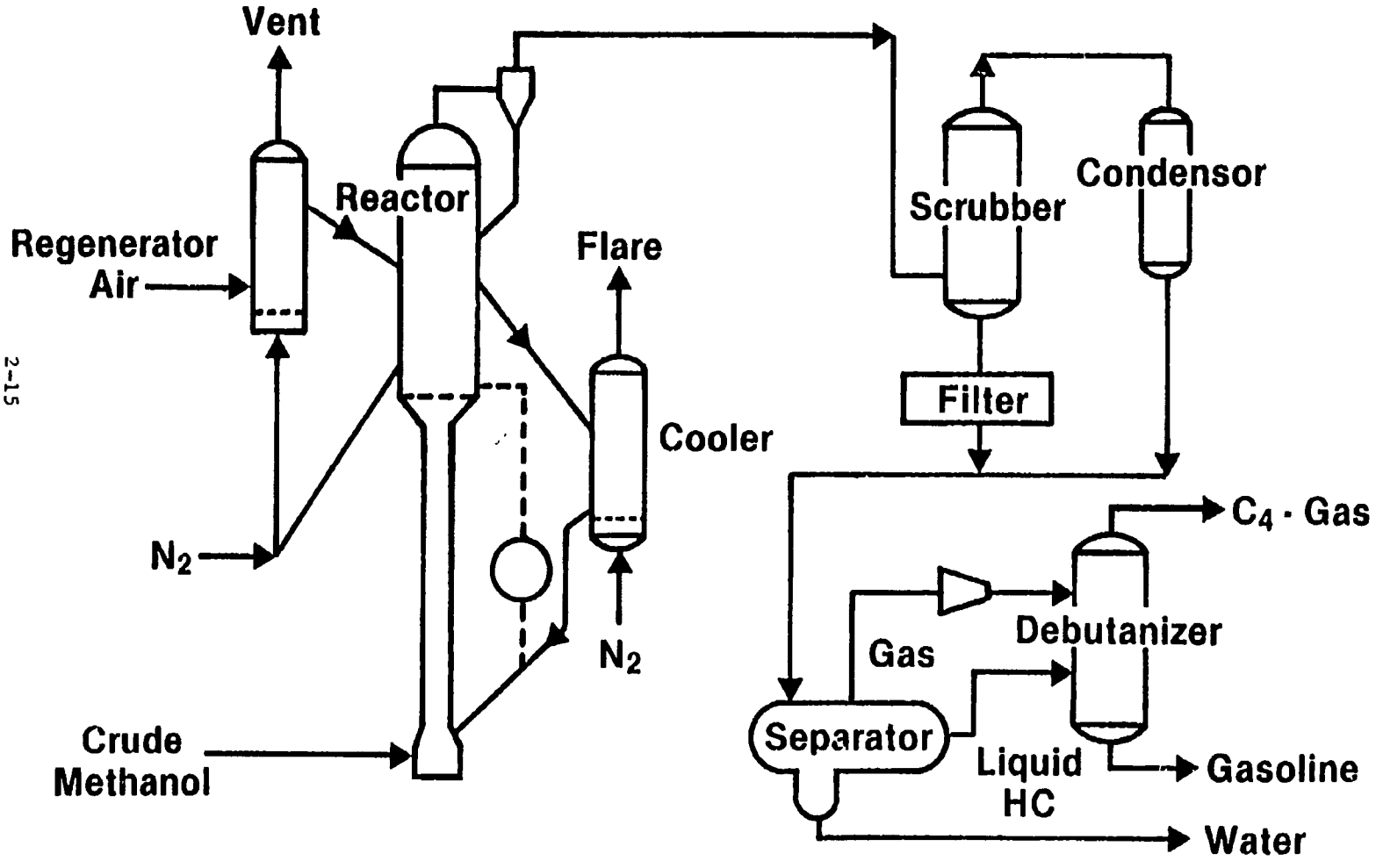


Figure 11