COMMERCIAL-SCALE DEMONSTRATION
OF THE LIQUID PHASE METHANOL (LPMEOH™) PROCESS:
INITIAL OPERATING EXPERIENCE

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ABSTRACT

The Liquid Phase Methanol (LPMEOH™) process uses a slurry bubble column reactor to convert synthesis gas (syngas), primarily a mixture of carbon monoxide and hydrogen, to methanol. Because of its superior heat management, the process can utilize directly the carbon monoxide (CO)-rich syngas characteristic of the gasification of coal, petroleum coke, residual oil, wastes, or other hydrocarbon feedstocks. When added to an integrated gasification combined cycle (IGCC) power plant, the LPMEOH™ process converts a portion of the CO-rich syngas produced by the gasifier to methanol, and the unconverted gas is used to fuel the gas turbine combined-cycle power plant. In addition, the LPMEOH™ process has the flexibility to operate in a daily load-following pattern, co-producing methanol during periods of low electricity demand, and idling during peak times. Coproduction of power and methanol via IGCC and the LPMEOH™ process provides opportunities for energy storage for electrical demand peak shaving, clean fuel for export, and/or chemical methanol sales.

Construction of the LPMEOH™ Process Demonstration Plant was completed in January of 1997 at Eastman Chemical Company's chemicals-from-coal complex in Kingsport, Tennessee. Following commissioning and shakedown activities, the first production of methanol from the 260 tons-per-day (TPD) plant occurred on April 2, 1997. Nameplate capacity was reached for

the first time on April 6, 1997, and production rates of over 300 TPD of methanol have been achieved. Since startup, availability for the LPMEOH™ Demonstration plant has exceeded 92%.

This paper provides a description of the LPMEOH™ process, the commercial applications for the technology, and a review of the startup and plant performance results at the Kingsport site.

I. INTRODUCTION

The LPMEOH™ technology was developed during the 1980's with the financial support of the U. S. Department of Energy (DOE). The concept was proven in over 7,400 hours of test operation in a DOE-owned, 10 tons-per-day (TPD) Process Development Unit (PDU) located at LaPorte, Texas.[1] The first commercial-scale demonstration plant for the technology was sited at Eastman Chemical Company's (Eastman's) coal gasification facility in Kingsport, Tennessee, with the help of a $92.7 million award under the DOE's Clean Coal Technology Program. Construction began in October of 1995 and concluded in January of 1997. After commissioning and startup activities were completed, operation began in April of 1997. During a four-year operating program, the LPMEOH™ Process Demonstration Plant will demonstrate the production of at least 260 TPD of methanol, and will simulate operation for the integrated gasification combined cycle (IGCC) coproduction of power and methanol application. The test plan will also seek to establish commercial acceptance of the technology and verify the fitness of the methanol product through a series of off-site, product-use tests. Total cost of the project, including the four-year demonstration test program, is forecast at $213.7 million.

Air Products and Chemicals, Inc. (Air Products) and Eastman formed the "Air Products Liquid Phase Conversion Co., L.P." partnership to execute the project and own the LPMEOH™ Demonstration Plant. Air Products manages the overall project and provides technology analysis and direction for the demonstration. Air Products also provided the design, procurement, and construction of the plant (i.e., a turnkey facility). Eastman provides the host site, acquired the necessary permits, operates the demonstration plant, supplies the supporting auxiliaries and the synthesis gas (syngas), and takes the product methanol. Most of the product methanol is refined to chemical-grade quality (99.85 wt% purity) via distillation and used by Eastman as chemical feedstock elsewhere in their commercial facility. A portion of the product methanol will be withdrawn prior to purification (about 98 wt% purity) for use in off-site, product-use tests.

This paper reviews: The **Commercial Application** for the LPMEOH™ process technology; the **Demonstration Plant - Test Plans**, highlighting the operational plans to confirm the commercial application; and, the **Demonstration Plant - Current Performance Results**, highlighting the operating results achieved to date.

II.   COMMERCIAL APPLICATION

Technology Description

The heart of the LPMEOH™ process is the slurry bubble column reactor (Figure 1).
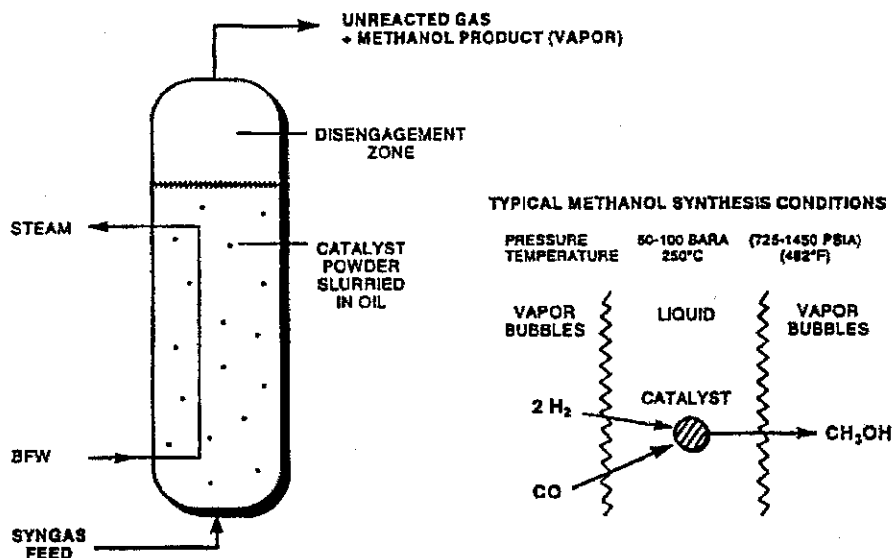

Figure 1. LPMEOH™ Reactor and Reaction Schematics

Conventional methanol reactors use fixed beds of catalyst pellets and operate in the gas phase. The LPMEOH™ reactor uses catalyst in powder form, slurried in an inert mineral oil. The mineral oil acts as a temperature moderator and a heat removal medium, transferring the heat of reaction from the catalyst surface via the liquid slurry to boiling water in an internal tubular heat exchanger. Since the heat transfer coefficient on the slurry side of the exchanger is relatively large, the heat exchanger occupies only a small fraction of the cross-sectional area of the reactor. As a result of this capability to remove heat and maintain a constant, highly uniform temperature through the entire length of the reactor, the slurry reactor can achieve much higher syngas conversion per pass than its gas-phase counterparts.

Furthermore, because of the LPMEOH™ reactor's unique temperature control capabilities, it can *directly* process syngas that is rich in carbon oxides (carbon monoxide and carbon dioxide). Gas-phase methanol technology would require that similar feedstocks undergo stoichiometry adjustment by the water gas shift reaction, to increase the hydrogen content and subsequent carbon dioxide (CO_2) removal. In a gas-phase reactor, temperature moderation is achieved by recycling large quantities of hydrogen (H_2)-rich gas, utilizing the higher heat capacity of H_2, as compared to carbon monoxide (CO). Typically, a gas-phase process is limited to about 16% CO in the reactor inlet, as a means of constraining the conversion per pass to avoid excess heating. In contrast, for the LPMEOH™ reactor, CO concentrations in excess of 50% have been tested routinely in the laboratory and at the PDU in LaPorte, without any adverse effect on catalyst activity.

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A second distinctive feature of the LPMEOH™ reactor is its robust character. The slurry reactor is suitable for rapid ramping, idling, and even extreme stop/start actions. The thermal moderation provided by the liquid inventory in the reactor acts to buffer sharp transient operations that would not normally be tolerable in a gas-phase methanol synthesis reactor. This characteristic is especially advantageous in the environment of electricity demand load-following in IGCC facilities.

A third differentiating feature of the LPMEOH™ process is that a high quality methanol product is produced directly from syngas rich in carbon oxides. Gas-phase methanol synthesis, which must rely on H_2-rich syngas, yields a crude methanol product with 4% to 20% water by weight. The product from the LPMEOH™ process, using CO-rich syngas, typically contains only 1% water by weight. As a result, raw methanol coproduced in an IGCC facility would be suitable for many applications at a substantial savings in purification costs. The steam generated in the LPMEOH™ reactor is suitable for purification of the methanol product to a higher quality or for use in the IGCC power generation cycle.

Another unique feature of the LPMEOH™ process is the ability to withdraw spent catalyst slurry and add fresh catalyst on-line periodically. This facilitates uninterrupted operation and also allows perpetuation of high productivity in the reactor. Furthermore, choice of replacement rate permits optimization of reactor productivity versus catalyst replacement cost.

IGCC Coproduction Options

The LPMEOH™ process is a very effective technology for converting a portion of an IGCC electric power plant's coal-derived syngas to methanol[2], as depicted in Figure 2. The process has the flexibility to handle wide variations in syngas composition. It can be designed to operate in a continuous, baseload manner, converting syngas from oversized gasifiers or from a spare gasifier. Alternatively, the process can be designed to operate only during periods of off-peak electric power demand, consuming a portion of the excess syngas and reducing the electricity output from the combined-cycle power unit. In this scenario, the gasification unit continues to operate at full baseload capacity, so that the IGCC facility's major capital asset is always fully utilized.

In either baseload or cycling operation, partial conversion of between 20% and 33% of the IGCC plant's syngas is optimal, and conversion of up to 50% is feasible. The required degree of conversion of syngas, or the quantity of methanol relative to the power plant size, determines the design configuration for the LPMEOH™ plant. In its simplest configuration, syngas at maximum available pressure from the IGCC electric power plant passes once-through the LPMEOH™ plant and is partially converted to methanol without recycle, water-gas shift, or CO_2 removal. The unreacted gas is returned to the IGCC power plant's combustion turbines. If greater syngas conversion is required, different plant design options are available.[3]
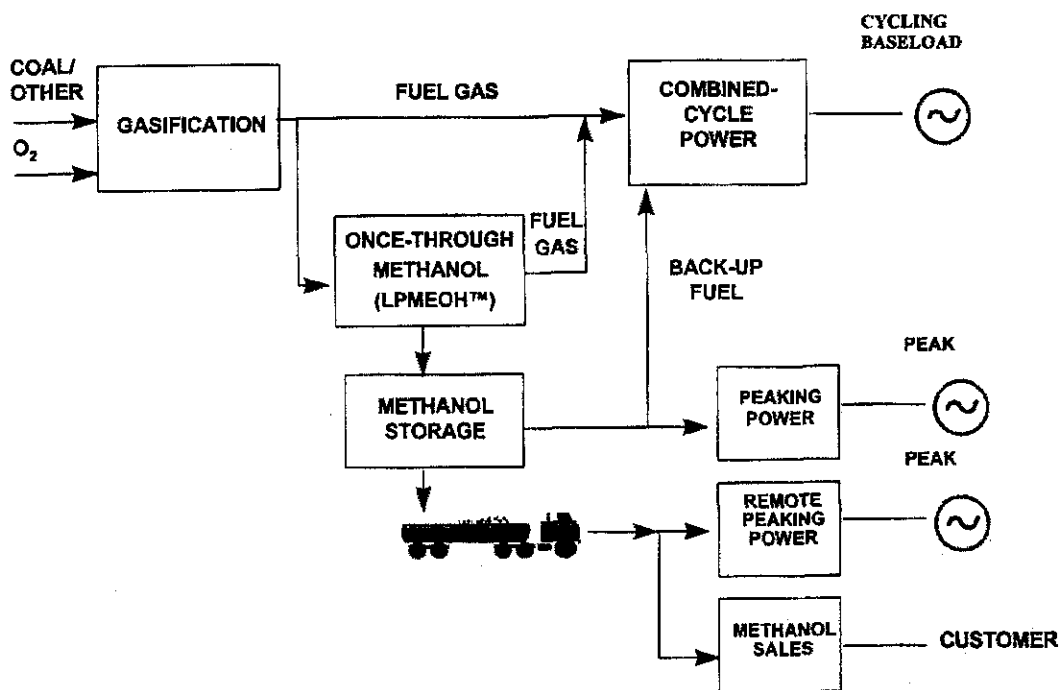
Figure 2.
Once-through Methanol Coproduction with IGCC Electric Power

Economics for Baseload Coproduction of Methanol and Power

Design studies for the LPMEOH™ process have focused principally on the aforementioned IGCC applications. For a given gasification plant size, the IGCC coproduction plant can be designed to accommodate a range of methanol to power output ratio's. For example,[4, 5] a gasification plant, with two gasifiers of 1735 million Btu (HHV) per hour output each, could be sized for baseload power output of 426 megawatts of electricity (MWe) and for baseload methanol coproduction of 500 TPD. If the baseload fuel gas value is $4.00 per million Btu, then 500 TPD of methanol can be coproduced from coal for under 50 cents per gallon.[3] This compares with new methanol plants which, using natural gas at $0.50 to $1.00 per million Btu as feedstock and the same basis for capital recovery, produce chemical-grade methanol delivered to the U. S. Gulf Coast at 55 to 60 cents per gallon.[6, 7] Methanol coproduction, by IGCC and the once-through LPMEOH™ process, does not require large methanol plant sizes to achieve good economies of scale. The gasification plant is necessarily at a large economical scale for power generation, so the syngas manufacturing economies are already achieved. Methanol storage and transport economies are also achieved by serving local markets, and realizing freight savings over competing methanol, which is usually shipped from the U. S. Gulf coast.

The 50 cents per gallon coproduction cost for a 500 TPD once-through LPMEOH™ plant size is competitive in local markets with new world-scale offshore methanol plants. An additional 3 to

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4 cents per gallon savings is attainable for a 1200 TPD LPMEOH™ plant size.[3] These additional savings might be used to offset higher freight costs to more distant customers, while still maintaining a freight and cost advantage over imported methanol from the Gulf Coast.

III. DEMONSTRATION PLANT - TEST PLANS

The preceding Commercial Application section highlighted the advantages of the LPMEOH™ process as part of an IGCC electric power generation system. To confirm these commercial advantages during operations, the demonstration test plan incorporates, but is not limited to, the following commercially important aspects of IGCC integration:

- **Syngas compositions will vary** with the type of gasification process technology and feedstock used in the power generation application. Therefore, operation over a wide variety of syngas compositions will be demonstrated.
- **Catalyst life,** operating on coal-derived syngas, must be demonstrated over a long period of time. Major parameters include reactor operating temperature, concentration of poisons in the reactor feed gas, and catalyst aging and attrition.
- **Reactor volumetric productivity** must be optimized for future commercial designs. Parameters include: High inlet superficial velocity of feed gas, high slurry catalyst concentration, maximum gassed slurry level, and removal of the heat of reaction.
- **Methanol Product,** as produced by the LPMEOH™ reactor from syngas rich in carbon oxides, must be suitable for its intended uses. Off-site methanol product-use testing will confirm the product specifications needed for market acceptability.

Although generation of electric power is not a feature of the demonstration project at Kingsport, the demonstration test plan is structured to provide valuable data related to the following:

- **coproduction** of electric power and value-added liquid transportation fuels and/or chemical feedstocks from coal. This coproduction requires that the partial conversion of syngas to storable liquid products be demonstrated.
- **energy load-following** operations that allow conversion of off-peak energy, at attendant low value, into peak energy commanding a higher value. This load-following concept requires that on/off and syngas load-following capabilities be demonstrated.

Three key results will be used to judge the success of the LPMEOH™ process demonstration during the four years of operational testing:

- resolution of technical issues involved with scaleup and first time demonstration for various commercial-scale operations;
- acquisition of sufficient engineering data for future commercial designs; and,
- industry or commercial acceptance.

The demonstration test plan provides flexibility to help meet these success criteria. Annual operating plans, with specific targeted test runs, will be prepared, and revised as necessary. These plans will be tailored to reflect past performance, as well as commercial needs.

The LPMEOH™ operating test plan outline, by year, is summarized in Table 1. The demonstration test plan encompasses the range of conditions and operating circumstances anticipated for methanol coproduction with electric power in an IGCC power plant. Since Kingsport does not have a combined-cycle power generation unit, the tests will simulate the IGCC application. In addition, the test program will emphasize test duration. The minimum duration for a test condition, apart from the rapid ramping tests, is 2 weeks. Numerous tests will have 3 to 6 week run periods, some 8 to 12 weeks, and a few key basic tests of 20 to 30 weeks.

The ultimate goal of the demonstration period is to reach a stable, optimized operating condition, with the best combination of the most aggressive operating parameters. These parameters, such as reactor superficial gas velocity, slurry concentration, and reactor level, will allow maximum reactor productivity to be achieved. Debottlenecking limitations of the demonstration plant will be an ongoing goal during the demonstration period.

Table 1. LPMEOH™ Demonstration Test Plan Outline	

Year 1	Catalyst Aging
	        Catalyst Life vs. LaPorte process development unit and Lab Autoclaves
	Process Optimization / Maximum Reactor Productivity
	        Catalyst Slurry Concentration (increasing to 40 wt%)
	        Reactor Slurry Level
	        Catalyst Slurry Addition Frequency Test
	        Gas Superficial Velocity
	Establishment of Baseline Condition

Years 2 & 3	Catalyst Slurry Addition and Withdrawal at Baseline Condition
	Catalyst Attrition/Poisons/Activity/Aging Tests
	Simulation of IGCC Coproduction for:
	    1. Syngas Composition Studies for Commercial Gasifiers
	        Texaco, Shell, Destec, British Gas/Lurgi, Other Gasifiers
	    2. IGCC Electrical Demand Load Following:
	        Rapid Ramping, Stop/Start (Hot and Cold Standby).
	    3. Additional Industry User Tests
	Maximum Catalyst Slurry Concentration (exceeding 40 wt%)
	Maximum Throughput/Production Rate

Year 4	Stable, extended Operation at Optimum Conditions 99% Availability Potential Alternative Catalyst Test Additional Industry User Tests

IV. DEMONSTRATION PLANT - CURRENT PERFORMANCE RESULTS

Kingsport Site

Eastman began coal gasification operations at Kingsport, TN in 1983. Texaco gasification converts about 1,000 tons-per-day of high-sulfur, Eastern bituminous coal to syngas for the manufacture of methanol, acetic anhydride, and associated products. Air Products provides the oxygen for gasification by a pipeline from an over-the-fence air separation unit. The crude syngas is quenched, partially shifted, treated for acid gas removal (hydrogen sulfide, carbonyl sulfide, and CO_2) via Rectisol, and partially processed in a cryogenic separation unit to produce separate H_2 and CO streams. The H_2 stream is combined with clean syngas to produce stoichiometrically balanced feed for a conventional gas-phase methanol synthesis unit, which is further polished in an arsine- and sulfur-removal guard bed. The methanol product reacts with recovered acetic acid to produce methyl acetate. Finally, the methyl acetate reacts with the pure CO stream to produce the prime product, acetic anhydride (and acetic acid for recycle).

Because the gasification facility produces individual streams of clean balanced syngas (Balanced Gas), CO (CO Gas), and H_2-rich gas (H_2 Gas), the LPMEOH™ Demonstration Plant design includes the capability to blend these streams into a wide range of syngas compositions. This flexibility enables the plant to simulate the feed gas composition available from any commercial gasifier.

Process Description

Figure 3 shows a simplified process flow diagram of the LPMEOH™ Demonstration Plant. Approximately half of the Balanced Gas fresh feed to the existing methanol unit is diverted to the LPMEOH™ Demonstration Plant, where it combines with the high-purity CO Gas and passes through an activated carbon guard bed. This bed removes iron and nickel carbonyls, which are poisons to methanol synthesis catalyst, down to ppb levels. The third feed stream, H_2 Gas, is the hydrogen-rich purge exiting the existing methanol unit. Since the H_2 Gas is at lower pressure than the other two feed streams, it is combined with the Recycle Gas stream, made up of unconverted syngas from the LPMEOH™ reactor, and compressed in the recycle compressor.

These two pairs of streams are then combined to form a single high pressure reactor feed gas stream that is preheated in the feed/product economizer against the reactor effluent. The feed gas is then sparged into the LPMEOH™ reactor, where it mixes with the catalyst slurry and is partially converted to methanol vapor, releasing the heat of reaction to the slurry. The slurry temperature is controlled by varying the steam temperature within the heat exchanger tubes, which is accomplished by adjusting the steam pressure.

Disengagement of the effluent gas (methanol vapor and unreacted syngas) from the catalyst/oil slurry occurs in the freeboard region of the reactor. Any entrained slurry droplets leaving the top of the reactor are collected in the cyclone separator. The product gas passes through the tubeside

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of the feed/product economizer, where it is cooled against the reactor inlet gas stream. Any condensed oil droplets are collected in the high-pressure oil separator and then returned to the reactor with the entrained slurry from the cyclone separator.

The product gas is cooled further in a series of air-cooled and cooling water exchangers, whereupon the product methanol condenses and collects in the high pressure methanol separator. Most of the unreacted syngas returns to the reactor after undergoing compression in the recycle compressor. The balance of the unreacted syngas is purged to the Eastman fuel gas system.

The condensed methanol contains dissolved gases, water, trace oil, and some higher alcohols. These impurities are removed in a two-column distillation train that produces a methyl acetate feed-grade methanol product. The bottom draw from the second column is a crude methanol stream heavy in higher alcohols, water, and any oil carried over from the reactor. This stream is sent to the existing distillation system for recovery of the methanol and disposal of the byproducts. Stabilized, fuel-grade methanol for off-site product-use testing will be produced at limited times during the demonstration period by using only the first distillation column.

Catalyst slurry is activated in the catalyst reduction vessel, which is equipped with a heating/cooling jacket, utility oil skid, and agitator. Pure CO, diluted in nitrogen, acts as the reducing agent. During the activation procedure, slurry temperature is carefully increased while monitoring consumption of CO to determine when the catalyst is completely reduced. At the end of this procedure, the catalyst is fully active and can be pumped directly to the reactor. As fresh catalyst slurry is added to the LPMEOH™ reactor, catalyst inventory is maintained by withdrawing an equivalent amount of partially deactivated or spent slurry.

Initial Operation

Table 2 summarizes the commissioning and startup milestones at the LPMEOH™ Demonstration Plant.

Table 2.

LPMEOH™ Demonstration Plant Milestones

• Groundbreaking	October 1995
• Plant Mechanically Complete	January 1997
• Eastman Begins Commissioning	February 1997
• Completed Startup	April 1997
• Syngas In	April 2, 1997
• Design Production of 260 TPD MeOH	April 6, 1997
• Greater Than 300 TPD MeOH	April 10, 1997
• Availability Since Startup	92%

In addition, a transportable laboratory was shipped to Kingsport in May of 1996 to test the long-term performance of a continuous stirred-tank autoclave on the coal-derived syngas at the Eastman complex. Over the past 20 years, Air Products has developed the skills and analytical techniques to sample syngas streams and detect concentrations of specific components at the parts-per-billion level. These tests indicated no unusually high levels of known catalyst poisons, and the autoclave produced a typical laboratory catalyst activity curve over a 28-day campaign.

Figure 4 shows performance results from the LPMEOH™ reactor during the first several months of operation. The data are reduced to a ratio of rate constant pre-exponential factors (actual vs. design value for fresh catalyst), using an in-house kinetic model, to eliminate the effects of changing feed composition or operating conditions. Typical exponential decay will appear as a straight line on a log-plot, as shown. The curve fit to data from a 4-month test at the LaPorte PDU in 1988/89 is included for reference. The plant results from the initial start-up in April of 1997 showed excellent initial activity, verifying the activation procedure for the catalyst. During the first month of operation, however, an accelerated change in performance occurred; whereas, the remaining operation from June through November matched the typical activity loss measured in the laboratory. This included the performance during the ongoing addition of fresh catalyst batches to the reactor to build inventory and maintain a viable overall level of activity. In fact, the eventual replacement rate of spent catalyst should maintain the average activity in the reactor at about half the fresh value, although that choice is ultimately an economic optimization of catalyst usage rate vs. reactor productivity. Notably, operations at the LaPorte PDU used natural gas feedstock for the generation of the CO-rich syngas fed to the reactor. In this "clean" environment, the methanol catalyst exhibited a very slow loss of activity with time.

An important feature of the LPMEOH™ process is the ability to remove spent catalyst from the reactor during operation; this also affords the opportunity to examine samples for changes in the microscopic structure and/or chemical make-up of the catalyst with time. Analyses of such samples from Kingsport have indicated a step-change in the concentration of iron on the catalyst surface during the initial six weeks, which cannot be correlated to the presence of iron carbonyl in the feed gas streams. This finding may be related to the detection of post-construction debris within various parts of the facility, or an incipient production of iron carbonyl within the new piping systems, characteristic of a passivation-like mechanism which decreased rapidly with time. Higher than expected levels of arsenic were also found on the catalyst samples. However, a subsequent changeout of Eastman's arsine-removal guard bed, and laboratory tests using arsine-doped syngas, failed to prove that arsine alone was responsible for the catalyst deactivation in the plant. Regardless, the plant originally came on-stream with less than a full charge of catalyst to mitigate the risk of exposure to anomalous contaminants during the initial start-up.

Based on these results, the reactor was drained and another partial charge of fresh catalyst was activated during December of 1997. The calculated catalyst activity curve since the restart is included in Figure 5, along with additional data from the transportable laboratory operating in parallel on the same reactor feed gas. The initial catalyst performance has been excellent, with methanol production again exceeding nameplate capacity and plant availability exceeding 99.9%

through the first six weeks. Also, a rapid decrease in activity did not occur during the initial month on-stream, as compared to the results from April of 1997. Furthermore, the activity maintenance in the LPMEOH™ reactor appears to exceed the results from the parallel laboratory run. However, while the initial activity is higher than the 1988/89 results from the LaPorte PDU, the decrease with time remains measurably greater. This disparity is thought to be caused by the presence of trace levels of catalyst poisons (iron, sulfur, arsenic, etc.) in syngas generated from coal.

Operation with CO-rich Syngas

Two test runs using a CO-rich feed gas to the LPMEOH™ reactor have been completed. The H_2/CO ratio of the reactor feed for these cases varied between 0.4 and 0.8. Methanol production matched the predicted quantity for the reactor operating conditions, and the catalyst deactivation rate under CO-rich syngas was equivalent to the H_2-rich rates before and after. The crude methanol composition from a test simulating feed from a Texaco coal gasifier (H_2/CO ratio = 0.8) is shown in Table 3. This methanol has levels of higher alcohols and water similar to as-produced methanol from the LaPorte PDU, which is important because the PDU methanol has already been used successfully in several fuel and chemical applications.

Table 3. Crude Methanol Composition from Texaco-type Feed Gas

	Kingsport #1 (wt%)	Kingsport #2 (wt%)	PDU (wt%)
Methanol	98.0206	98.1442	97.459
Ethanol	0.2999	0.3116	0.593
2-Propanol	0.0328	0.0285	*
1-Propanol	0.0962	0.1030	0.198
2-Butanol	0.0251	0.0258	0.048
iso-Butanol	0.0107	0.0115	0.003
Methyl Propionate	0.0058	0.0059	*
n-Butanol	0.0496	0.0570	0.093
3-Methyl-2-Butanol	0.0104	0.0112	*
2-Methyl-2-Butanol	0.0094	0.0098	*
Methyl Butyrate	0.0066	0.0067	*
2-Methyl-1-Butanol	0.0122	0.0131	*
1-Pentanol	0.0255	0.0299	0.066
3-Pentanol	0.0067	0.0071	*
2-Pentanol	0.0073	0.0079	0.003
Methyl Formate	0.0000	0.0000	0.368
Methyl Acetate	0.0000	0.0000	0.041
Dimethyl Ether	0.0000	0.0000	0.301
Water	1.3000	1.1400	0.543
Mineral Oil	0.0812	0.0868	0.283

* refers to compounds not detected in sample because of analytical technique; however, compounds are probably present in sample, and have been accounted for as other compounds of similar physical properties.

Future Activities

During 1998, efforts will continue to sample the catalyst from the reactor and monitor plant performance to quantify the long-term catalyst aging characteristics under coal-derived syngas. In addition, the slurry concentration in the reactor will be increased to determine the maximum volumetric productivity of methanol. Additional operations with CO-rich syngas and other reactor feed gas compositions are planned.

V. CONCLUSION

The LPMEOH™ process is now being demonstrated at commercial scale under the DOE Clean Coal Technology Program. The demonstration plant, located at Eastman Chemical Company's Kingsport, Tennessee coal gasification facility, has produced in excess of the 260 TPD of methanol nameplate capacity from coal-derived syngas. Since startup of the unit in April of 1997, overall availability has exceeded 92%, while the more recent campaign in 1998 has achieved greater than 99% availability. The startup and initial operation proceeded without injury or environmental incidents, and Eastman has accepted all methanol produced at the LPMEOH™ Demonstration Plant for use in downstream chemical processes.

Successful demonstration of the LPMEOH™ technology will add significant flexibility and dispatch benefits to IGCC electric power plants, which traditionally have been viewed as strictly a baseload power generation technology. Now, central clean coal technology processing plants, making coproducts of electricity and methanol, can meet the needs of local communities for dispersed power and transportation fuel. The LPMEOH™ process provides competitive methanol economics at small methanol plant sizes, and a freight and cost advantage in local markets vis-à-vis large offshore remote gas methanol. Methanol coproduction studies show that methanol can be produced at less than 50 cents per gallon from an abundant, non-inflationary local fuel source, such as coal. The coproduced methanol may be an economical hydrogen source for small fuel cells, and an environmentally advantaged fuel for dispersed electric power.

VI. ACKNOWLEDGEMENT

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