Gas/Liquid Membranes For Natural Gas Upgrading

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DISCLAIMER

ABSTRACT

Efforts this quarter have concentrated on field site selection. ChevronTexaco has nominated their Headlee Gas Plant in Odessa, TX for a commercial-scale dehydration test. Design and cost estimation for this new site are underway. A HazOp review was conducted. Potting and module materials testing continued. Preliminary design of the bench-scale equipment continues. A status meeting was held in Morgantown, WV with the DOE Project Manager.

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INTRODUCTION

Gas Technology Institute (GTI) is conducting this research program whose objective is to develop gas/liquid membranes for natural gas upgrading to assist DOE in achieving their goal of developing novel methods of upgrading low quality natural gas to meet pipeline specifications.

Kværner Process Systems (KPS) and W. L. Gore & Associates (GORE) gas/liquid membrane contactors are based on expanded polytetrafluoroethylene (ePTFE) membranes acting as the contacting barrier between the contaminated gas stream and the absorbing liquid. These resilient membranes provide much greater surface area for transfer than other tower internals, with packing densities five to ten times greater, resulting in equipment 50 – 70% smaller and lower weight for the same treating service.

The scope of the research program is to (1) build and install a laboratory- and a field-scale gas/liquid membrane absorber; (2) operate the units with a low quality natural gas feed stream for sufficient time to verify the simulation model of the contactors and to project membrane life in this severe service; and (3) conducted an economic evaluation, based on the data, to quantify the impact of the technology. Chevron, one of the major

producers of natural gas, has offered to host the test at a gas treating plant. KPS will use their position as a recognized leader in the construction of commercial amine plants for building the unit along with GORE providing the membranes. GTI will provide operator and data collection support during lab- and field-testing to assure proper analytical procedures are used. Kværner and GTI will perform the final economic evaluation. GTI will provide project management and be responsible for reporting and interactions with DOE on this project.

EXECUTIVE SUMMARY

The cofunding agreement with ChevronTexaco continues under discussion. ChevronTexaco's Chinchaga Gas Plant in Alberta, Canada will not be increasing capacity as planned. Since they do not have a commercial need for the contactor, they have withdrawn that site and are seeking another suitable location. We continue seeking alternative hosts and sites as a backup. A meeting was held with ChevronTexaco in Denver last quarter, 2002 to identify potential locations. Most of their needs are outside the North American market.

Early in 2003, ChevronTexaco identified a potential test site in West Texas. The application here is for a full-scale dehydration unit, similar in size as originally proposed, but for a different natural gas processing application. A meeting was held with ChevronTexaco, GTI and KPS at the Headlee Gas Plant in Odessa, TX, to investigate testing, contract terms, schedules, and responsibilities.

During this quarter, a HazOp review was conducted at KPS offices in Houston, TX. The review was conducted as a "what-if" analysis, as in what would happen if this valve or instrument or operator misperformed. What would be the consequence of that action, what is the probability that it would happen and what is the impact on personnel and equipment is next decided. Mitigating design and operational procedure changes were then identified. For this analysis, focus was on issues directly affecting the planned tie-ins. Assignments were given to the appropriate organization for the changes.

A meeting was held with Tony Zammerilli, DOE Project Manager, in Morgantown, PA to review status of the project. This project has been delayed due to the time required to secure an appropriate site after the originally proposed site became unavailable. GTI has slowed down the project so that the original funding would be available. However, the cost of the test has increased. KPS and ChevronTexaco have increased their planned co-funding, but there is still a gap. He indicated that there is no out-year funding for Gas Processing projects in the DOE budget. He indicated that he would be responsive to reasonable changes in the program direction to help ensure the test occurs, within the bounds of the contract. The Contract Administrators must approve any changes to schedule and costs. GTI will plan to submit a change to the schedule next quarter, if necessary.

EXPERIMENTAL

ChevronTexaco module:

The modified simulation program has been used for designing a 50 MMscfd membrane contactor module for industrial scale dehydration testing. ChevronTexaco wants to demonstrate the technology in Odessa, Texas for possible subsequent utilization at a new planned platform outside the US.

The design pressure and temperature is 83 barg (1200 psig) and 115 F. The gas has to be dried from saturated (76 lbs/MMscf) to 7 lbs/MMscf. The offshore application will require a higher pressure and additional water removal. ChevronTexaco and KPS are negotiating commercial terms for a "try and buy" sales agreement for the test unit. They are planning a 180-day endurance test with 3 performance test periods throughout the endurance test. During the performance tests, gas and liquid flow rates, glycol purity (water content of the lean glycol), and temperatures will be varied to provide modeling data required to project performance of the offshore application.

The project is being re-scoped for this new site and application. ChevronTexaco will perform the site preparation and installation. KPS will design the membrane contactor and contactor skid. The key component, the membrane contactor, will be produced in cooperation with the membrane manufacturer, Gore, and the module manufacturer, SGL Carbon Group. The commissioning, start-up and tests will be performed in close cooperation with GTI, ChevronTexaco, and KPS. In addition to technical support, GTI will also be heavily involved in the sampling, evaluation of the data, and perform a third party evaluation of the results.

The first critical milestone for this site is the tie-ins to be performed during a major plant shut-down in mid-October, 2003. The Haz-Op analysis is planned for late August, 2003. Testing would begin during the second half of 2004.

KPS has received design conditions for the final offshore application of the membrane contactor as well as operating conditions at the Headlee test site. This information has been used together with the simulation program tuned from Colorado-results and pressure drop measurements[1] done with one of the Colorado test-modules for designing the final

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[1] Pressure drop measurements:

From pressure drop tests performed at Allum, Sandefjord in June 2003 on one of the Colorado test modules with both a maximum water rate of 10 m^3/h and a maximum air rate of 180 m^3/h and at superficial Reynolds numbers in the area 9 – 86 (the corresponding Reynolds number for the offshore application will be approximately 1500), the pressure drop coefficient for turbulent flow, k, is determined to be 2000. This seems to be a conservative estimation since the pressure drop coefficient has not converged at the maximum Reynolds number of 86. This means that we may expect a lower pressure drop than calculated by the formula below.

The pressure drop formula for design of the ChevronTexaco module is as follows:

membrane module. The active length of the membrane module will be 4.1 meters with an internal diameter of approx. 0.75 meters (the final diameter will be set after exact determination of the coating thickness). The total length of the canister will be given when the potting thickness and length of drainage section is determined.

The operating conditions at Headlee are very different from the conditions at the final site. Consequently a lot of effort has been used to define acceptance criteria for the membrane contactor performance at Headlee conditions that apply for final site conditions.

Preparations for a HAZOP have been made and were conducted late August. The work included the design of the membrane contactor equipment and equipment necessary to adapt the membrane contactor to operate at the site. Updated descriptions of the back pressure controller (BP) and membrane protection system (MPS), preliminary process descriptions and operational procedures have been made. A formalized P&ID for the BP and MPS system has also been made.

Detailed descriptions of the full-scale test have been made and incorporated in the proposed agreement between ChevronTexaco and KPS. The terms and conditions in this agreement have been evaluated as well as the economical risk related to the project.

A systematic evaluation of different companies to manufacture the BPand MPS systems has been made. A given company, Tronrud Engineering, in Norway is qualified and is chosen as the manufacturer for these components in this project.

Potting project:

The present potting material has its limitation in the casting of larger diameters due to high exothermic peak and subsequent cracking of cured material. Therefore, a search for a new thermosetting material was initiated.

Resin survey:

Ten resin systems were chosen for initial screening. The following parameters were tested and evaluated:

- exothermic heat
- viscosity
- infiltration behavior (distribution around membranes and spacers)
- flexibility

$$\Delta P = 1000*\rho*L*v^2$$

ρ = density of natural gas

L = length between gas inlet and gas outlet

v = superficial velocity of gas in canister

- adhesion to the membrane (peeling tests)

The six most promising systems were chosen for the chemical immersion test to evaluate chemical resistance.

The resins include room temperature curing PU-systems (polyurethane), EP-systems (epoxy) and high temperature curing epoxy-system (80°C) from four different suppliers.

Chemical immersion test:

The most common gas treatment absorbents were picked out for the test where resin samples (including membrane and spacer) are exposed for 24 weeks at 60°C. The following solvents were chosen:

- TEG
- MEA
- MDEA
- aMDEA (highly activated from BASF)
- Morphysorb
- Selexol/Genosorb

As a measure for chemical resistance, the adhesion between membrane/PTFE and resin was chosen in addition to swelling of sample. Chemical resistance test will be performed after 6, 12, and 24 weeks. The test was completed this quarter.

Parallel to the chemical testing, the following activities will be performed:

- potting simulations, i.e. study of the rheological behavior of approx. 3 kg samples of the various resins in a plexiglass mould of length/diameter 720 mm which is filled with membrane sheets and spacer material
- building dummies of the full size diameter and thickness (approx. 40 kg resin), both to see the rheological behavior and the curing performance in full scale
- identify the new potting material.

RESULTS AND DISCUSSION

Chemical immersion test/potting simulation/dummy test:

The chemical tests were completed after 24 weeks of exposure. The report from the test is in preparation, but it is clear that there were no big changes in performance during the last weeks. Some initial tests regarding mechanical bending have been completed. A preliminary conclusion is that the new epoxy system from Vantico is much better (sufficient mechanical strength for supporting the membrane bundle) than the reference system (Fuller), where mechanical strength was not detectable.

A new series of chemical immersion test was started in the beginning of August with the first check point in week 38. The background for doing this second immersion test is

twofold: first to have more than one resin system qualified for the ChevronTexaco project with hopefully improved characteristics compared to the existing system; and second to improve the properties of the resin system against the physical solvents.

As mentioned in last progress report, the potting simulation was already completed for the Vantico system with acceptable result. Potting tests will also be done for the new qualified systems from the second immersion test.

Dummy tests will be performed with the Vantico system next quarter. Included in the dummy test is casting of pure potting material in full scale (i.e. the design diameter and potting thickness), casting of potting material in a filled PMMA mould (transparent mould of half the full size) and finally casting of potting material in a filled CFRP mould of full scale. The tests will give us information regarding flow of resin/leveling in the mould, adhesion of resin to the membranes and canister and most important possible formation of cracks due to exothermic reaction/thermal expansion.

CONCLUSION

No conclusions have been reached at this point.

REFERENCES

None