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DEVELOPMENT OF A MEMBRANE-BASED PROCESS FOR THE TREATMENT OF OILY WASTE WATERS

Contract No. DE-AC22-92MT92005

September 16, 1993

Contract Date: March 4, 1992
Anticipated Completion Date: December 4, 1993
Government Award for FY1992: $294,200

Program Manager: Scott B. McCray
Principal Investigator: Scott B. McCray
Technical Project Officer (COR): Gene Pauling

Reporting Period: March 5 to June 4, 1993

from
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NOTE: US/DOE Patent Clearance is **not** required prior to the publication of this document.

LIST OF FIGURES

LIST OF TABLES

None.

EXECUTIVE SUMMARY

This is a quarterly report from Bend Research, Inc., (BRI) to the U.S. Department of Energy (DOE) for work performed under Contract No. DE-AC22-92MT92005, titled "Development of a Membrane-Based Process for the Treatment of Oily Waste Waters." This report covers the period from March 5 to June 4, 1993.

The overall goal of this program is to develop a system based on reverse-osmosis (RO) membranes that can treat oily water economically. This system will be based on the use of thin-film-composite (TFC) membranes that consist of a selective coating placed on a solvent-resistant hollow-fiber support. For this program, we plan to develop solvent-resistant hollow-fiber supports and coat them with a "loose RO" coating. We developed the coating, which is designated TTM, in previous work for the treatment of oily waste waters.

During this reporting period, work was focused on arranging for a demonstration test of this technology. Due to unforeseen delays in installing the equipment at the demonstration site, only limited experiments could be performed during this reporting period. During the next reporting period, we plan to begin long-term testing at the demonstration-test site. The demonstration test and the final report are the only tasks remaining in this program.

I. INTRODUCTION

This is a quarterly report from Bend Research, Inc., (BRI) to the U.S. Department of Energy (DOE) for work performed under Contract No. DE-AC22-92MT92005, titled "Development of a Membrane-Based Process for the Treatment of Oily Waste Waters." The purpose of this program is to develop a system based on reverse-osmosis (RO) membranes that can treat oily water economically. This system will be based on the use of thin-film-composite (TFC) membranes that consist of a selective coating placed on a solvent-resistant hollow-fiber support. For this program, we plan to develop solvent-resistant hollow-fiber supports and coat them with a "loose RO" coating. We developed the coating, designated TTM, in previous work for the treatment of oily waste waters. This report covers the period from March 5 to June 4, 1993.

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II. PROJECT DESCRIPTION

This program is divided into seven tasks. A summary of the work to be performed in this program follows.

Task 1: Develop Hollow Fibers

Hollow-fiber supports will be made from high-strength, solvent-resistant polymers. These fibers will be physically robust and have 1) high permeability to assure high fluxes, and 2) smooth lumen (interior) surfaces to assure uniform coating of the hollow-fiber support with the permselective coating.

Task 2: Evaluate Hollow Fibers

The fibers made in Task 1 will be evaluated in a series of tests to ensure they are suitable for this application. These tests include 1) examining the texture of the lumen surface, 2) measuring the permeability of the fibers, 3) measuring the strength of the fibers, and 4) measuring the solvent resistance of the fibers.

Task 3: Make Small-Scale Modules

Small-scale hollow-fiber modules will be made using the fibers, and the lumens of the fibers will be coated with our loose-RO TTM coatings. The modules will be evaluated in standard tests to ensure the integrity of the coating.

Task 4: Test Small-Scale Modules

The small-scale modules made in Task 3 will be tested in the laboratory under controlled conditions. The modules will be evaluated on feed streams of oily waste waters obtained from various sources. Parametric and long-term tests will be conducted.

Task 5: Construct Large-Scale Modules

Large-scale modules will be constructed using standard module-preparation procedures developed at Bend Research. These modules will be constructed for use in a demonstration unit to be provided by the contractor.

Task 6: Operate Demonstration Unit

The effectiveness of this technology will be demonstrated by operating the large-scale modules on actual oily waste waters. Field-test sites will be identified and prepared for the demonstration of this technology. A test plan will be developed before the demonstration is performed.

Task 7: Technology Transfer

Journal articles and conference and symposia presentations will be prepared. This technology will be transferred to the oil and gas industry and the scientific community.

III. PROJECT STATUS

During the previous reporting period, our commercialization partner, AquaAir Environmental, Inc., (Bend, Oregon) shipped the demonstration unit to Friendswood, Texas, the site of the demonstration test. Figure 1 shows a simplified schematic of the demonstration unit. Due to unforeseen delays in preparation of the demonstration-test site, only limited experiments were performed with the demonstration unit. These results are described below.

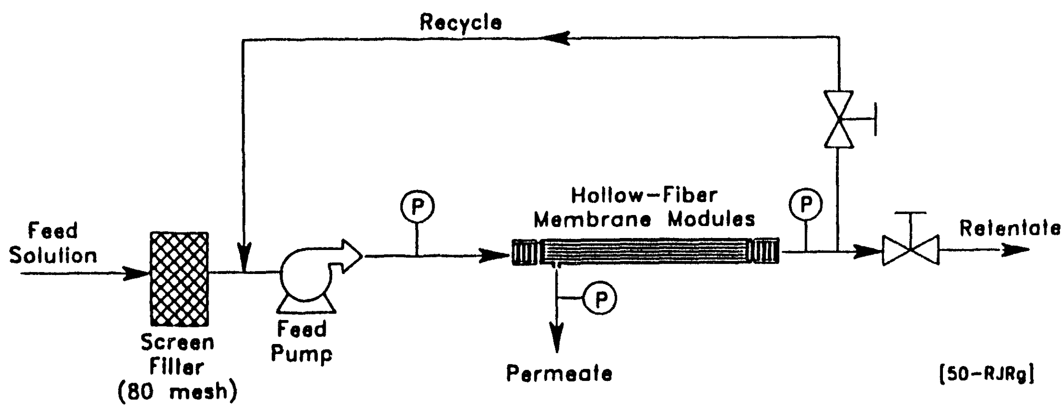

Figure 1. Simplified Schematic of the Demonstration Unit

The first test performed with the demonstration unit was to compare the performance of the TTM-20 and TTM-60 coatings when operated on oily water. Figure 2 shows the results of these tests. In these tests, the feed stream contained approximately 1000 ppm oil and grease and approximately 10,000 ppm salts. The permeate from each module tested contained less than 7 ppm oil and grease--a rejection of oil and grease of 99.3%. The permeate was of sufficient quality to meet all known discharge regulations in the Gulf Coast area.

As expected, the data show that the flux through the modules increases with pressure. The module with the TTM-20 coating had a significantly higher flux than the module with the TTM-60 coating. We believe two factors contributed to the higher flux of the TTM-20 module. First, the TTM-20 coating has a higher water permeability than the TTM-60 coating. This means that at the same operating pressure, the flux through the TTM-20 module will be higher than that through the TTM-60 module.

Second, the TTM-20 module has a lower rejection for dissolved salts than does the TTM-60 module. This means that the osmotic-pressure difference across the TTM-20 module will be lower than that across the TTM-60 module, as illustrated in Figure 3. This results in a higher net driving force for the TTM-20 module and a correspondingly higher water flux.

Based on these results, we intend to continue the demonstration tests with TTM-20 modules. These modules show promise of providing high water fluxes with high rejections for oil and grease.

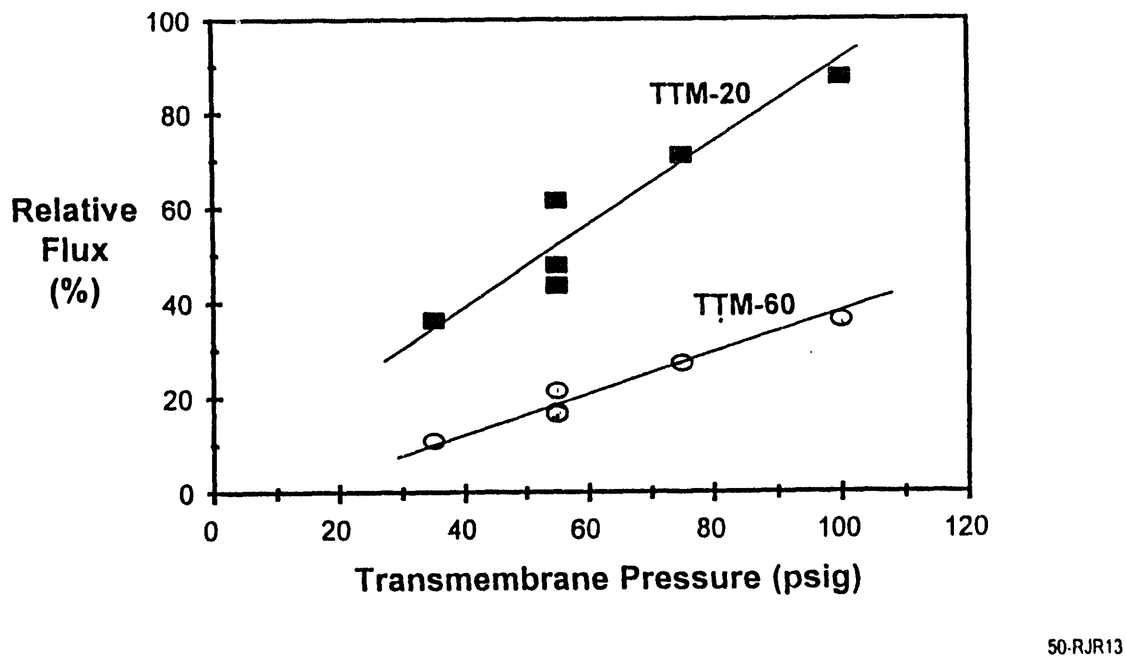

Figure 2. Relative Water Flux Versus Transmembrane Pressure for a TTM-20 and TTM-60 Hollow-Fiber Modules

Conditions:	Feed:	~10,000 ppm salts (mostly Ca^{+2})
		~1,000 ppm oil and grease
	Permeate:	<7 ppm oil and grease

IV. PLANNED ACTIVITIES

During the next reporting period, we plan to begin long-term testing using the demonstration test unit. The demonstration test, preparation of the final report, and technology transfer are the only tasks remaining in this program.

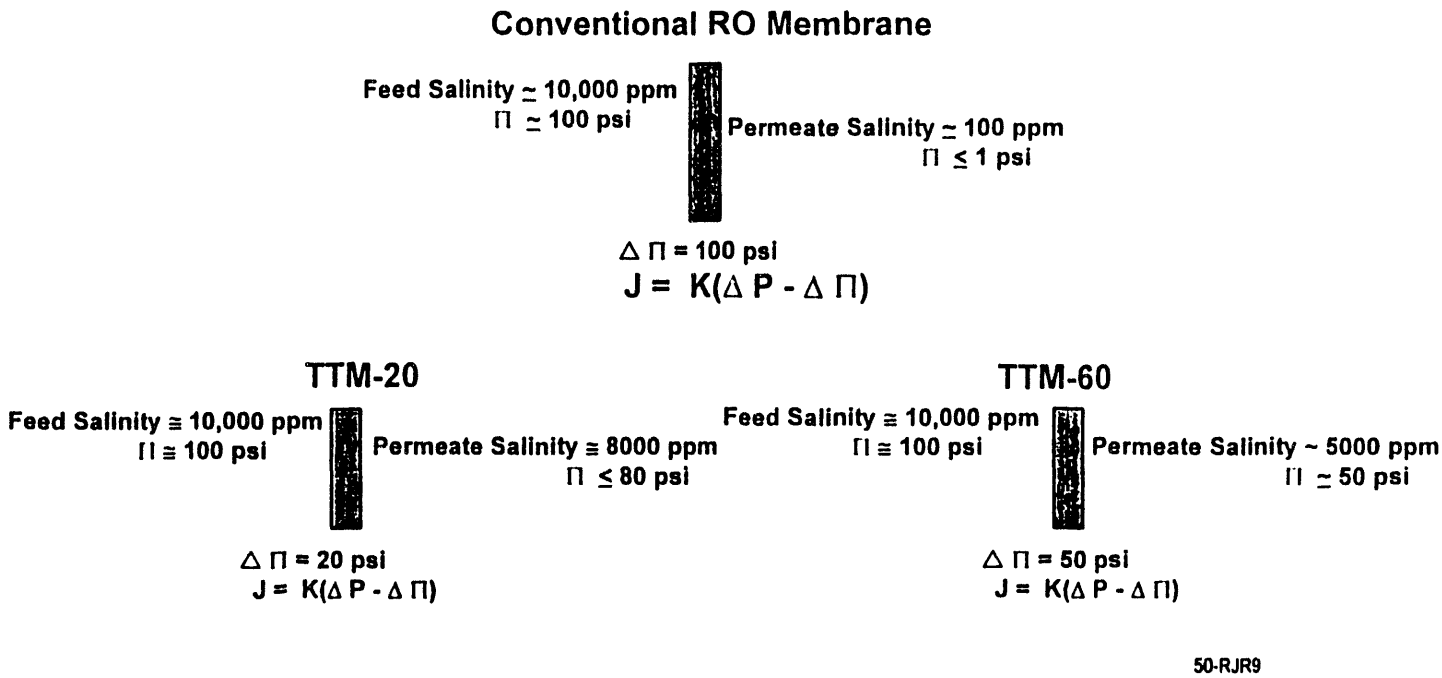

Figure 3. Effect of Osmotic Pressure on Membrane Performance

Key: π = osmotic pressure
K = water permeability
J = water flux
P = operating pressure

V. SUMMARY

During this reporting period, we installed the demonstration unit at a test site near Houston, Texas. Initial test results showed that the TTM-20 module had a higher flux than the TTM-60 module. Each type of module produced a permeate of sufficient quality for discharge.

Report Distribution List

Three copies to: Document Control Center, U.S. Department of Energy Pittsburgh Energy Technology Center, P.O. Box 10940, MS 921-118, Pittsburgh, PA 15236-0940

References:

None.

Publications

Portions of these results were presented verbally at the Energy Sources Technology Conference & Exhibition, which was held January 31 to February 4, 1993, in Houston, Texas.

Portions of the results of this work were also presented at the 1993 Summer National Meeting of the American Institute of Chemical Engineers, which was held August 15-18, 1993, in Seattle, Washington. A copy of the preprint prepared for that meeting is attached. We plan to submit this preprint for publication.

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