CERAMIC MEMBRANE ENABLING TECHNOLOGY FOR IMPROVED IGCC EFFICIENCY

QUARTERLY TECHNICAL PROGRESS REPORT

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ABSTRACT:

This quarterly technical progress report will summarize work accomplished for Phase 1 Program during the quarter October – December 1999 in the following task areas:

Task 1 Oxygen Transport Membrane (OTM) Materials Development

Task 2 Composite OTM Development

Task 4 Process Development

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A. Introduction

The objective of this program is to conduct a technology development program to advance the state-of-the-art in ceramic Oxygen Transport Membranes (OTM) to the level required to produce step change improvements in process economics, efficiency, and environmental benefits for commercial IGCC systems and other applications. The IGCC program is focused on addressing key issues in materials, processing, manufacturing, engineering and system development that will make the OTM a commercial reality.

The objective of the OTM materials development task is to identify a suitable material that can be formed into a thin film to produce the target oxygen flux. This requires that the material have an adequate permeation rate, and thermo-mechanical and thermo-chemical properties such that the material is able to be supported on the desired substrate and sufficient mechanical strength to survive the stresses involved in operation.

The objective of the composite OTM development task is to develop the architecture and fabrication techniques necessary to construct stable, high performance, thin film OTMs supported on suitable porous, load bearing substrates.

The objective of the process development task of this program to demonstrate the program objectives on a single OTM tube under test conditions simulating those of the optimum process cycle for the power plant.

B. Experimental Data

B.1. OTM Materials Development Experimental Data

Efforts are underway to find material compositions which are superior to the current lead candidate PSO1. Discs and tubes of new compositions have been tested for oxygen flux. Several compositions have shown improved oxygen transport properties over PSO1 at temperatures lower than 850°C. Oxygen flux tests using a He purge gas on a 1mm disc of a new composition at 800°C resulted in significantly higher fluxes.

B.2. Composite OTM Development Experimental Data

High quality dense OTM films on porous supports is the primary goal of this task. Defects in the dense film of a composite OTM membrane diminish performance due to a decrease in selectivity. Because of this, we are establishing test procedures to quantify the extent of defects in the film of the composite OTM.

B.2.2. Flux Measurements on Composite OTM Discs

A composite OTM comprised of a PSO1 film deposited on a porous PSO1 disc was prepared and tested using He purge gas for oxygen permeation. At 900°C an oxygen flux of ~50 % of target flux was obtained. The disc was tested for >360 hours with no decline in flux. This is a very encouraging result as it shows the stability of the membrane.

It is important to have high strength of the porous support to enable robust elements to be successfully developed. Therefore, several improved substrates are being investigated. A composite OTM comprised of a PSO1 film deposited on a new porous substrate yielded O_2 flux comparable to the composite PSO1 on porous PSO1 disc at 900°C, but the new support is expected to be significantly stronger. The long-term stability of this composite disc is being studied.

B.3. Process Development Experimental Data

Permeation tests were run on a composite tube at 1050ºC, 1000ºC and 900ºC. The maximum measured fluxes under ideal conditions are approaching 100% of our target flux.

C. Results and Discussion

PSO1 is the current lead candidate for the OTM, however, new material compositions with superior characteristics to those of PSO1 are being investigated. Discs and tubes of alternative compositions to PSO1 have been prepared. Significantly higher oxygen fluxes have been measured at 800°C on a 1mm disc of a new composition.

High quality, defect-free dense films are desirable in a composite OTM. Room temperature leak tests provide an efficient method for OTM quality control of supported membranes without the added complexity of a high temperature seal that is required in oxygen permeation tests.

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High temperature permeation tests were conducted on a composite OTM tube at 900°C, 1000°C and 1050°C. Oxygen fluxes approached 100% of the commercial target flux.

D. Conclusion

The DOE-IGCC program has commenced and material, composite and process development is in full swing. New material compositions with superior characteristics to those of PSO1 are being investigated, and several show promise. Optimization of high quality films on porous supports continues. Oxygen fluxes measured on composite tubes are approaching 100% of our target flux.

References

[1] Handbook of Chemistry and Physics, 71st edition, 1990-1991, Editor-in-Chief: David R. Lide, CRC Press, Boca Raton, Ann Arbor, Boston.