PROJECT facts

Advanced Research

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U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Membrane Seal Development for Gas Separation Systems

Background

Coal is a potential source of clean hydrogen fuel for use in fuel cells, power turbines, and various process applications. In order to realize the vision of a hydrogen-based energy economy, efficient, low-cost gas separation systems are needed to provide high-purity oxygen (O_2), both to enhance the coal gasification reaction, and to extract hydrogen (H_2) from the resulting gas product stream. Inorganic membrane-based separation systems hold promise for these applications, and as a means to remove carbon dioxide (CO_2) from gasified coal, thereby enabling its separation for commercial utilization or for long-term storage as an undesirable greenhouse gas.

Objectives and Technical Approach

The primary objective of this project, performed by the Pacific Northwest National Laboratory (PNNL) and administered by the National Energy Technology Laboratory (NETL), is to develop the "seals" that are a key component of high-efficiency, low emissions fossil fuel conversion. Development of these seals also supports the U.S. Department of Energy (DOE) Office of Fossil Energy (FE) Clean Coal Utilization and FutureGen programs. In the short term, this project is focused on developing the seals needed to hermetically join the various ceramic and metallic inorganic membranes and support structures that currently are being considered for use in high-temperature gas separation systems. The sealing material not only must be compatible with both the membrane and support materials, but also must be physically and chemically stable over the lifetime of the device - typically on the order of several thousand hours - at the temperatures, pressures, gas atmorpheres, and thermal cycling conditions typical of the electrochemical and physical separation processes employed with gasified coal and air.

"Materials joining" is fundamental to FE's technology integration strategy because it enables the development of higher-level, applications-oriented technologies such as gas separation device fabrication and solid oxide fuel cell stack manufacture. As such, the long-term goals of this project are to establish, in parallel, the underlying materials science and corresponding joining technology that will facilitate deployment of the high-temperature electrochemical gas and energy extration technologies currently under development. Several types of inorganic membranes are being developed for hydrogen and oxygen separation. Research approaches currently supported by FE and monitored by NETL include microporous membranes and solid mixed ionic/electronic conducting oxide membranes, both under development at Oak Ridge National Laboratory (ORNL); and palladium-based separation membranes, under development at Los Alamos National Laboratory (LANL).

CONTACTS

Robert R. Romanosky
Technology Manager
Advanced Research
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4721
robert.romanosky@netl.doe.gov

Patricia A. Rawls
Project Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-5882
patricia.rawls@netl.doe.gov

K. Scott Weil
Principal Investigator
Pacific Northwest National Laboratory
902 Battelle Boulevard
P.O. Box 999
Richland, WA 99352-1793
509-375-6796
scott.weil@pnl.gov

PROJECT DURATION

10/01/05 to 09/30/09

COST

Total Project Value
$1,100,000

DOE/Non-DOE Share
$1,100,000 / $0

ADDRESS

National Energy Technology Laboratory

1450 Queen Avenue SW
Albany, OR 97321-2198
541-967-5892

2175 University Avenue South
Suite 201
Fairbanks, AK 99709
907-452-2559

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

One West Third Street,
Suite 1400
Tulsa, OK 74103-3519
918-699-2000

CUSTOMER SERVICE

1-800-553-7681

WEBSITE

www.netl.doe.gov

To overcome difficulties related to the joining of dissimilar materials under extreme conditions of heat and chemical composition, such as those encountered in a gasifier, PNNL researchers recently developed a method of ceramic-to-metal brazing referred to as air brazing. This important technique differs from traditional active metal brazing in two important ways: (1) it utilizes a liquid-phase oxide-noble metal (silver-copper) melt as the basis for joining, and therefore exhibits high-temperature oxidation resistance; and (2) the process is conducted directly in air without the use of fluxes and/or inert cover gases. The current project continues development of the air brazing technique along two distinct paths: (1) a series of scientific studies to explore how the Ag-CuO (silver copper oxide) base filler metal can be modified to alter the metallurgical and brazing properties, as, for example, the addition of a higher melting point noble metal, palladium (Pd), to the filler metal; and (2) an engineering investigation of air-brazed joint properties, specifically hermeticity (permeability to hydrogen and oxygen) as a function of coal as exposure. The general approach to developing the air brazing technique has been to focus primarily on membranes for hydrogen separation, in particular, microporous alumina.

Accomplishments

Researchers continue to advance their understanding of the underlying wetting/adhesion mechanisms for this unique braze, and to further develop the air-brazed joining capability through performance testing using such devices as that shown in Figure 1. The next objectives in this program are to: (1) finalize the work on the Pd-Ag-CuO system, including determining joint strength as a function of Pd content; (2) complete the first round of long-term coal gas exposure testing; and (3) develop a means to carry out brazing outside of a standard furnace, e.g., by using an internal exothermic heat source buried within the air-braze filler metal foil, or by employing inductively coupled heating. In addition, development of the joining technology will continue in order to support ORNL's nanoporous alumina hydrogen membrane work, which is being conducted in collaboration with Alfred University.

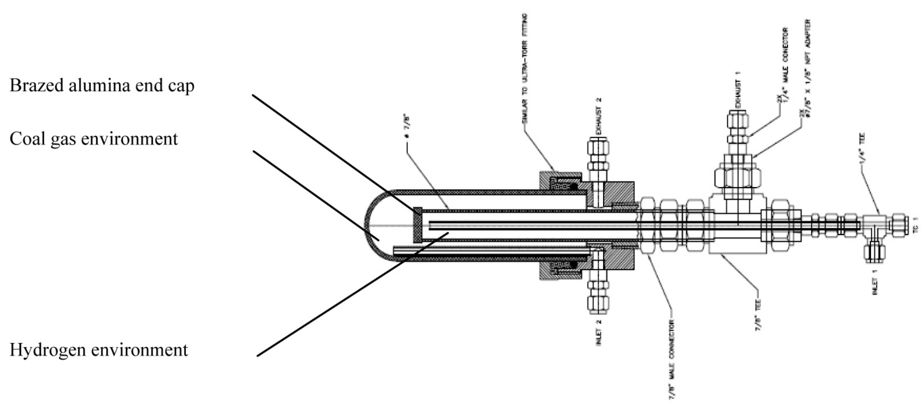

Figure 1: Schematic of the tubular specimen employed in coal gas exposure testing of air braze filler metals.