II.B.1 The Integration of a Structural Water-Gas-Shift Catalyst with a Vanadium Alloy Hydrogen Transport Device

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Objectives

The objective of this work is to produce a device, scalable in nature, which performs both the water-gas-shift and hydrogen separation functions for a stream of synthesis gas derived from gasification of coal. WRI proposes to develop a device that would improve a hydrogen production system. By using this approach, total hydrogen will be maximized and an additional benefit would also be derived from the reduction in capital cost of the plant by the removal of one step in the process by integrating water-gas-shift with the membrane separation device.

Introduction

The research topic for this project requires a system that combines water-gas-shift technology with separation technology for coal-derived synthesis gas. The justification of such a system would be improved efficiency for the overall hydrogen production. By removing hydrogen from the synthesis gas stream, the water-gas-shift equilibrium would force more carbon monoxide to carbon dioxide and maximize the total hydrogen produced. Additional benefit would derive from the reduction in capital cost of plant by the removal of one step in the process by integrating water gas shift with the membrane separation device.

Approach

This project consists of three steps in the improvement of the hydrogen production system: 1) an improved monolithic water-gas-shift catalyst that provides efficient conversion of carbon monoxide and structural support for a stacked assembly of membranes, 2) an improved vanadium alloy hydrogen transport membrane suitable for the chemical and physical environment of the coal-derived synthesis gas stream, and 3) an integrated stacked catalyst and membrane assembly scalable for commercial devices and economically designed for mass production. The structural water-gas-shift catalyst will have a formulation that will eliminate the friable nature of current iron oxide based pellets. The shape of the catalyst will be important in the structure. Standard ceramic processing techniques will be used to formulate, mix, extrude and sinter porous corrugated sheets of catalyst. Testing of the ceramic for catalytic activity and compression strength will be conducted.

A series of trinary vanadium alloys will be obtained. These alloys will be based on previous research on vanadium alloys as hydrogen transport materials and enhanced for improved brazing performance. The alloys will be fabricated into foils and tested for hydrogen sulfide, steam and chlorine stability, hydrogen flux, braze strength, and hydrogen embrittlement resistance versus temperature and hydrogen concentration.

A device will be designed and fabricated in which the water-gas-shift catalyst acts as a structural part of the stacked components. The device will be tested for pressure integrity, hydrogen transport, catalyst activity, and performance improvements over current technology. The tests will be conducted in a syngas stream from a fluidized bed coal gasifier located at WRI. For the project, WRI will be partnered with the Department of Chemical and Petroleum Engineering at the University of Wyoming.