Thesis Defense

Student: Jason Eargle

Title: Development and Analysis of a Conceptual Design for a Thermally Efficient Hybrid Sulfur Hydrogen Production Process

Date/Time: Monday, May 22, 2006 at 10:00 am (changed to Tuesday, June 13)

Location: ME Conference Room

Committee Members: Dr. Travis Knight (Advisor)  
Dr. Maximilian Gorensek – Savannah River National Laboratory  
(Second Reader)

Graduate Studies Representative: Dr. Abdel Bayoumi

Abstract

The Savannah River National Laboratory (SRNL) has been tasked by the DOE Office of Nuclear Energy, Science & Technology with developing the Hybrid Sulfur (HyS) cycle for hydrogen production as part of the Nuclear Hydrogen Initiative (NHI). HyS is conceptually the simplest of the thermochemical cycles. It involves only sulfur chemistry and has only two reaction steps. Through a joint effort between SRNL and USC, a conceptual design for a HyS hydrogen production process was modeled using Aspen Plus™ software, a procedure developed to extract stream heating and cooling data into Aspen HX-Net™ heat integration software, and minimum utility requirements for the process determined. The electrical and thermal requirements of the flowsheet were used to develop a target thermal efficiency for hydrogen production.

A systematic approach was used to optimize energy utilization. The likely ranges of several key operating parameters (e.g. decomposition reactor temperature and pressure, electrolyzer temperature and pressure, etc.) were established. Sensitivity analyses were performed for many combinations of the key parameters in which small operating parameter changes were made to heat exchange and pressure change operations to determine which had the greatest effect on the net thermal efficiency of the process. The results were used to suggest changes in flow sheet configuration and to manipulate parameters that would increase overall efficiency.

Heat exchanger networks were developed for the final flow sheet design using well known heat integration techniques. The actual utility requirements of the heat exchanger network were used to determine a net thermal efficiency of the HyS hydrogen production process.

A net thermal efficiency of 46.8% (Higher Heating Value, or HHV) was predicted for the initial version of the flowsheet. After some design changes and operating parameter optimization,
a target thermal efficiency of 54% (HHV) was achieved. Several heat exchanger networks were developed for this flow sheet that operate at approximately 100 to 105% of the previously calculated heating utility targets. Practical networks are likely closer to 105% of target. Thus, the HyS flow sheet can be expected to operate at net thermal efficiencies of 52.5% (HHV) or better.