SAND2006-7158C

Sulfuric Acid Decomposition with Heat and Mass Recovery Using a Direct Contact Exchanger

2006 Annual Meeting of the American institute of Chemical Engineering

Fred Gelbard[1], Robert C. Moore[1], Milton E. Vernon[1], Edward J. Parma[1], Dion A. Rivera[2], **Howard B. J. Stone[1]**, James C. Andazola[1], Gerald E. Naranjo[1], and Paul S. Pickard[3].

(1) Advanced Nuclear Concepts, Sandia National Laboratories, POB 5800, Albuquerque, NM 87185, (2) Biomolecular Imaging & Analysis, Sandia National Laboratories, POB 5800, Albuquerque, NM 87185, (3) Advanced Nuclear Concepts (Manager), Sandia National Laboratories, POB 5800, Albuquerque, NM 87185

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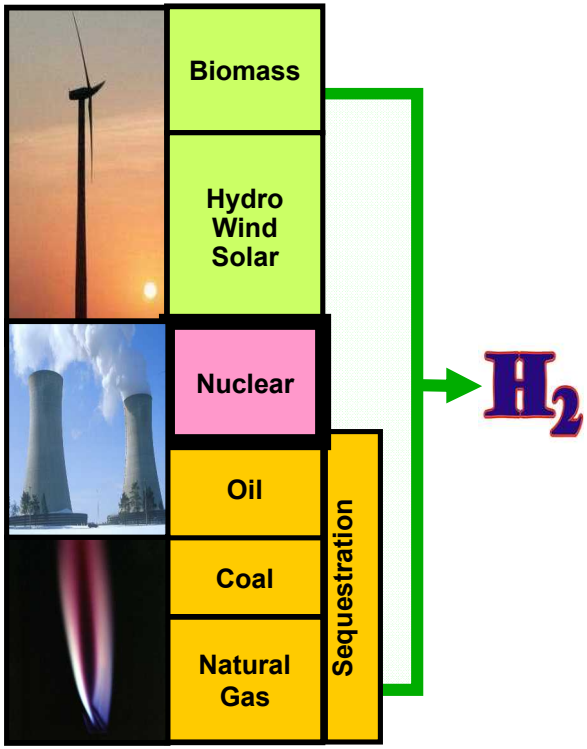
Nuclear Hydrogen Initiative



- The US DOE is investigating H_2 production using all primary energy sources
- Nuclear Hydrogen Initiative (NHI) is focusing on production options using very high temperature gas cooled reactors (VHTR). Research includes:
- *Thermochemical cycles and high temperature electrolysis to produce hydrogen from water*
- *The development of high temperature heat exchanger materials and designs needed for the temperatures and pressures of VHTR*

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Sulfur Thermochemical Cycles

Sulfur Based Thermochemical Cycles

Sulfur Iodine

(1) $H_2SO_4 \rightarrow H_2O + SO_2 + 1/2O_2$

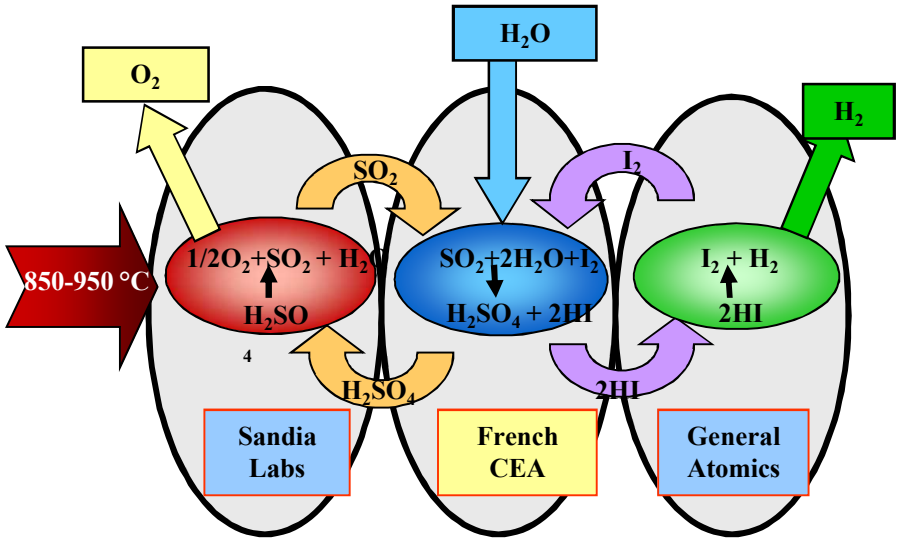
(2) $2HI \rightarrow I_2 + H_2$

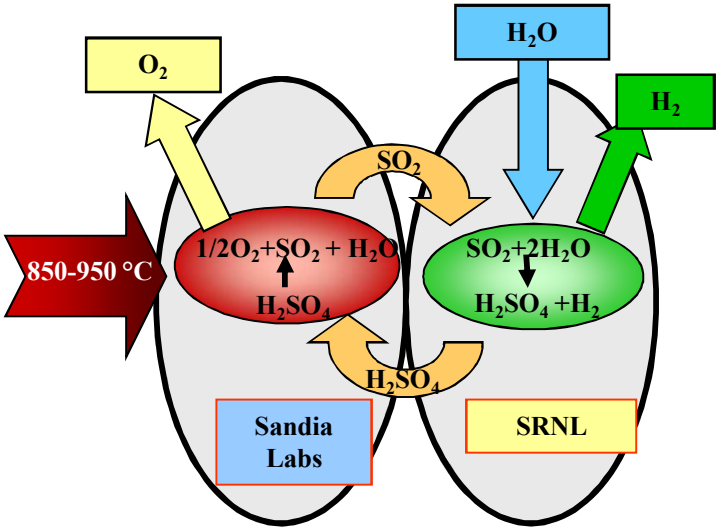
(3) $2H_2O + SO_2 + I_2 \rightarrow H_2SO_4 + 2HI$

Hybrid-Sulfur

(1) $H_2SO_4 \rightarrow H_2O + SO_2 + 1/2O_2$

(2) $2H_2O + SO_2 \rightarrow H_2SO_4 + H_2$





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Sandia Programmatic Goals

- Develop and construct a H_2SO_4 decomposition process with a production capacity of 100 – 200 l SO_2/hour (equivalent to 100 – 200 l H_2/hour)
- Integrate the Sandia H_2SO_4 decomposition process with the two other sections of the S-I cycle, being developed by General Atomics Corporation and the French Commissariat a l'Energy Atomique (CEA)
- The full S-I cycle is to be operated at the General Atomics Facility in San Diego in 2007

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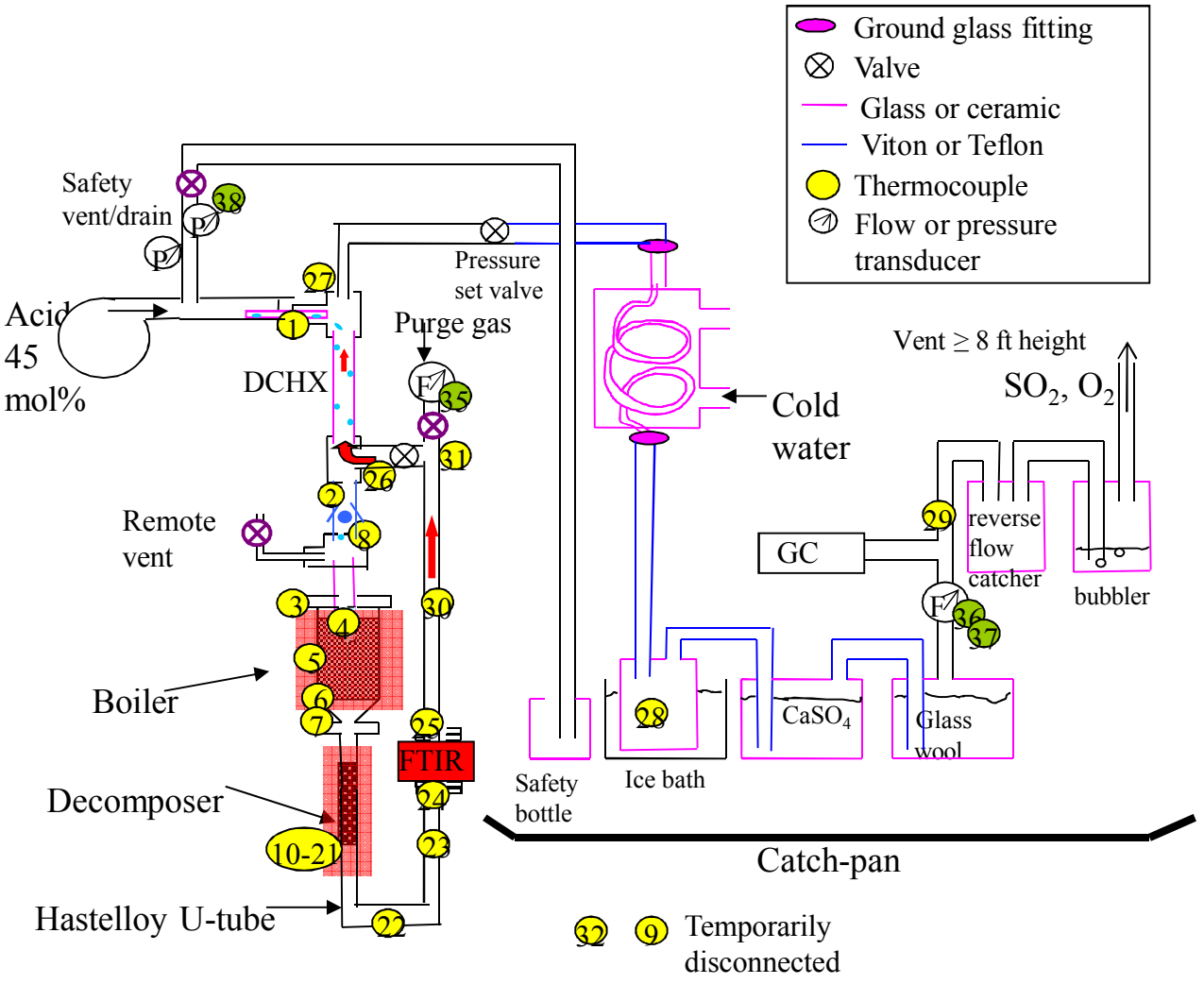
Experimental Design

- Construction of glass lined steel, Hastelloy and glass
- Ozturk et al (1995) direct contact heat/mass exchanger
- Gravity feed of acid into acid boiler/superheater/decomposer
- Platinum catalyst
- Operating conditions: acid decomposition 750 to 875ºC and pressures between 6 to 11 bar.

Experimental System



Surrounding chemical sorbent roll around tent perimeter

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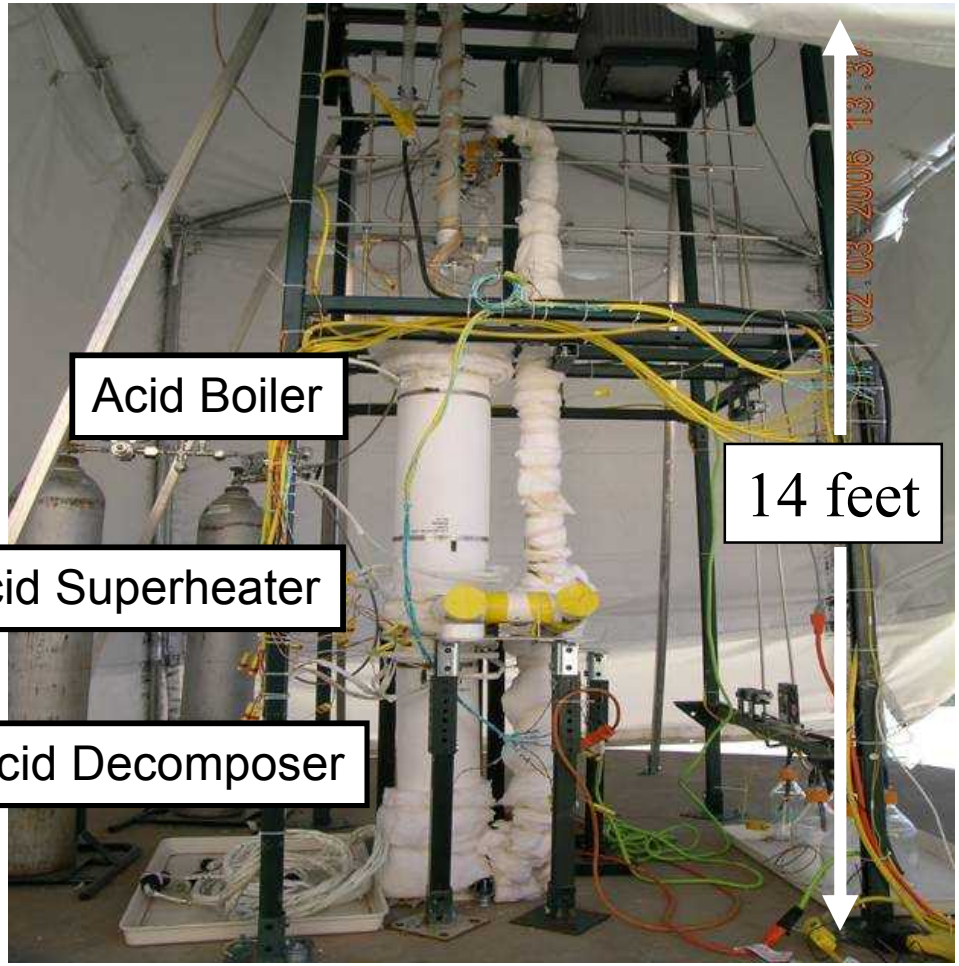
Experimental System

- Constructed of highly corrosion resistant metals, glass, and ceramics
- Sections of the process were bolted or compression fit together
- Although significant improvement was observed, problems with corrosion and high-temperature connections continued



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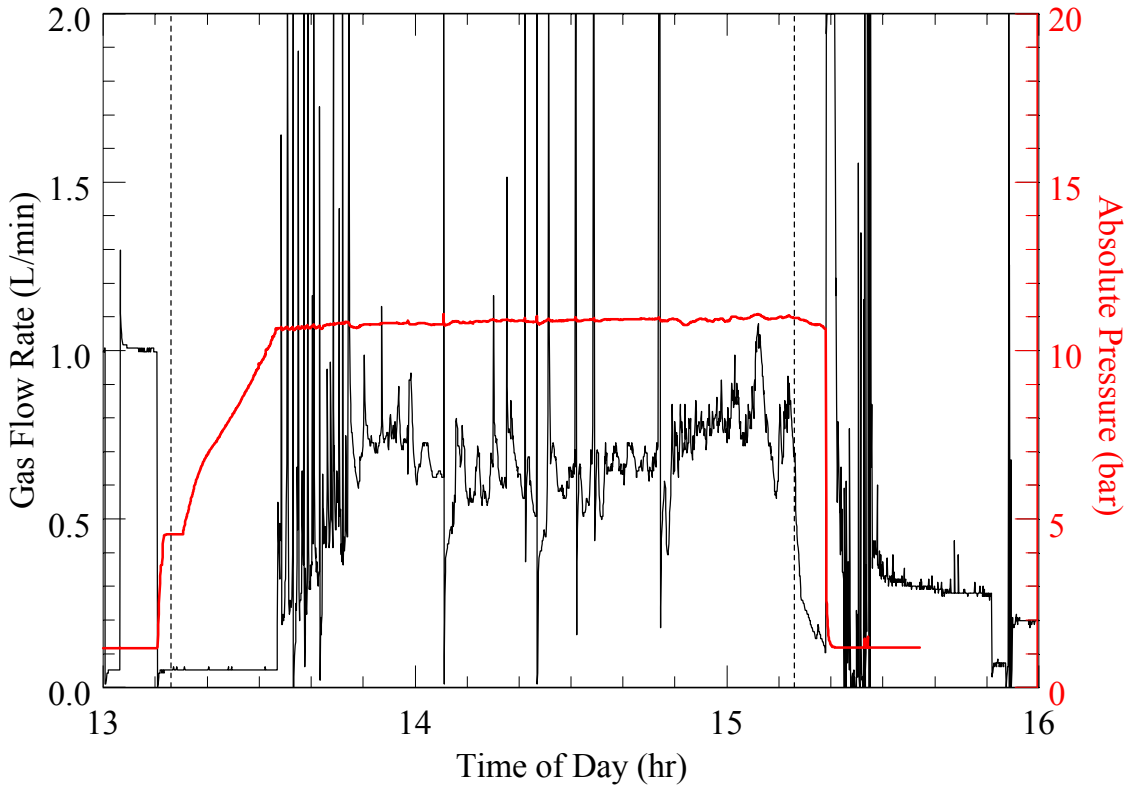
Experimental Results



Total gas flow rate of effluent and system pressure for pressurized acid test at 11 bars. The vertical broken lines on the left and right correspond to the times at which the acid pump was turned on and off, respectively.

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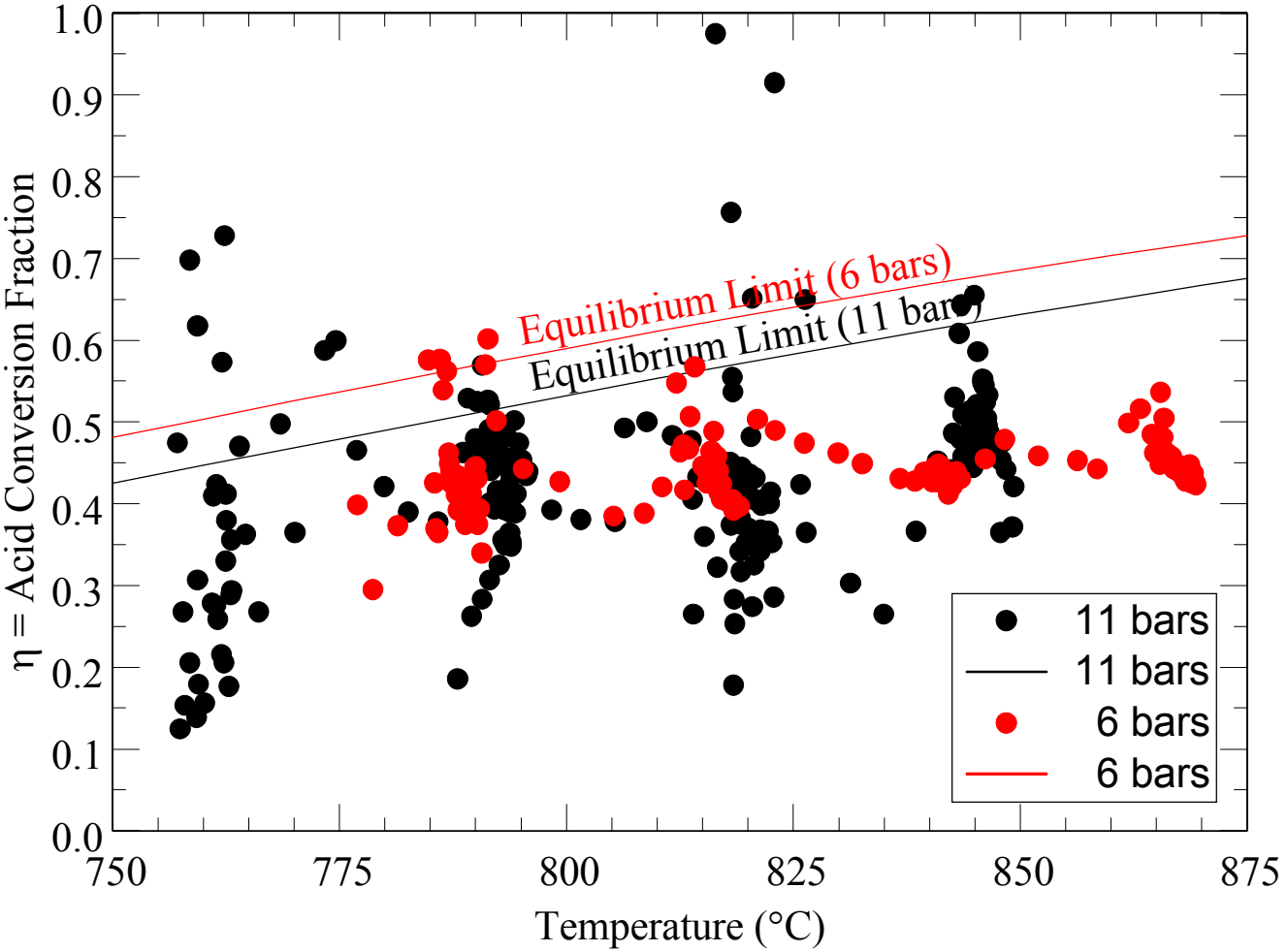
Experimental Results



Comparison between conversion fractions at 6 and 11 bars over the temperature range 750 °C to 875 °C. Values in red and black are for6 and 11 bars, respectively.

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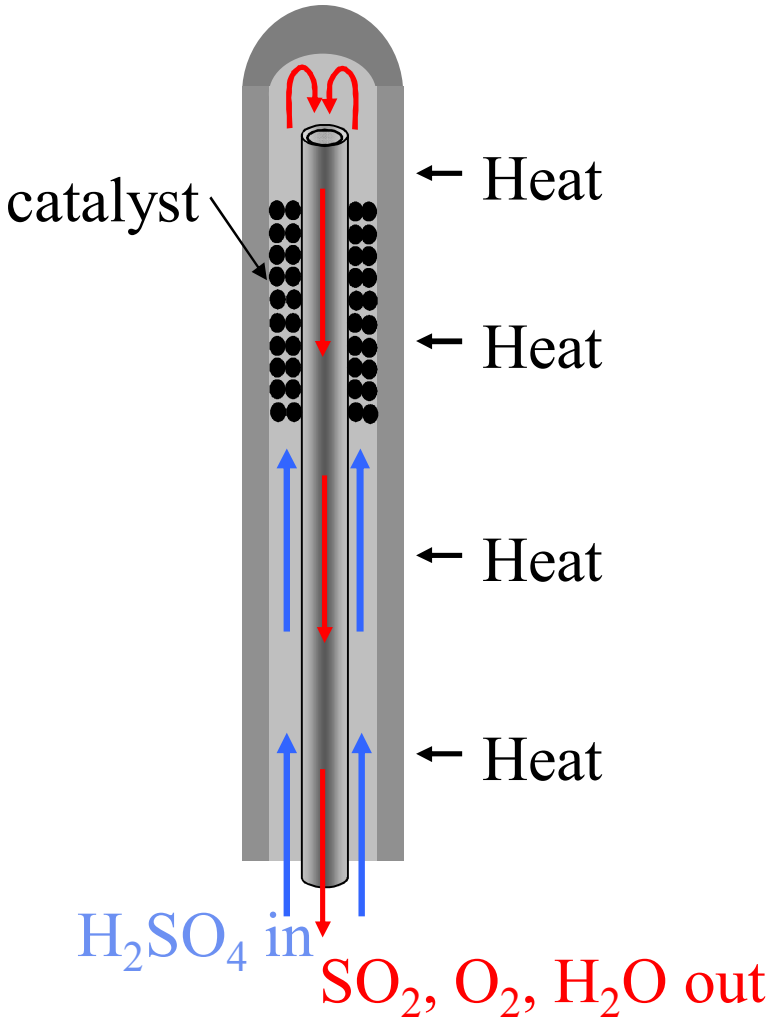
Observations from Experiments

- The apparatus was successfully operated at 750 to 875ºC at pressures between 6 to 11 bar.
- Issues with corrosion, and high-temperature connections
  - Even though the materials of construction were glass lined steel and Hastelloy corrosion was evident
  - Metal to metal connections failed due to metal warping at temperatures in excess of 600ºC
- These issues have led to a new design using a silicon carbide alloy as the construction material

Future Work: Integrated Sulfuric Acid Boiler/decomposer

- New design based on a dual-tube bayonet type heat exchanger
- Silicon carbide construction
- Heat recuperation throughout process
- No high temperature connections



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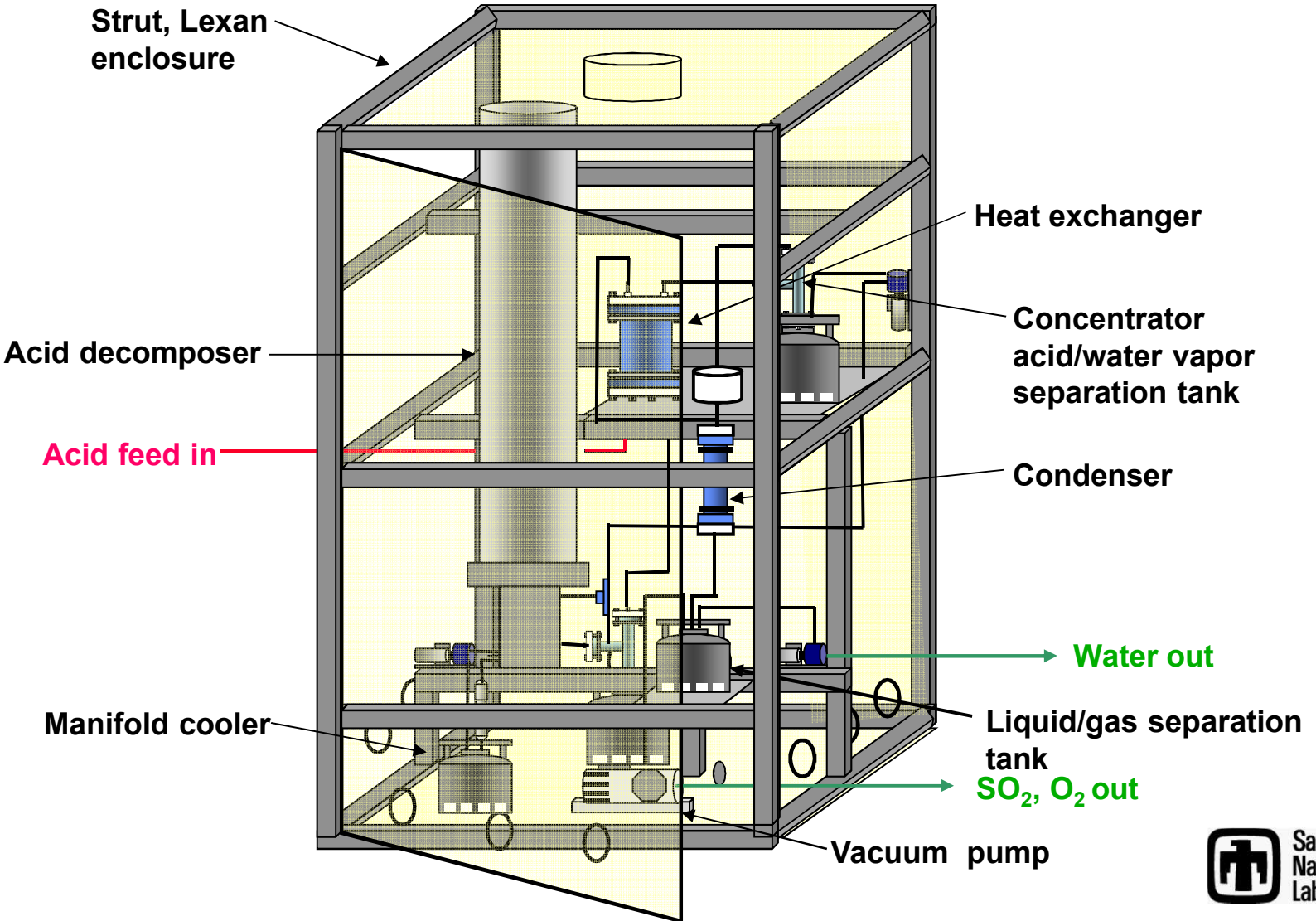
Future Work: Sulfuric Acid Process Skid Configuration



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Acknowledgements

The work was funded under the United States Department of Energy Nuclear Hydrogen Initiative Program

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000

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