PINK HYDROGEN ENERGY

Nuclear Hydrogen Formation Utilizing Thermochemical Hybridized Steam Electrolysis

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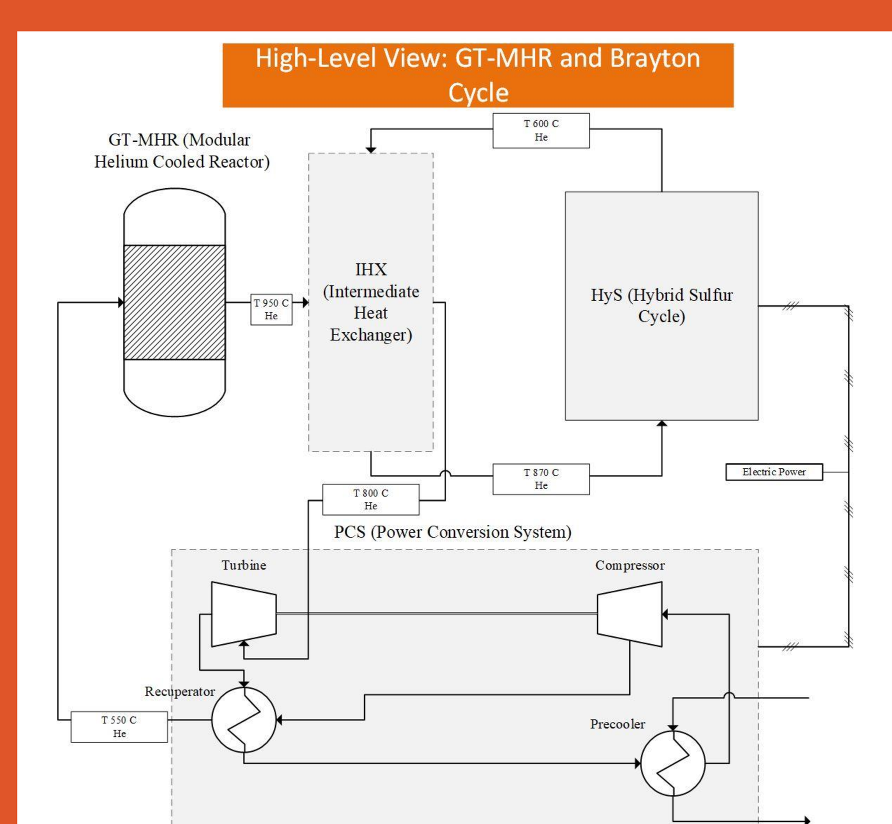
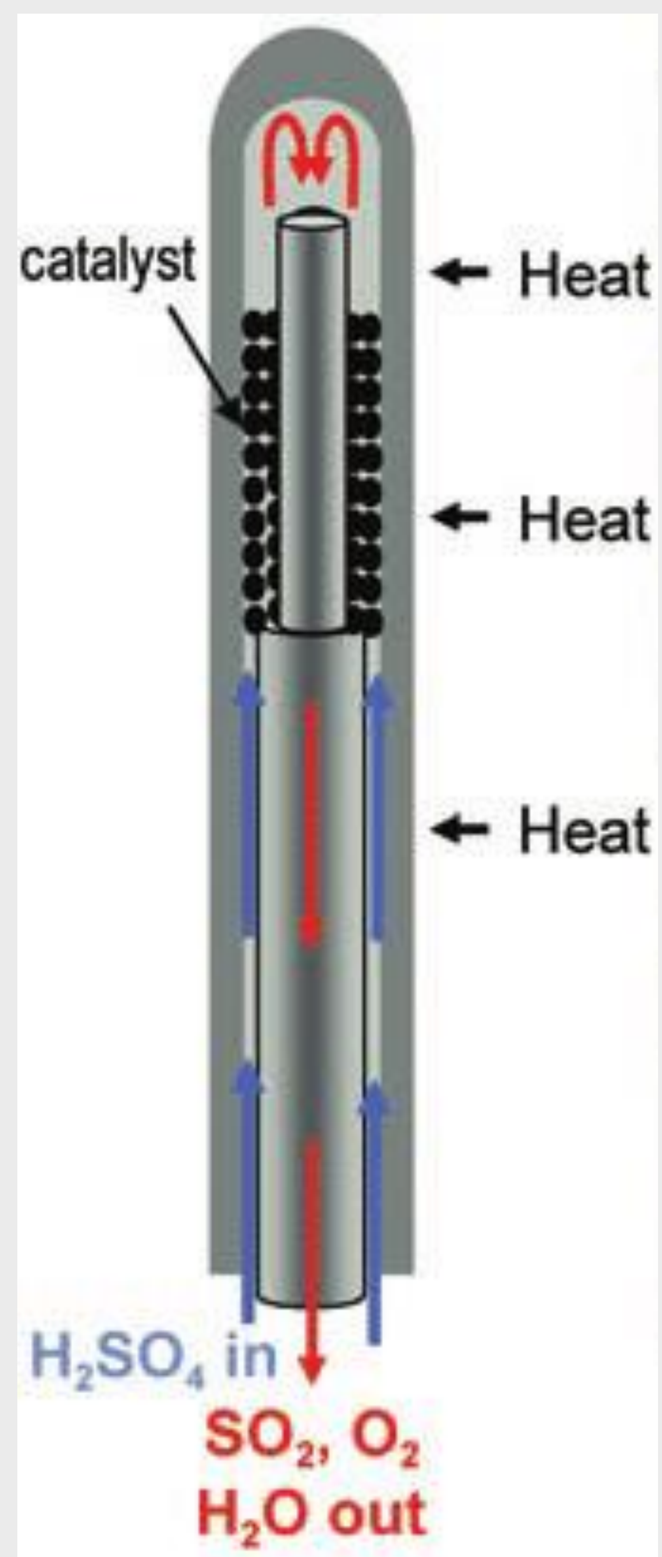
NEXT UP, HYDROGEN

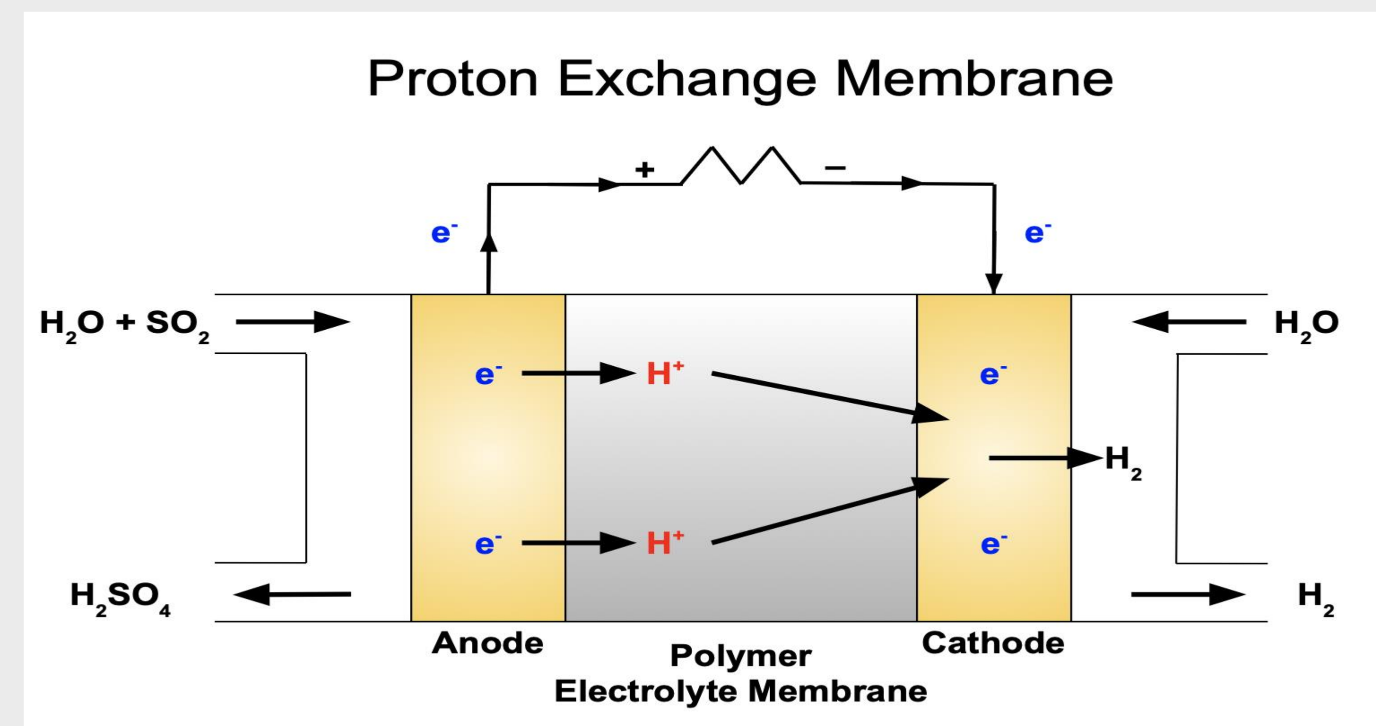
- Nuclear energy is the largest carbon-free energy source in the United States.[1],[2]
- Nuclear energy production methods are more reliable than renewable sources, allowing nuclear energy to supplement green energy.[1]
- At times of low energy demand, unutilized thermal energy and power can be used to produce hydrogen.[3],[4]
- Hydrogen in its molecular form, H_2, has a great capacity for energy-storage and industrial applications.[5]
- Hydrogen fuel is currently produced as a byproduct of natural gas production or other processes that involve carbon.[5]
- Hydrogen fuel production via nuclear power is considered a carbon-free process.[5],[9]
- One way of producing hydrogen is through the Westinghouse Sulfur Cycle. This cycle uses an electrolysis cell combined with a sulfuric acid degradation reactor to break water down into hydrogen and oxygen.



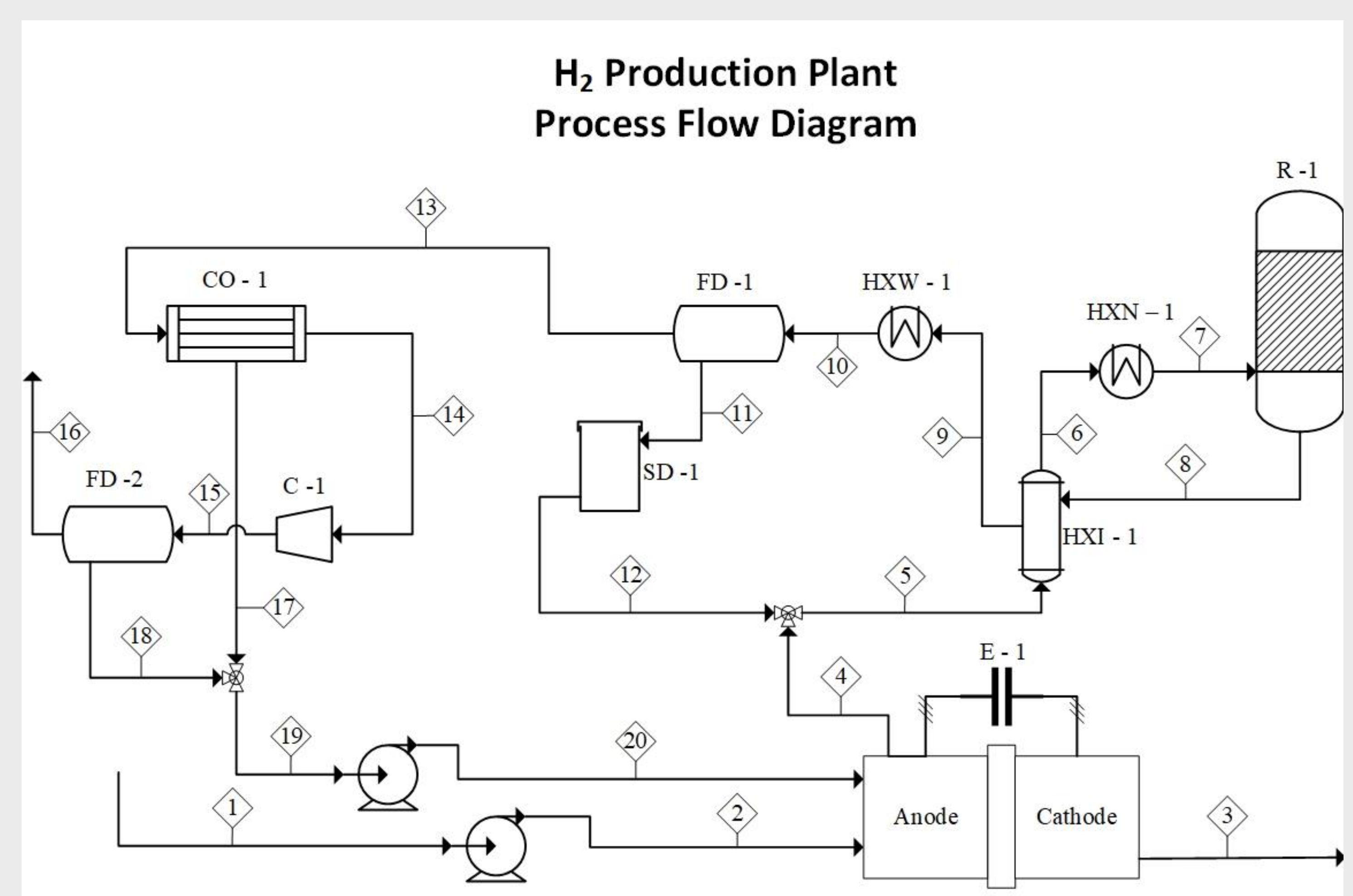
Overview of Hydrogen Production Plant in Relation to Nuclear Reactor and Power Generation.[8]



Silicon Carbide Bayonet Reactor used in thermal decomposition of H_2SO_4.[6]



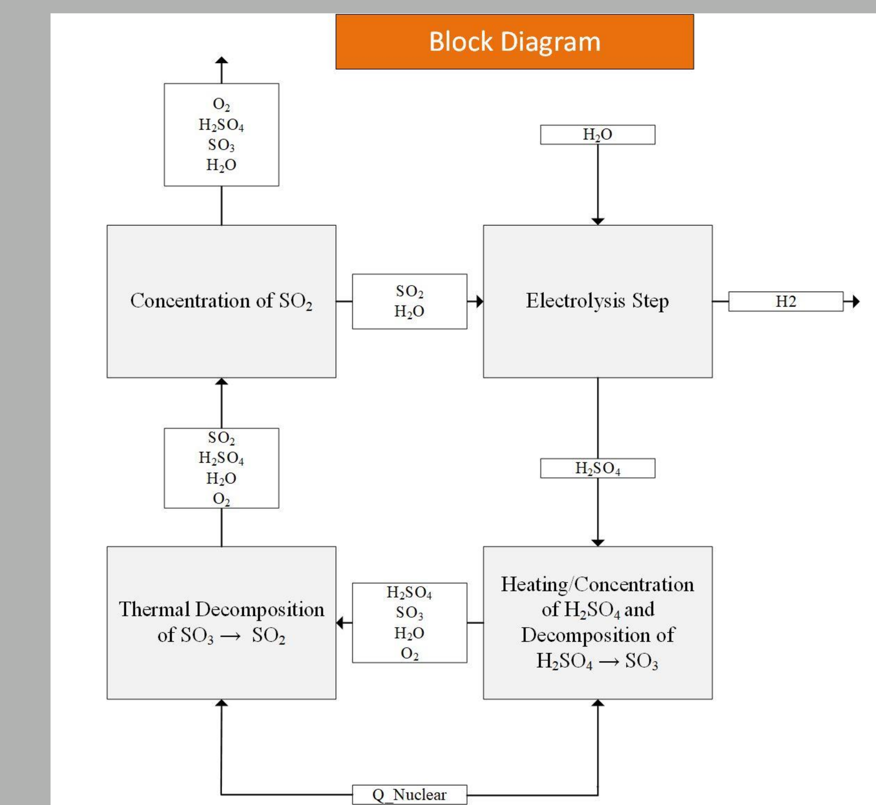
Proton Exchange Membrane (PEM) electrolysis of sulfur dioxide and water to produce hydrogen.



Process Flow Diagram (PFD) of Westinghouse Model-Based Hydrogen Production Plant.

TAKEAWAY RESULTS

- Daily production output of 170 metric tons of H_2, with operation ramp-up in the hours of 12am – 6am.
- Original design incorporates one bayonet reactor and one proton-exchange membrane (PEM) fuel cell.
- For thermal decompositions above 1200 K, a nuclear reactor temperature above said temperature is necessary[9]. For this process, the GT-MHR (Gas Turbine – Modular Helium Cooled Reactor) conceptual nuclear reactor is considered.[8]
- Final cost of produced hydrogen in the range of \$1.64/kg[5] to \$3.85/kg[9].
- Hydrogen production plant will be located near areas like Philadelphia, by the Delaware River, and northern Illinois, near the Illinois and Mississippi Rivers.



Block Diagram Process Flowsheet with Chemical Species.

Reaction Kinetics [7]

$$H_2SO_4\,(aq) \rightarrow H_2O\,(g) + SO_2\,(g) + 1/2\,O_2\,(g) \quad (1)$$

$$SO_2\,(aq) + 2\,H_2O\,(l) \rightarrow H_2SO_4\,(aq) + H_2\,(g) \quad (2)$$

Future Work

- Improve thermodynamic efficiency by reducing heat losses in system.
- Continue to develop and evaluate alternative electrolysis technologies.
- Evaluate material lifetime and degradation using process condition variation.
- Investigate long-term global economic impacts of development of this technology.
- Consider methods to utilize additional green sources of energy in operations.

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