



Materials Development Makes Large Scale Hydrogen Production a Reality

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The Sulfur-Iodine (S-I) cycle is a thermochemical water-splitting reaction that utilizes thermal energy from a high temperature heat source such as a nuclear reactor or a solar tower to produce hydrogen. The cycle consists of three sections: Bunsen Reaction, Sulfuric Acid Decomposition and HI Decomposition that are currently being developed by the French CEA, Sandia National Laboratory, and General Atomics, respectively. The key advantage of the S-I cycle is that it has no effluent and the reactants are in easily transportable liquid or gaseous form. It has a projected cycle thermal efficiency of 47% which makes it one of the best economical prospects for large scale industrial production of hydrogen. An integrated bench scale demonstration loop sponsored by DOE and French CEA will be in operation at General Atomics in 2007.

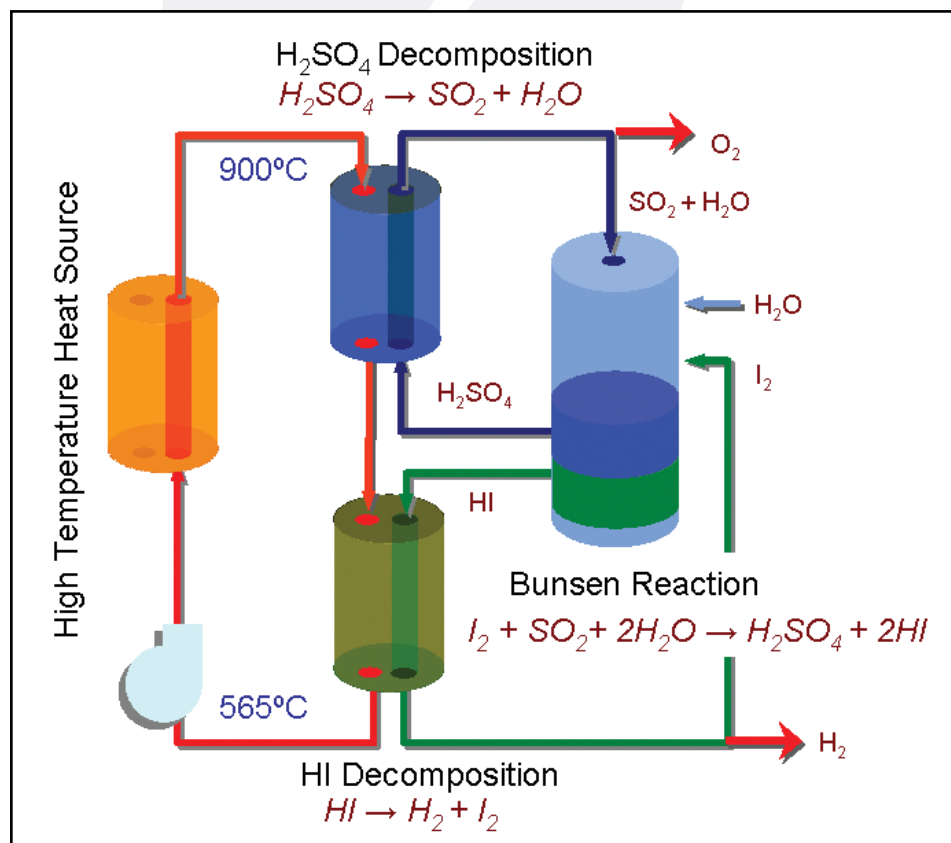
A key issue in scaling up the S-I cycle has been the corrosive nature of the chemicals that are involved. The identification and qualification of construction materials to fabricate components such as heat exchangers, boilers and reactors are two of the main objectives of the Nuclear Hydrogen Initiative.

Extensive materials development work during the past three years coupled with experience accumulated over the last three decades has helped to distinguish suitable materials with low corrosion rates in the harsh environment encountered in the three different sections. For the high temperature sulfuric acid decomposition step, Alloy 800 and Hastelloys have long been the established materials of choice. When dealing with concentration and evaporation of sulfuric acid, Fe-Si alloys have been shown to perform well in those environments. Recent advancements in SiC based ceramic component processing and novel heat exchanger

designs have opened up the possibility of using this class of ceramic materials for these two applications. For handling the extremely corrosive liquid iodine and HI acid in the HI decomposition section, Ta and Ta-W alloys were found to have the best corrosion resistance with a corrosion rate of less than 0.05mpy. In the high temperature setting with gaseous HI and iodine, Hastelloys have been qualified as suitable construction materials. The material requirements for the Bunsen section are less demanding and glass lined steel and Nb alloys have been shown to adequately fulfill the need to contain the various acids found in this section.

The first phase of materials development for the S-I cycle has been completed

as components of the bench scale demonstration loop have been fabricated based on the knowledge gained so far. More extensive materials testing including long term immersion testing, stress corrosion cracking and high temperature creep behavior studies to help characterize the materials in the working environments are underway. In addition, long term component level testing and equipment design (like cladding) to minimize the use of expensive Ta and Nb alloys in component fabrication are also essential. Such information is necessary for the design and construction of the pilot scale S-I demonstration planned for 2012.



A schematic showing the three sections of the S-I cycle coupled to a heat source.