Status of the I-NERI Sulfur-Iodine Integrated-Loop Experiment

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Sandia National Laboratories (SNL), General Atomics Corporation (GA) and the French Commissariat à l'Energie Atomique (CEA) are participants in a international collaborative effort to construct a laboratory-scale Sulfur-Iodine (S-I) process capable of producing 100-200 L/hr of hydrogen. This project is being conducted as an International Nuclear Energy Research Initiative (INERI) project supported by the CEA and the U.S. DOE Nuclear Hydrogen Initiative. The process has been constructed at General Atomics facility in San Diego, CA and testing is ongoing.

The S-I cycle consists of three main processing steps: thermal decomposition of sulfuric acid, production of hydrogen iodide and the decomposition of hydrogen iodide to produce hydrogen. SNL is responsible for the sulfuric acid decomposition section, the French CEA the hydrogen iodide production section and GA the hydrogen iodide decomposition section. The process sections are constructed on skids and are integrated through a chemical storage skid. All chemicals used in the process are transferred between the skids through the chemical storage skid with the exception sulfur dioxide that is transferred directly from the SNL skid to the CEA skid.

Phase I of this project involved integration of the three process sections into a complete S-I cycle. The initial integrated operation was performed in April of 2008 and is documented in the SAND Report titled “Results of Phase 1 Testing of the Sulfur-Iodine Integrated Laboratory-Scale Experiment”. Phase II of the work includes completion of initial integrated shakedown operations, control verification tests (interface skid operations, production rate tests, shutdown tests), transient response tests (startup, shutdown, flow rate perturbations, mismatched flow rates), and cross talk tests (inter skid contamination and response) and process improvements or modifications as budgets permit. The results from phase I of the project along with additional stand-alone and integrated tests have identified issues for each process section that have been addressed in phase II work. These include redesign and replacement of major system components, corrosion control and modification of process monitoring. Several identified problems have led to very significant process modifications. However, for all three process sections, all major modifications have been completed.

The General Atomics hydrogen iodide section has undergone several modifications and has been successfully operated multiple times to produce hydrogen. The hydrogen iodide reactor has been replaced with a smaller unit to decrease the time for preheating the unit and reach equilibrium while operating. Using the smaller reactor, hydrogen has been produced at a rate of 10 to 75 L/hr. Problems with differential pressure cells used throughout the process for monitoring and control have been eliminated by replacing the units with higher quality units. Ta alloy corrosion problems were encountered due to hydrogen embrittlement of Ta vessels and piping. Most of these issues have been mitigated for the ILS with either modified operational conditions, or periodic replacement. Longer term solutions are being developed and will be tested in FY09.

The French CEA has completed major modifications to the Bunsen section and the section is ready for additionally testing of the Bunsen reactor at this time. Completed modifications include: installation of a new Bunsen reactor equipped with Raschig ring packing and differential pressure cells for enhanced process control and a redesign and modification of the system for transferring iodine from the chemical storage skid to the CEA skid. In addition to these modifications, additional integrated testing with the SNL acid decomposition section has been completed and the transfer of chemicals between the CEA section and the SNL sections is now considered routine. The CEA will begin testing the new Bunsen reactor within the next few weeks as part of integrated operation with the SNL process section.

In the SNL acid decomposition section, system modifications include incorporation of an acid neutralization step to the process cooling water system to prevent corrosion of the circulating water chiller used in the process, an increased efficiency of the acid concentrator and the addition of a pressure control system to maintain a constant pressure in the acid decomposer. The acid decomposition process has been successfully operated multiple times over the past five months in the stand-alone and integrated modes. In the last operations of the process, the effect of temperature on acid decomposition was determined at a pressure of 1 bar. The results indicate the production of sulfur dioxide begins to decrease between 750 and 800ºC with a decrease in gas production of 50% at 700ºC. No sulfur dioxide was detected at 650ºC.

The GA hydrogen iodide decomposition section and SNL acid decomposition section of the S-I process are ready for additional integrated testing. All modifications have been completed and successful stand-alone tests have been performed with the new equipment. Major equipment modifications have been completed to the CEA section and the process is ready to begin testing of the newly installed Bunsen reactor. Testing of the Bunsen reactor will be performed in the stand-alone and integrated mode.