Thermal & Fluids Analysis Workshop 2002

In-Situ Resource Utilization (ISRU) Thermal, Fluid, and Process Modeling

NASA-JSC
Tom Simon
281-483-7547
tsimon@ems.jsc.nasa.gov

Abstract

In-Situ Resource Utilization (ISRU) Thermal, Fluid, and Process Modeling

Modeling of In-Situ Resource Utilization technologies and systems have been performed to support trade studies and ground testing. The models are used to determine promising methods and technologies of producing consumables for various missions including both robotic and manned missions to the moon and Mars. Testing of these technologies and overall systems rely on the models to help size components and develop operating procedures for specific production goals. This presentation will focus on the modeling done in support of an ISRU system that is sized for a robotic Mars sample return mission, producing 32 grams/hour of methane and 62 grams/hour of oxygen. This paper will cover the water electrolysis subsystem analysis and design, including testing to date.

In-Situ Resource Utilization (ISRU)

- **Modeling Performed**
  - **By NASA and Others**
  - **Support Trade Studies**
  - **Support Testing**
    - **Component Design**
    - **Subsystems**
    - **End-to-End Systems**

- **ISRU Background**
  - **Living Off The Land**
  - **Develop Systems To Provide Consumables**
  - **To Support Robotic and Human Exploration**
  - **Can Reduce Cost and Increase Safety**

Specific JSC ISRU Modeling

- Trade Studies
  - Determine Systems Best Suited To Meet Goals Of Missions: Qualitative
  - Size Systems To Provide Estimate Of System Parameters: Quantitative
- Testing Support
  - JSC Testing Of Technologies
    - Requires Design (If JSC Fabricated)
    - Requires System Design and Modeling

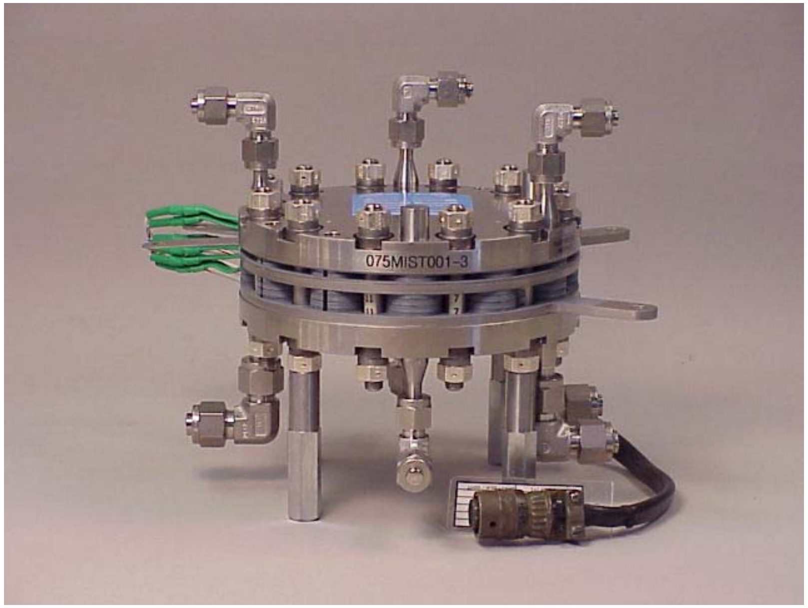
Modeling Supporting JSC Testing

- 2nd Generation ISRU System Design & Testing
  - Main Components
    - CO_2 Freezer (Lockheed Martin)
    - Sabatier Reactor (JSC)
    - Water Electrolysis (Hamilton Sundstrand)
    - Common Bulkhead Cryogenic Storage Tank (Lockheed Martin)
  - Sized For Robotic Mars Sample Return Mission
    - 32 g/hr of CH_4, 62 g/hr of O_2
    - 280 kg/yr (618 lb/yr) of CH_4, 543 kg/yr (1197 lb/yr) of O_2 (24 hrs/day Operation)

Modeling Supporting JSC Testing

- Water Electrolysis Subsystem Design
  - System Requirements Defined
  - System Components Designed or Procured To Support Hamilton Sundstrand Built Electrolyzer
- Sabatier Reactor Subsystem Design
  - System Requirements Defined
  - Sabatier Reactor Model, Design, and Fabrication
  - System Components Designed or Procured To Support JSC Built Sabatier Reactor

MIST Water Electrolysis Unit System Configuration

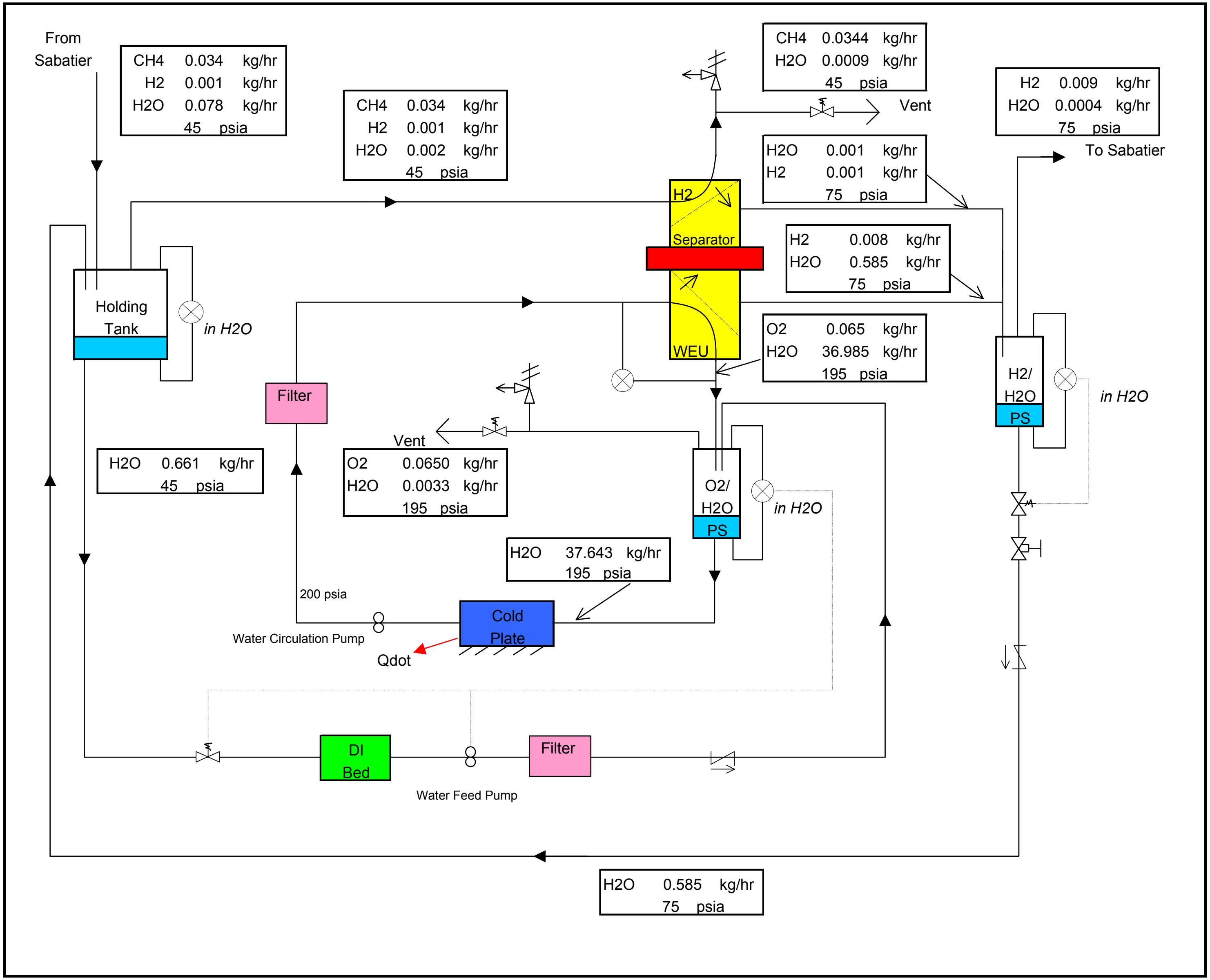


- MIST Liquid Anode Feed WEU From Hamilton Sundstrand
- Design of WEU System Configuration
  - Mass Flow Rate Calculations
  - Set Requirements for Hardware
  - Select Hardware
  - System Schematic
  - Pro/Engineer Model

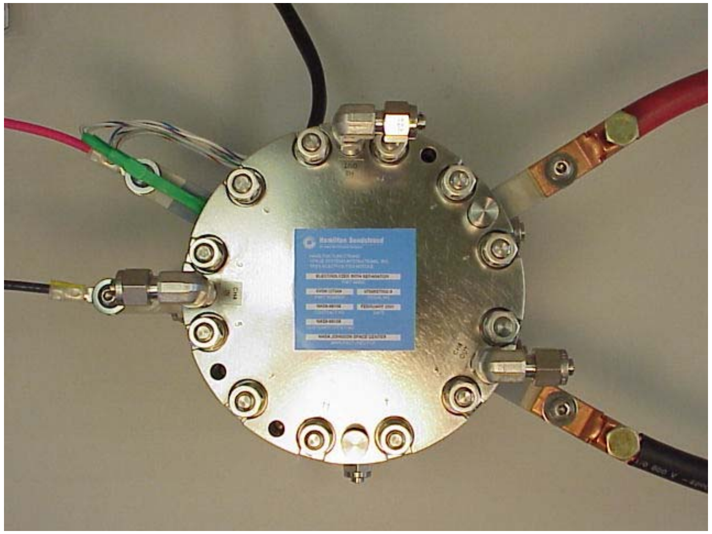
Where to begin?

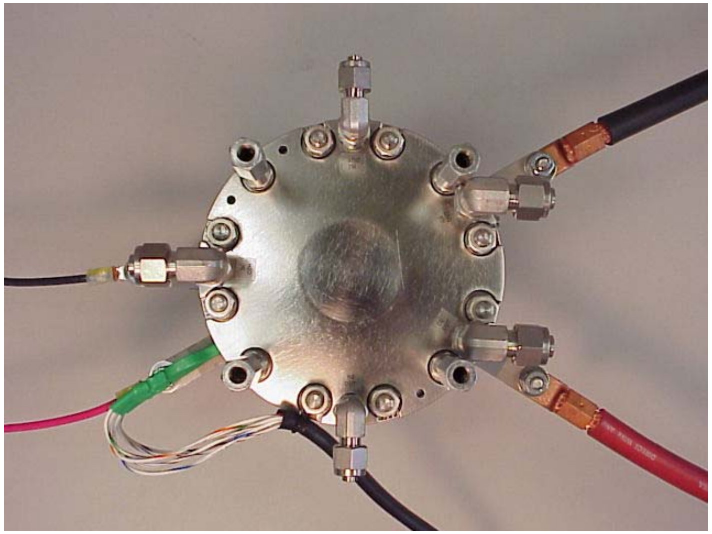
- Inputs
  - Recommendations from Hamilton Sundstrand
  - Improvements desired over first ISPP breadboard
- Procedure followed
  - Determine the WEU requirements
  - Select components and configuration of system to meet requirements
  - Select miniature, flight like components

Fluid Analysis



WEU Requirements





- Hydrogen Separator
  - Methane and Hydrogen go in
  - Two outlets
    - Methane
    - Hydrogen
- Water Electrolysis Unit
  - Water goes in
  - Two outlets
    - Hydrogen and water
    - Oxygen and water

Selected Components To Purchase

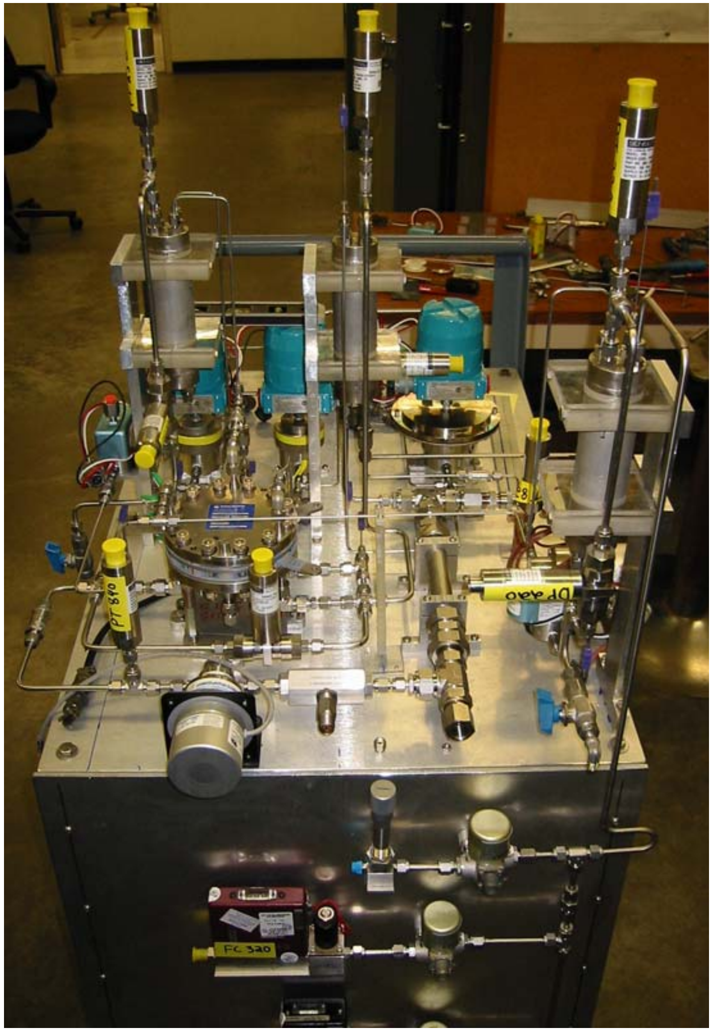
- Finding the right components
  - Searching the internet for miniature components that meet the requirements
  - These components include:
    - Water feed pump
    - Water circulation pump
    - Latching solenoid valves
    - Delta pressure transducer
    - Feed line filter
    - Circulation loop filter
    - Check valves
    - Cold Plate
    - Cartridge Heaters

Components Designed for In-House Fabrication

- On-site produced hardware
  - Sizing components to meet our needs
  - These components include
    - Phase Separator Tanks
      - Three units to separate water and gases
    - Deionization bed
      - Cation resin bed to remove possible iron, chrome, and platinum ions from water feed line

Second Generation Breadboard Schematic

System Assembly



MIST WEU Conclusion

- Initial configuration completed
- MIST hardware scheduled to be delivered in November

Conclusion

- Detailed Modeling and Analysis Is Required To Transform Theoretical Systems Into Actual Systems
  - Fabrication and Procurement of Hardware
  - Operational Procedures For System
  - Characterization of System For Use In Studies