The First Step in VU's Solar Hydrogen Process:

Development of a Solar Thermal Reactor for the Reduction of Metal Oxide Particles

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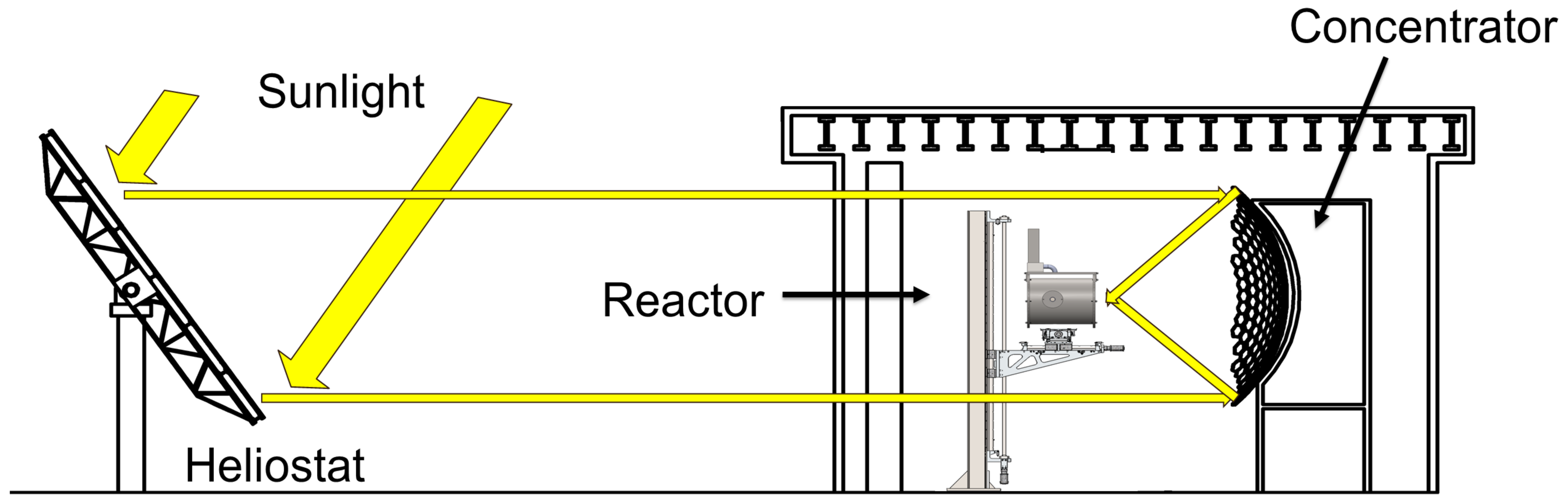
Introduction

With the current uncertainty in the future of fossil fuel energy, solar energy has risen as a competitor for large scale energy production. Many have argued that one of the most promising futures for solar energy is the production of solar chemical fuels. A solar thermal reactor has been designed to experimentally investigate promising paths for reducing metal oxide particles to reduced oxidation states (e.g. Fe_2O_3 to Fe_3O_4) utilizing concentrated solar energy. This reactor is windowless, able to withstand temperatures in excess of 1700 K, and has a feed system with variable particle residence time. Furthermore, this reactor utilizes a universal instrumentation system. A large-scale metal oxide reactor would serve as the first step in a metal oxide solar chemical cycle for the production of hydrogen. This hydrogen would be used in fuel cells to generate electricity or as a base material for the production of more traditional hydrocarbon fuels.



Schematic of Valparaiso University's Solar Energy Research Facility

Metal Oxide Solar Chemical Cycle

- Concentrated solar heat reduces metal oxide particles
- Electrolysis utilizes electrical work to split water
- Reduced particles reduce the required cell potential
- At the anode, the particles are oxidized to their original form
- At the cathode, gaseous hydrogen is collected as a fuel

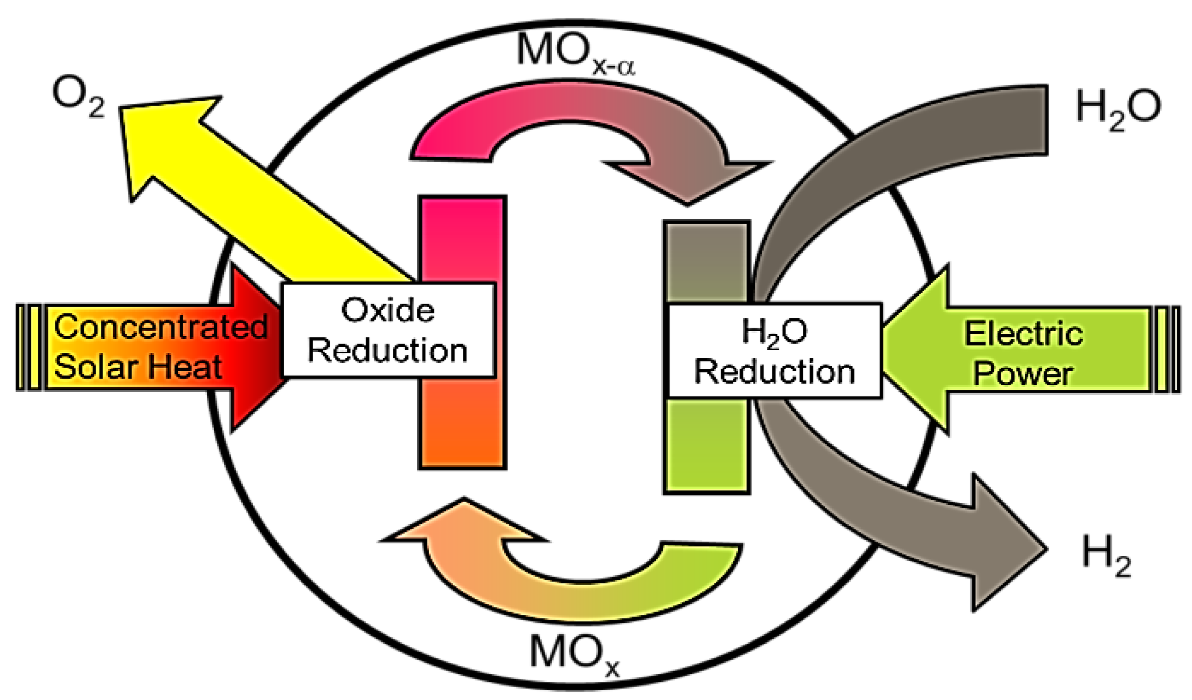


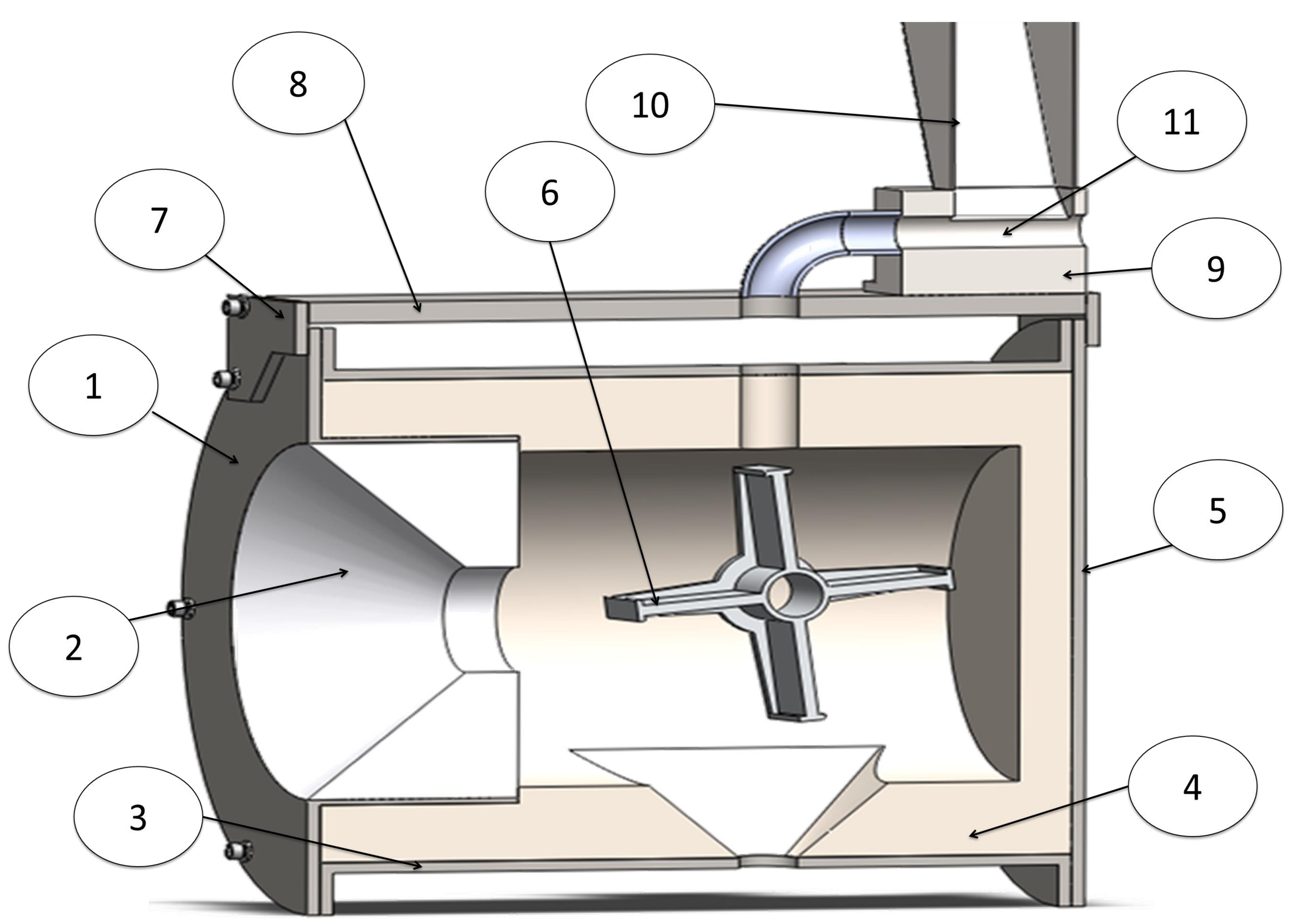
Diagram of a Metal Oxide Solar Chemical Cycle

Project Scope

Design a reactor to facilitate the reduction of metal oxide particles
This reactor:

- Utilizes concentrated solar energy
- Is windowless (open to air)
- Withstands temperatures up to 1700 K (2600 ^{0}F)
- Has a quasi-continuous feed system
- Has variable particle residence times
- Is compatible with particle sizes between 325 mesh and 1 mm
- Has a instrumentation system with graphical user interface

Reactor Design



Cross Sectional View of the Solar Thermal Reactor

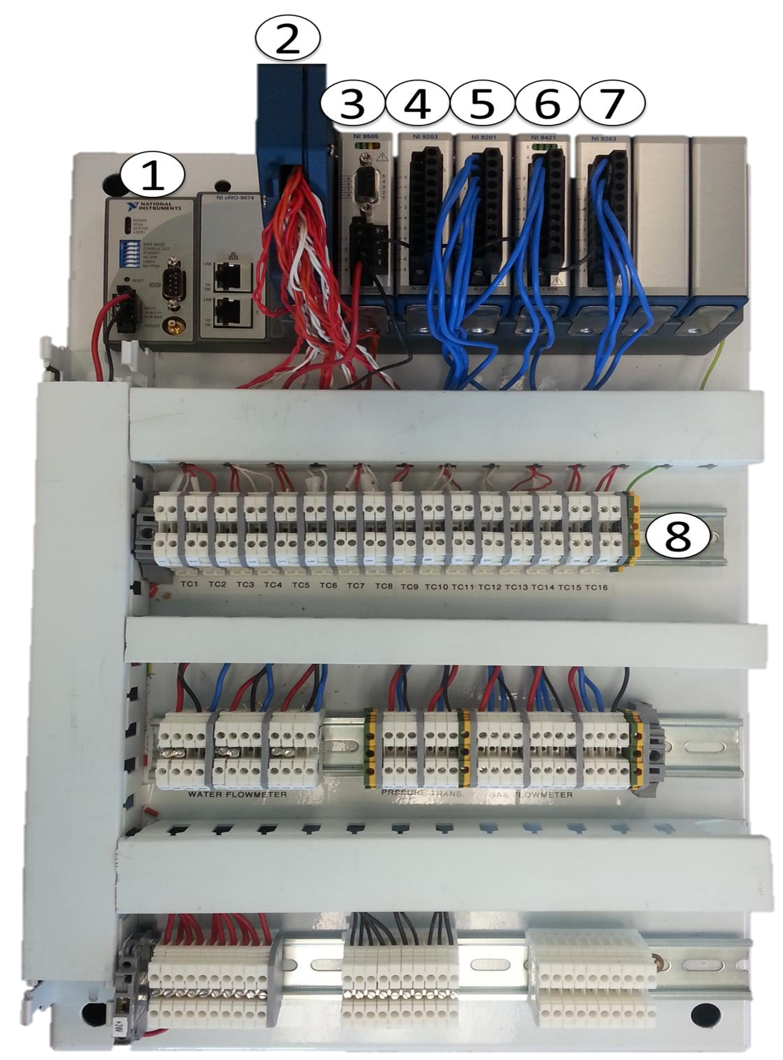
Reactor Components

1. Stainless Steel Front Plate
2. Zirconia Felt Aperture
3. Stainless Steel Shell
4. Alumina Mat Insulation
5. Stainless Steel Back Plate
6. SiC Paddlewheel
7. Mounting Bracket
8. Mounting Table
9. Feed System Base
10. Metal Oxide Particle Hopper
11. Screw Feed Auger

Instrumentation System

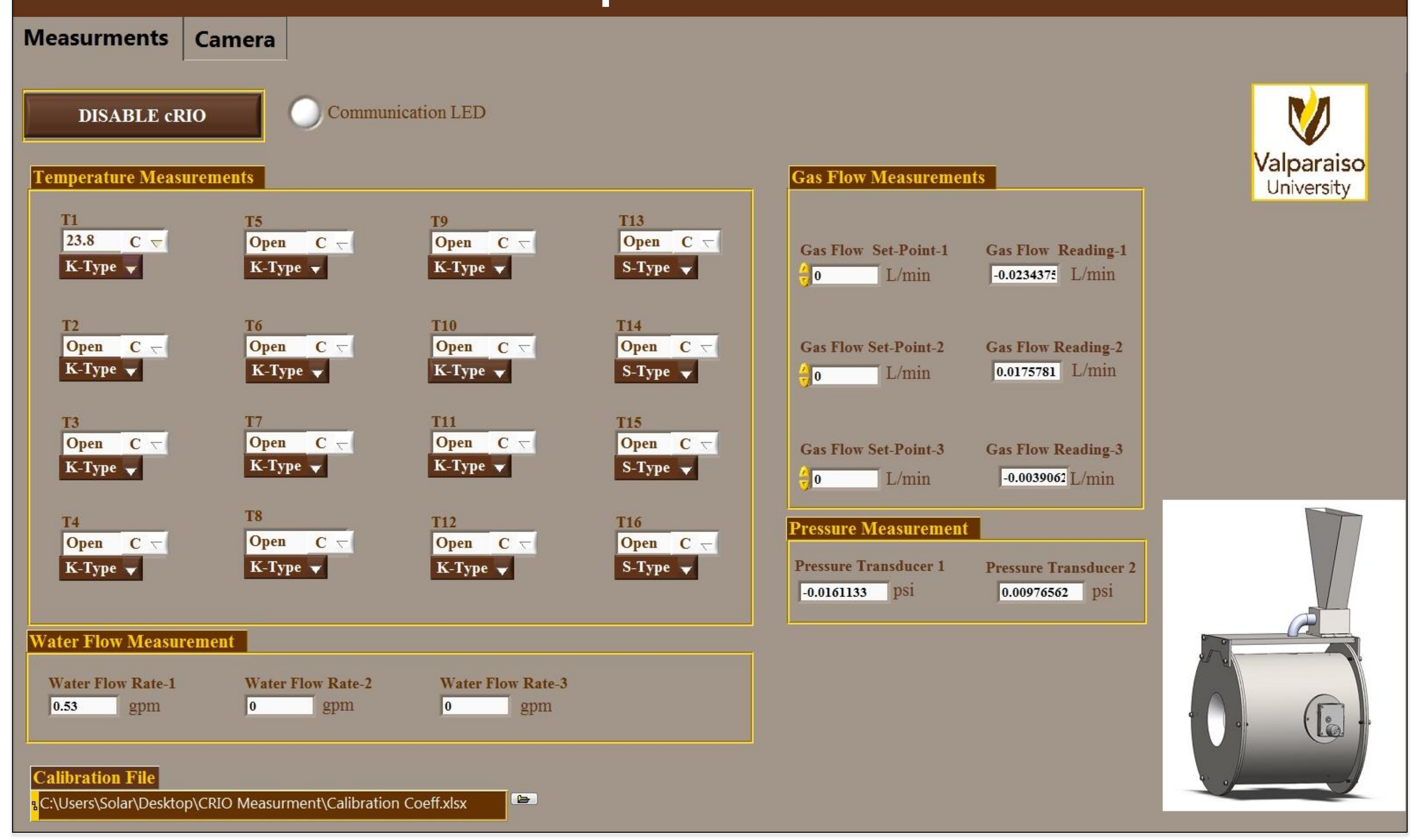
Temperature	Analog Voltage	Solar Flux	Digital Signal
Pressure	0-5 V	Feed System Motor	0-24 VDC
Gas flow rate	0-5 V	Paddlewheel Motor	0-24 VDC
Water flow rate	Digital Pulse	Shaft Position	0-5 V

Electrical Cabinet



1. National Instruments CompactRIO
2. Isothermal Thermocouple Module
3. Brushed DC Servo Drive Module
4. ± 10 mA Current Input Module
5. ± 10 V Voltage Input Module
6. 24 V Digital Input Module
7. ± 10 V Voltage Output Module
8. Terminal Blocks

LabVIEW Graphical User Interface



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Proceedings of the 2013 International Mechanical Engineering Congress & Exposition IMECE 2013
November 15-21, 2013, San Diego, CA USA
DRAFT Paper # 67015