Heterogeneous Redox Experimental Apparatus Development
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Project Overview

Oxidation and Reduction Processes

- **Furnace Reduction Step**
  - Measured reduction temperature of 950°C
  - Reaction: MeO₃ → MeO₂ + ½ O₂

- **Air**
- **CO₂-Splitting Oxidation Step**
- Reaction: MeO₂ + ½ O₂ → MeO₃

Bilevel Mass Flow and Temperature Controller

- **Specifications**
  - MFC Warmup Time: 30-60 min
  - MFC Max and Min Flow Rate: 2000 sccm (NOTE: each MFC was rated for He or Ar)
  - MFC Input Pressure: up to 30 psig
  - MFC Pressure Drop: 5 to 10 psid

- **Air**
- **MeO₂ + ½ O₂ → MeO₃**
- **CO₂-Splitting Oxidation Step**

WAGO Holder

- We developed 3D printed components that hold the 3 and 5-pin WAGO connectors and interfaces with the 10 Series T-Connector.

Machined Elements

- We machined custom components of the setup that were unavailable for direct purchase. We used various machines in the manufacturing lab, such as the CNC mill, vertical mill, horizontal band saw, CO₂ laser cutter, and various hand tools. As we machined each part, we documented each step in detail so that it could be accurately repeated.

Tube Connections

- We used 1/8” Stainless Steel tubing to route the compressed air throughout the system. Then, we used various Swagelok fittings to go from the tube into the elements of the system. Some of the connections required Teflon tape to create an extra tight seal. The system can hold pressure at 40 psi without leaking.

Laminar Flow Element

- **To measure the gas flow rate after the solenoid valves, we used a laminar flow element and pressure transducer to accurately measure the gas flow at that point. The velocity of the gas was found by the equation:**

  \[ Re = \frac{VD}{v} \]  

  \[ Re \]: Reynolds's Number
  \[ V \]: Velocity of the gas
  \[ D \]: Diameter of pipe
  \[ v \]: Velocity of gas

- Because the value of Reynolds's number was less than 2300, we considered the flow to be laminar.

Conclusion

- Through many iterations and modifications, we achieved successful creation of an apparatus to model the chemical oxidation and reduction steps of Cobalt Oxide. We present the results of our experiments used to verify control of the gas delivery elements of the apparatus, including the mass flow controllers, solenoid valves, and flow measurement system.

References

- https://scholar.valpo.edu/cus/482