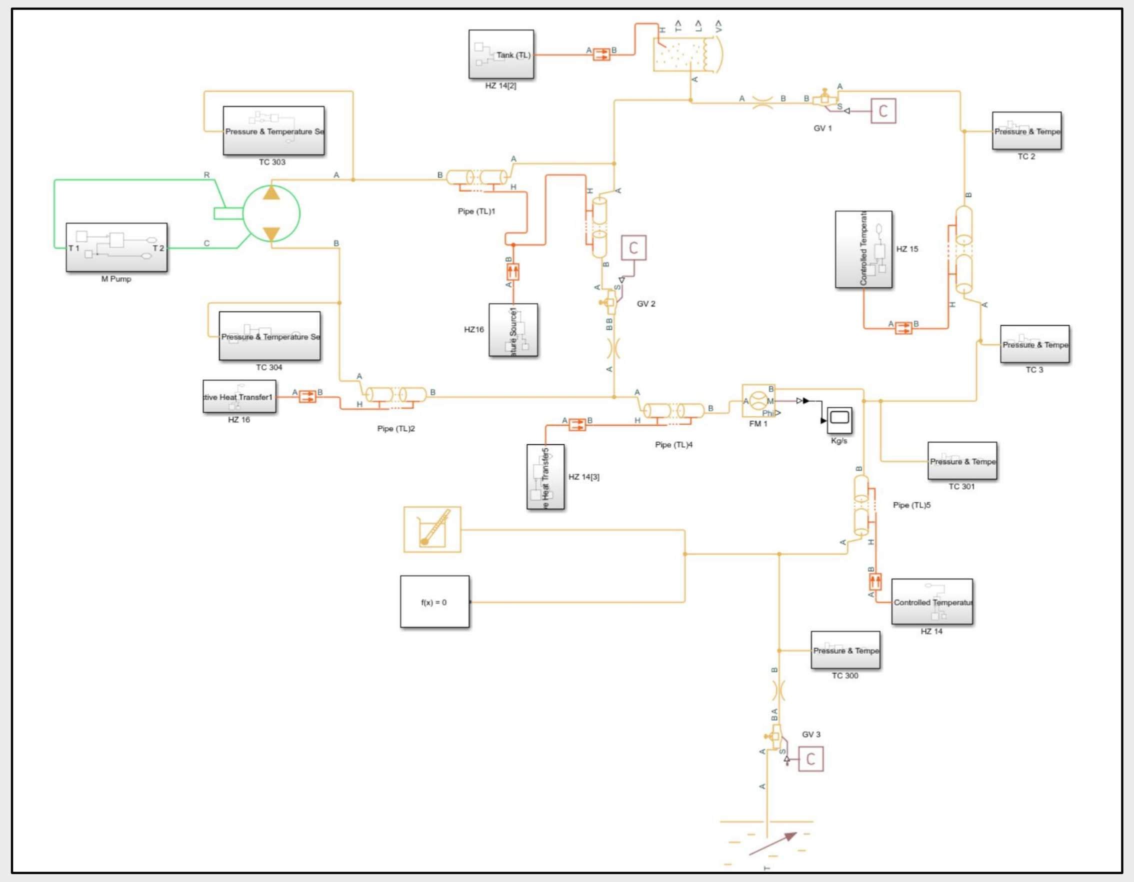
Simulink Sodium Loop Model

Application of MATLAB Simulink software to model experimental sodium loop facility to test accuracy and feasibility of Simulink-based sodium models.

Glovebox for Experimental Liquid Sodium (GELS)

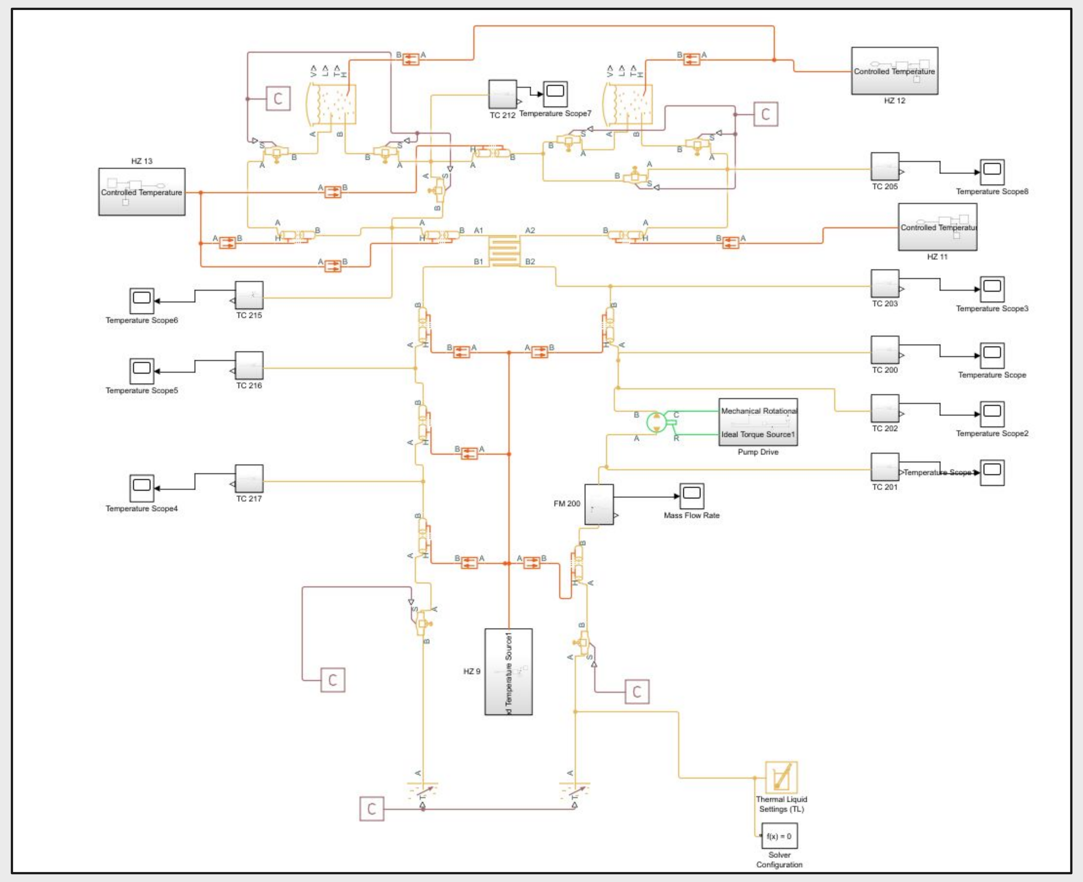
- Existing experimental sodium facility currently under construction at Oregon State University
- Designed to run long-term materials testing in liquid sodium to assess materials for use in Sodium Fast Reactors
- Consists of 3 sub-loop assemblies:
  - Primary Loop or High Temperature Instrumentation Loop (HTIL)
  - Corrosion Experiment Loop (CEL)
  - Diagnostic Loop or Purification Loop
- GELS is equipped with pressure transducers and thermocouples allowing for verification of our model by comparing it to experimentally obtained data.
- Operates between 300-600 ℃

Oregon State University



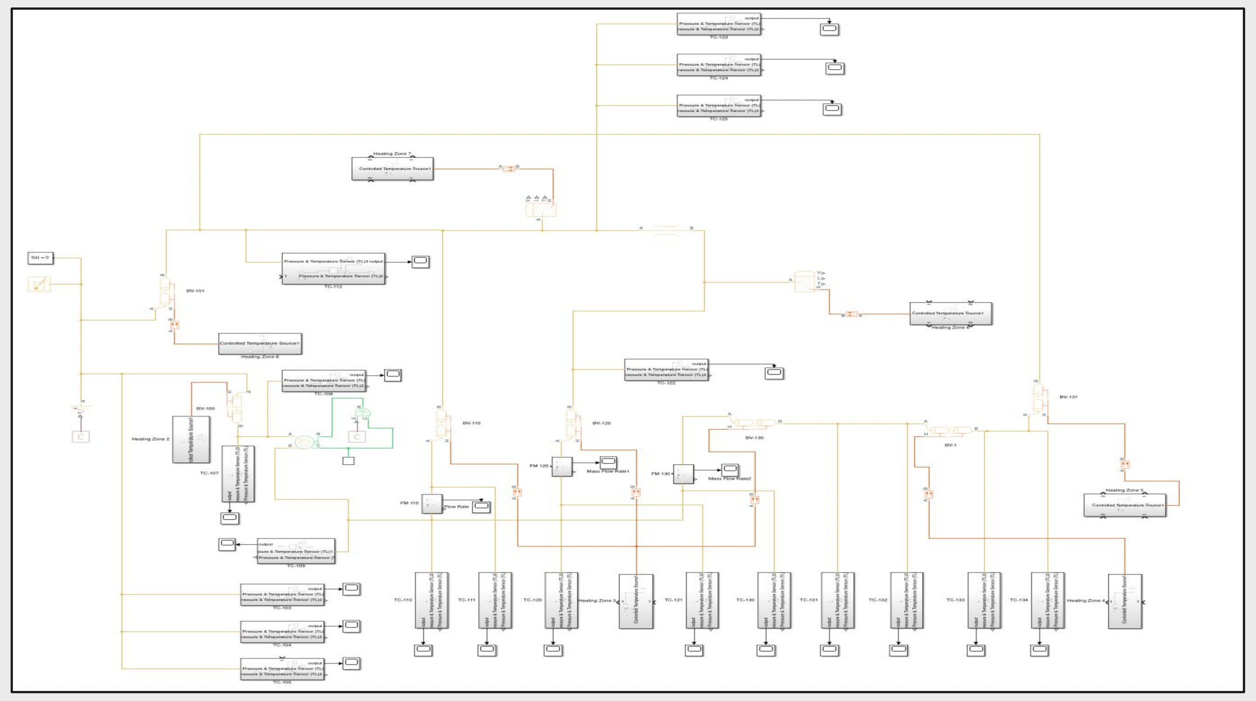
Primary Loop (HTIL)

- Main components are moving-magnet pump and a vessel to conduct materials testing in flowing liquid sodium.
- Thermal expansion tank allows sodium to expand when it heats up without risking leaks or ruptures due to thermal expansion of the liquid metal.
- Thermocouples and flow-meters placed throughout the loop to monitor the sodium and identify hot spots.
- Gravity-drained system.



Corrosion Experiment Loop (CEL)

- Equipped with two corrosion vessels for long-term materials corrosion testing in liquid sodium.
- Includes conduction pump to circulate sodium and heat exchanger to distribute heat throughout the loop's volume of sodium.
- Pipe sections and crucibles are heated to avoid solidification of sodium and clogging of the lines.
- Bypasses implemented for both crucibles to allow the draining of one without interrupting ongoing experiments.



Diagnostic/Purification Loop

- Cold trap serves to purify sodium. The sodium is cooled here and reaches saturation, so impurities precipitate out of the sodium melt onto the steel wool packing of the cold trap.
- Plugging meter obstructs flow at a rate proportional to oxide impurity, allowing the monitoring of oxygen content in the sodium to control corrosion damage.
- The main purpose of the diagnostic loop is to gather information about the sodium regarding temperature and impurity content and log the data on the host PC

Incentive for Simulating

- Many more tests can be run through a simulator compared to a physical system, expediting a multitude of processes.
- Creating simulations of potential designs allows safety testing prior to construction, increasing safety and reducing costs .
- Built in measurement systems allow for accurate data collection at any point, without the need for system deconstruction.
- Allows simple solving of complex pipe equations using flowchart modules

Laminar Flow: $f = \frac{64}{Re}$

Smooth Pipe Turbulent Flow: $f = \frac{0.316}{Re^{1/4}}$

Completely Turbulent Flow: $f = [1.14 + 2\log_{10}(\frac{D}{\varepsilon})]^{-2}$

Transition Region: $f = \{-2\log_{10}[\frac{(\varepsilon/D)}{3.7} + \frac{2.51}{Re\,(f^{1/2})}]\}^{-2}$

Practical Considerations

- Sodium's fluid flow and heat transfer properties are very different from water's so the fluid properties were adjusted accordingly.
- Sodium systems utilize unorthodox pump designs like conduction pumps or moving-magnet pumps, so generic fixed-displacement pumps were used to model these components, adjusting the displacement to match the desired flow rate of sodium.
- Temperature and flow-rate readouts were obtained by placing mass-flow rate or temperature sensor blocks where the instrumentation is placed in the physical loop.
- Components such as the corrosion crucibles, the thermal expansion tank, and the cold trap were represented by generic tank elements to obtain fluid level measurements over time.