The Expansion of the SMR Thermal Loop

Miriam Morales[1] | Hampton DuBose | Matt Whetham[2] | Austin Downey[2]

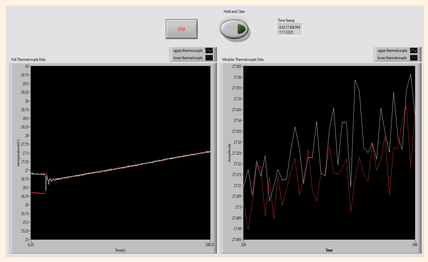
Governor's School for Science and Mathematics, Hartsville, SC[1], Molinaroli College of Engineering and Computing, University of South Carolina, Columbia, SC[2]

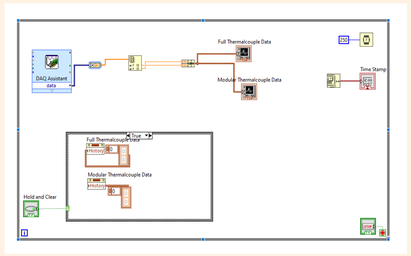
Abstract

As the growth of nuclear energy utilization increasing in South Carolina so have the consideration of proper nuclear systems such as this SMR Thermal Loop System. SMR (Small Modular Reactor is a modern method of nuclear design systems and cautious manner of efficiently controlling the energy released during nuclear fission. During this project, we wanted to see our limitations and basis for how we would expand and best incorporate our current system. We started by making a CAD model of the SMR and thinking of ways to increase the amount of data we can collect from the system. For example, the next step in our expansion was to add threaded pipe extensions horizontally so we can have more space for other sensors besides the two thermocouples. We thought of this while considering the heat rod and the unavailability of possessing a longer heat rod.

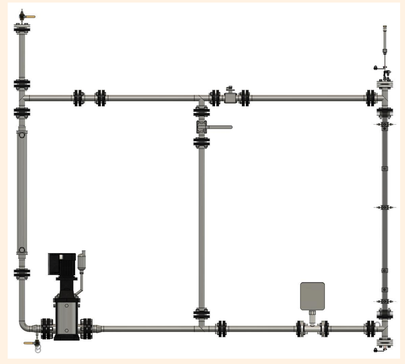
Methods

- CAD Software
  - Using physical measurements from the SMR, we built each part and extension pipes using Fusion360
- Consideration of Materials and Cost Value
  - We ensured the cost of material was not beyond what we were capable of, and we could expand our system around the current SMR
- GitHub
  - We used GitHub to properly load our design files in both Fusion360 and Inventor format
- LabVIEW
  - We used a programing and data acquisition platform to allow us to sort our data in graphs as well as our code.



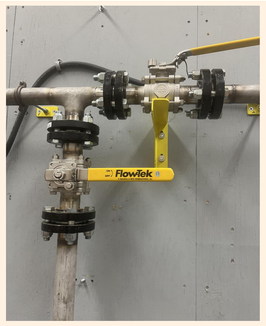


CAD Model and Real Model



- (Left) This is our SMR Thermal Loop system that we based our CAD Model off to get the appropriate measurements. We were also able to find the materials online and base the materials from the purchase source.
- (Right) This is our CAD Model on Fusion360 each component was built individually then placed appropriately in an assembly.

How it works

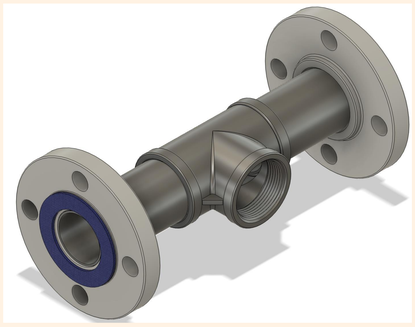


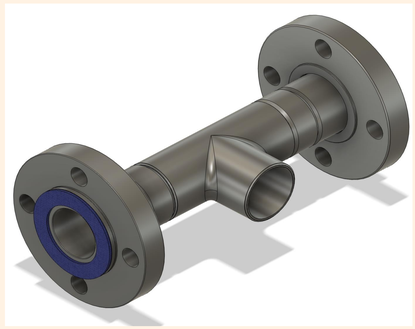
Our system is first filled up with water then the pump Fig. 3) rotates the water through the pipes to get rid of as much air as possible. Then the valves (Fig. 2) direct where the water fill, we leave these open as the SMR is turned on. In Fig. 2, we have the heat pipe generates heat as water circulates through the system. This water increases from 25 C° to around 40 C° while the SMR runs for about three hours.

Goals

- We want to expand our SMR without buying another heat rod since it is expensive.
- We want to build around the current SMR we have so we do not waste material.
- We want to build a successful SMR Thermal loop to use as a test bed for digital twins.
  - A digital twin is a system of a model that gets updated in real time.
- We would like to be able to use our data so we can help incoming nuclear companies. The rise of using nuclear design system is becoming popular so our model could help other properly use SMR systems.

Next Steps: Extension Pipes





Threaded Extension (Left) and Welded Extension (Right)
The threaded extension would be used first to see how the system would work as intended and later we would apply the welded extension.

Conclusion

In the end, we were able to create a fully functional CAD Model onto GitHub while maintaining the structure which will allow future prospective students to continue this work. This SMR Thermal Loop system is functional and able to collect data. Once we can obtain the proper material for our extension pipes, we can add more sensors. These sensors will lead us to successful digital twins.

This material is based upon work supported by the Air Force Office of Scientific Research (AFOSR), United States through award no. FA9550-21-1-0083 and no. FA9550-21-1-0082. This work is also partly supported by the National Science Foundation, United States grant numbers 1850012, 1937535, and 1956071. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation or the United States Air Force.