Molten Salt Reactor Heat Exchanger

Overview
Molten Salt Reactors (MSR) are a next generation nuclear power plant design that boast great safety, efficiency, and sustainability. These power plants require a primary heat exchanger to transfer the heat generated in the nuclear core to a secondary loop. As there are no commercial MSR power plants, there are no commercial heat exchangers built for this specific purpose. Bechtel has tasked this group with designing a 100 MW heat exchanger to be used in a molten salt reactor with the potential to be scaled to fit a range of systems and power outputs.

Objectives
Bechtel gave the design team several specific objectives with this project. These objectives are listed below:
- Design a 100 MW heat exchanger for a MSR
- Select the molten salts to be used in the primary and coolant loops
- Select the material used to construct the heat exchanger
- 3D print a model of the final heat exchanger

Approach
- This project relied heavily on research. The team took the first month to orient themselves on the specific technologies pertaining to MSRs
- Using the custom needs matrix provided by Bechtel, the team narrow refined all the conducted research
- The team selected FLiBe as both the fuel and coolant salt due to its highly beneficial thermal properties, which in turn have a positive impact on efficiency.
- The team decided to pursue a printed circuit heat exchanger (PCHE) due to its high energy and space efficiency combined with a high durability.
- The team chose to make the heat exchanger out of Hastelloy N due to its ability to withstand the high temperature (700-900 C) and corrosive environment of molten salts.
- The team estimated core heat exchanger properties such as salt flow rate and inlet/outlet temperatures based on research values
- After initial estimate calculations, the team designed a preliminary counter-flow PCHE
- This design was shared with Bechtel, and was ultimately refined using their in-house advanced thermal plant modelling software, Thermoflow.
- The team used this data to refine the original design and ultimately produce the final product
- CAD models were created to display the unique features of the design for 3D printing

Outcomes
The team designed a next generation MSR heat exchanger capable of withstanding intense temperature and chemical conditions. The heat exchanger is extremely efficient and has a lifetime of approximately 28 years. The heat exchanger is 2.5 x 2.16 x 5 meters. Given the amount of heat being transferred, this is a highly efficient design.