Heat Exchanger Design for Molten Salt Small Modular Reactor

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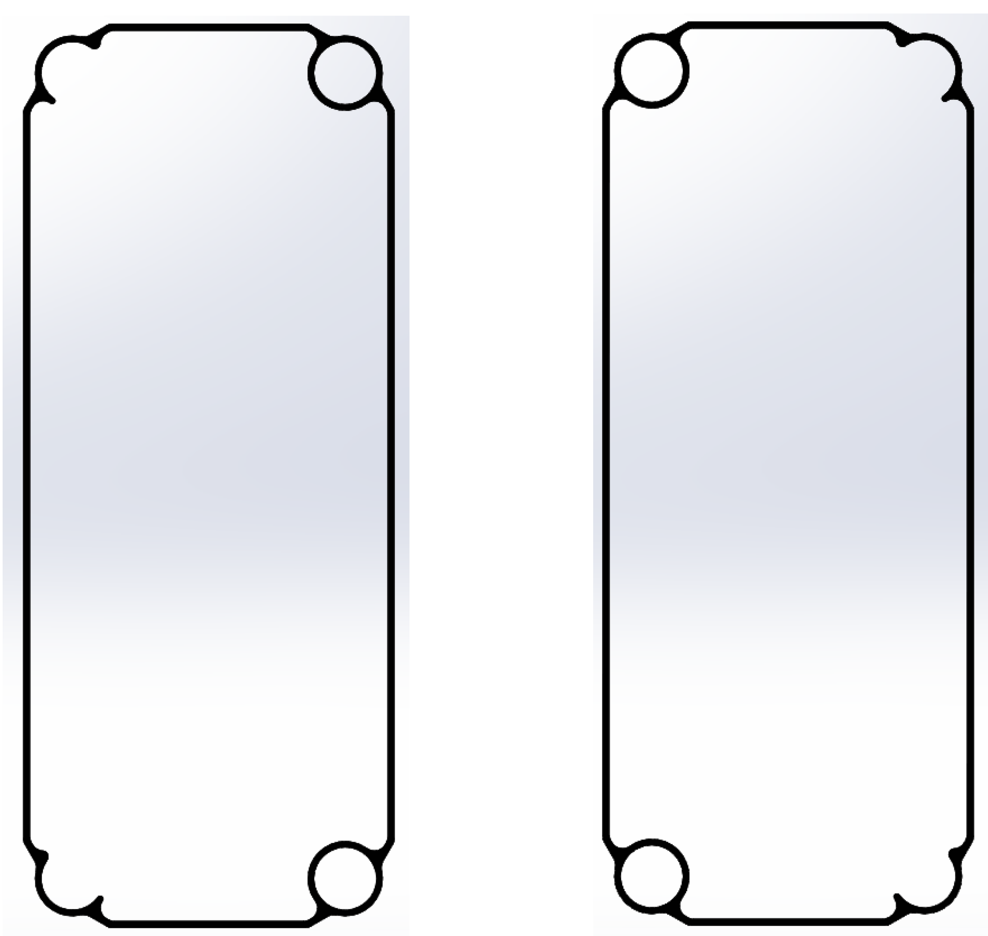
Stainless Steel 316H

The material chosen for this design is Stainless Steel 316H. 316H is a steel alloy a high carbon steel alloy with excellent corrosion resistance to the FLiNaK molten salt. 316H also performs well under high pressure environments like those in this heat exchanger. As with most steels, this alloy isn't too costly to manufacture, making it an affordable option.



Gaskets

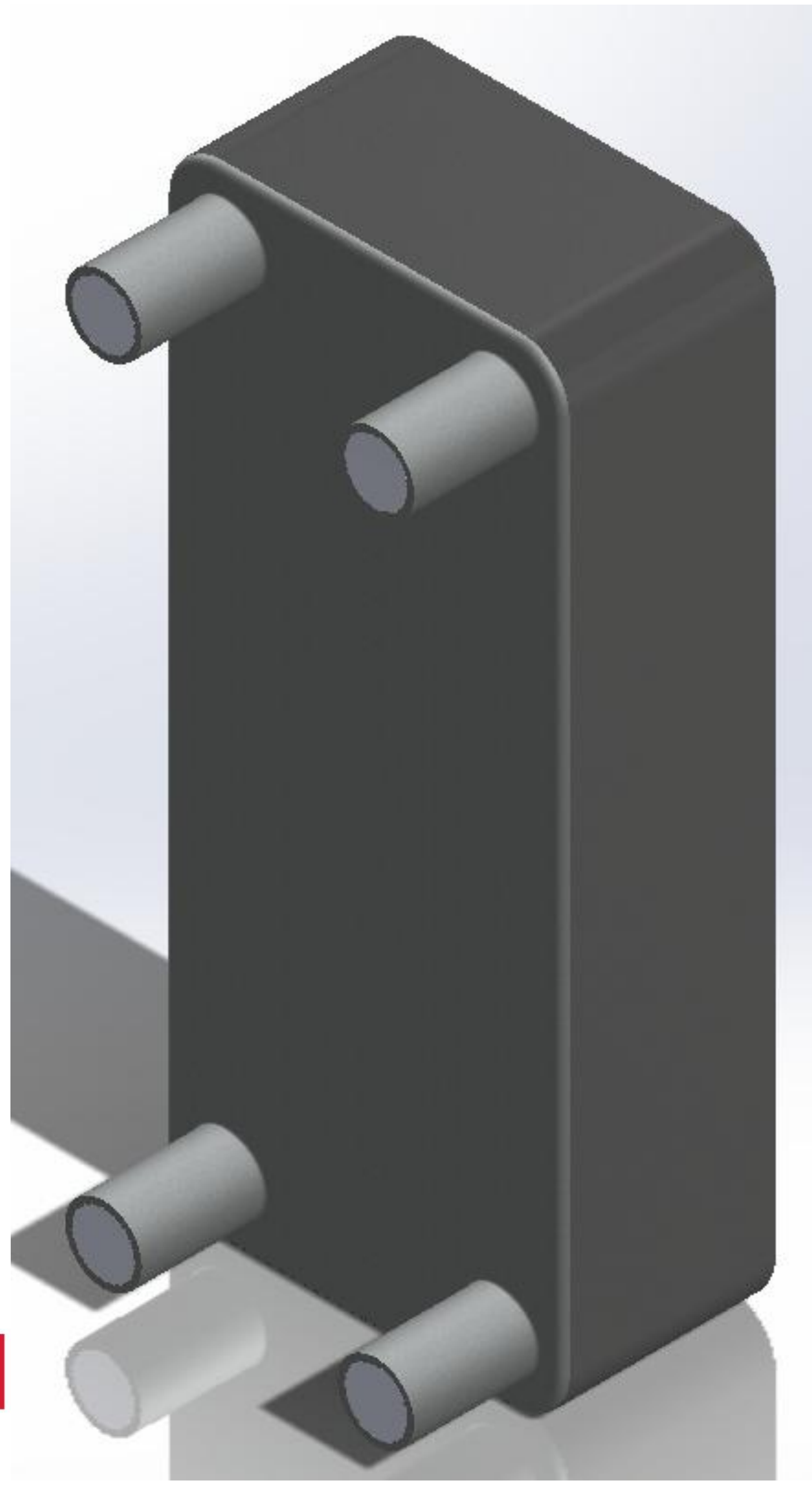
Gaskets are used in between the plates to direct the flow of the molten salt. The gaskets alternate between letting the left and right channels flow through the plates, allowing an alternating flow pattern of hot and cold. They line up with each plate, though don't have any holes as they are meant to be compressed to fill any gaps between the plates.

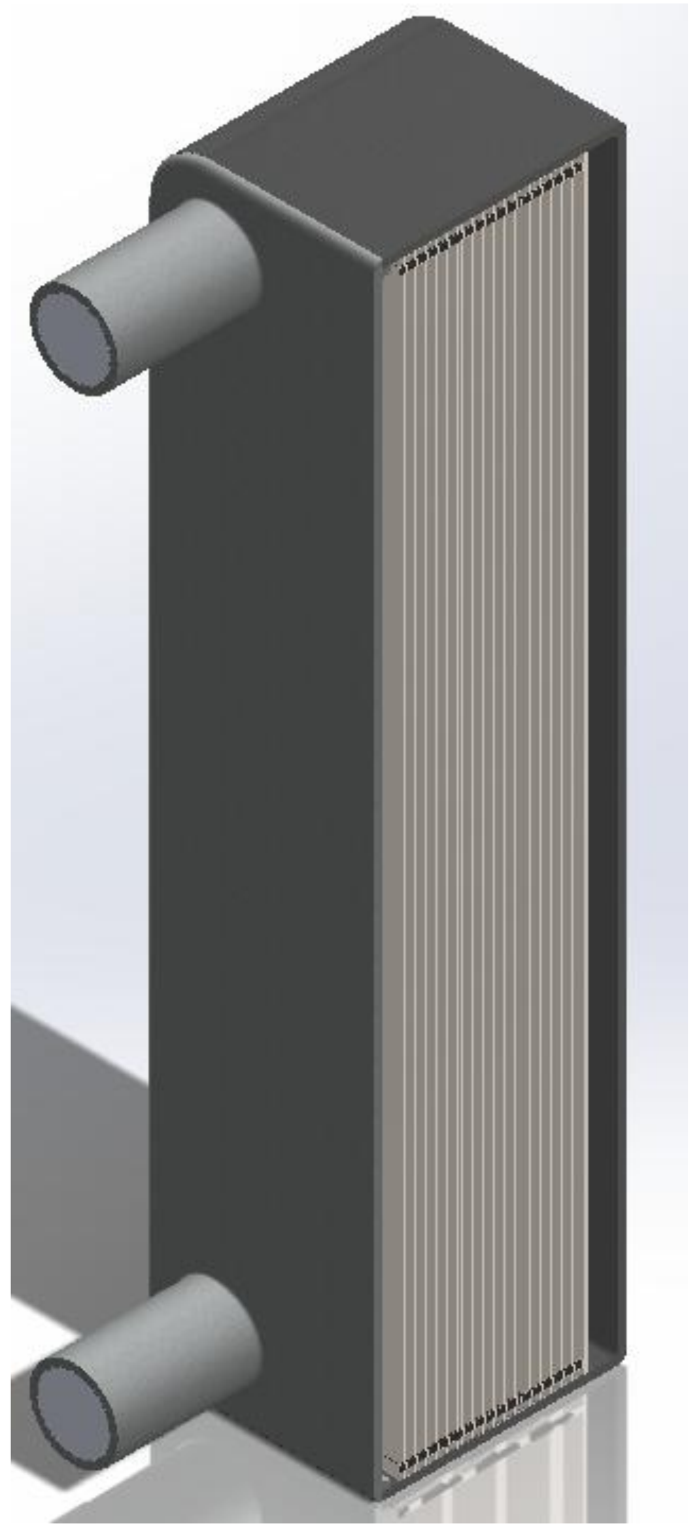
Plate Design

The basis of using plates in a heat exchanger comes from thermodynamics. The larger the surface area means more contact points between the two surfaces, leading to more heat transfer between the two. Plate heat exchangers take many thin plates and stick them close together while leaving a little gap in between. In this gap flows the liquid, either hot or cold, so it can touch the faces of two different plates. This causes each plate to have one face completely cold and one plate completely hot.

Since the plates are very thin, it is quick for the hot parts of the plate to dissipate onto the cold, and the large surface area lets these changes be reflected back into the liquids quickly. The cold liquid is able to absorb some of the heat from the hot liquid, while the hot liquid loses some of its heat to the cold liquid. For a molten salt reactor, the molten salt is cooled enough as to not cause a meltdown but still retain enough heat to stay in liquid form.

Full Model





Section View

How It Works

The heat exchanger starts by taking in the hot molten salt coming out of the core into the top left pipe. This liquid is cooled by the coolant salt, which enters from the top right pipe. The gaskets alternate between letting the hot liquid into the exchanger and the cold liquid in, letting the hot liquid to be surrounded by a cooler liquid. The hot liquid exits the exchanger from the bottom left to return into the core while the coolant salt exits the bottom right to head to either another heat exchanger or to be air cooled.

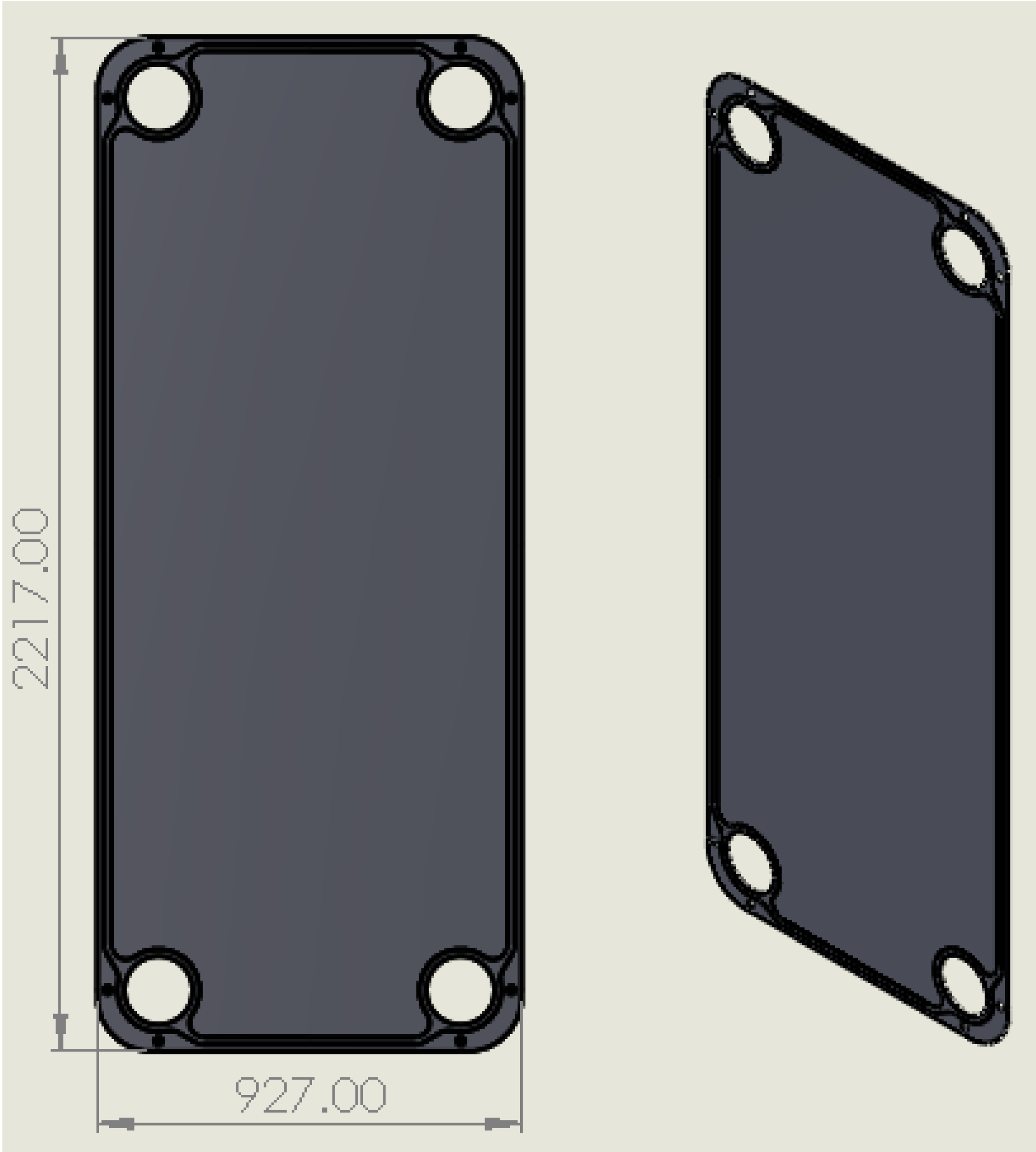
Acknowledgement

This work was supported by the Nebraska Public Power District through the Nebraska Center for Energy Sciences Research at the University of Nebraska-Lincoln.

Plate Specifications

Each plate is 2217mm tall, 927mm wide and 6mm thick, with the base plate being 3mm thick and the border extended another 3mm. This provides ample room for the molten salt to flow through as well as a large enough surface area to allow heat to properly transfer all while being relatively thin.

Each plate is identical to one another except the back two. The backmost plate has all four holes filled up as to stop any flow into the main housing, while the second backmost has the right two holes filled up to stop the flow of the cooling salt, allowing the zone between these two plates to be the last flow channel for the hot salt.



Going Forward

The design for the heat exchanger is complete, and early simulations suggest it will perform up to standards to be used in a molten salt reactor. A model should be developed and tested to see if everything works as predicted. Solidworks, while very helpful, is not always perfect to real world conditions.

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