Fluid and Heat Simulations for a Sand Battery

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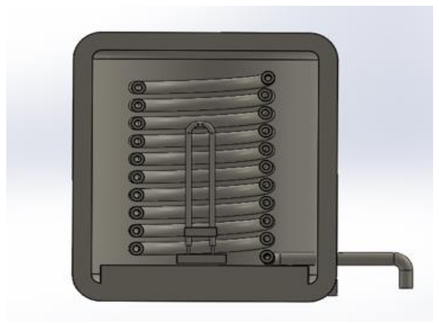
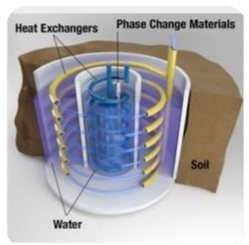
Aim of the Project

Design and demonstration a fluid flow simulation, that shows the best suited fluid for a sand battery to store heat energy and it distribute over time.

Background

- Sand batteries are a type of thermal energy reservoir that uses a renewable energy source such as solar energy to heat water within the pipes and in turn heat up the sand which will store the heat energy.
- Energy stored in the sand is then taken back into the water in the pipes and sent to houses and building to heat or power the residential area.
- The sand stored in silos can reach up to 500-600° C and can maintain that temperature for up to two months.
- Due to the long lasting heat and energy conversion, sand batteries can be much more cost effective than alternative batteries.
- Large scale sand batteries are a relatively new concept that have begun being manufactured, because of this water is being used as it is common and can be easily used at this scale.
- A smaller scale model based on previous group project prototype will be used to develop the project and ensure consistency between testing.
- This project explores the use of different fluid in the sand batteries system to find if there is a better alternative to increase the heat transfer rate which would lead to a more efficient battery.



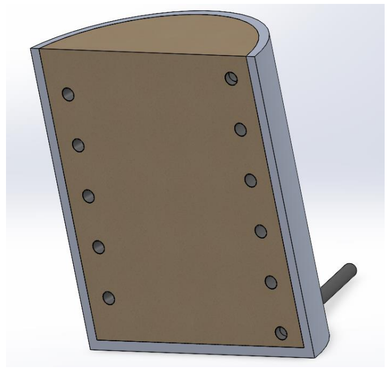


Fluid types

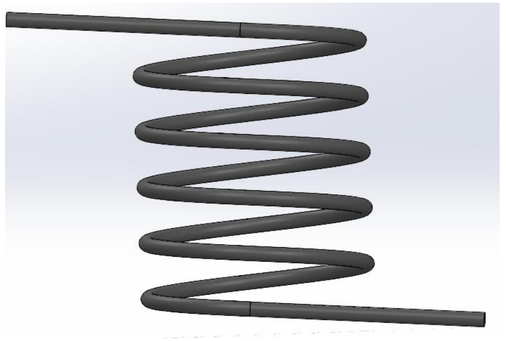
The original fluid used in a sand batter is water because of its high heat transfer properties. One of the main issues with the use of water is that it can only reach a temperature of 100° C before evaporating into steam, this causes a restriction on the water's temperature limiting it to near 80° C to stop any super heating and pipe damage.

There are a few choices of fluid substitution that can be considered such as, Refrigerant a234, anti-freeze, coolant, oil, and air. These fluids are able to withstand various temperatures, resulting in different heat transfer readings. The found heat transfer readings can be compared to the original fluid used in the battery.

The simulation of the fluid flow and temperature change was carried out due to the pre-existing model not being fully built last semester. Hence, simulation of the various fluids on heat transfer rate was tested by the help of Solidworks.



Final concept



The simulation model is based on a Burko Boiler made from stainless steel as the tank, the piping inserted is a common underfloor PE material known as aluplex piping, and the sand material values being used in the simulation on inserted from a high silica content sand.

With the changing fluids the only constant between each is the flow rate within the piping system

Testing and simulation

To test the effectiveness of the fluids within the sand battery solidworks was used as it has access to a library of tools and materials including the fluids being tested.

Because of it being a simulation there was no wait period during or between any tests held, this greatly increased the amount of tests that could be done in a short period of time and easily allowed for the changing of fluid types and properties when needed.

Increasing the initial temperature of the sand held in the sand battery will allow for a wider range of results rather than maintaining an average temperature. The sands temperature will also correlate to the maximum temperature reachable by each fluid in the simulation

Results and Conclusion

The testing showed various results as each fluid type yeilded different properties. With water having been used as the control it was found to be easy to compare and contrast the results. The first ffluid tested was refrigerant a234, it's capability of withdrawing large amount lsnof heat from an area and ejecting the heat to a deseganted location as it does in a household fridge.. Second was the coolant, with the many options of how much water content two types were chosen, 100%coolant and a 50/50 coolant and water mixture, after initial testing of them the water/coolant mixture prooved to be better suited. Oil was similarly suited as various water contents were available, because of this the same approach was taken with the same to water contents being ised, alltho the end results were not as good. The last tested fluid was air, airs natural insulation property makes it great at taking in heat and storing the heat as it moves throughout the piping system and disperse the heat withiin any households or buildings it is pumped throughout.

Afyer multiple test had been carried out and the resulta were compare, it was found that water was still one of the better fluids to use in a sand batter. This may differ is an external heat source such as a heating coil is inteo to the sand battery, removing the need to low boiling point fluids to heat the sand to a lower temperature then it can hold.

Acknowledgements

Supervisor – Patrick Curran
Lecturer – Emma Kelly

References

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