The effect of the configuration of a heat exchanger in a thermal storage

Martin Buitink, Simon Hageman, Richard van Leeuwen

m.n.buitink@saxion.nl; s.p.w.hageman@saxion.nl; sustainableenergysystems.led@saxion.nl
M.H. Tromplaan 28 Postbus 70.000, 7500 KB Enschede

Lectoraat: Sustainable Energy Systems

www.saxion.nl/onderzoek/areas-and-living/duurzame-energievoorziening

Heating dwellings with PVT and water buffer

Most heat pumps are ground source or air source based heat pumps. A ground source heat pump requires drilling, which is expensive and not always possible. An air source heat pump requires some outdoor space and is less efficient when it is freezing. SolarFreezer has developed an alternative using a water buffer and PVT-panel as a heat source. PVT is a normal solar panel with a heat exchanger on the back to extract thermal energy from the panel. The water buffer can be placed in the crawl space. The whole Solar-Freezer system was monitored in a dwelling over a year. In the monitored year, a SCOP of 3.8 was calculated [1].

The water buffer can be a source of energy. A heat exchanger is placed in this buffer. The heat exchanger consists of several thin but long flat plates. The buffer delivers a lot of latent heat when ice is formed. The buffer system works well, but there are ways to improve the heat transfer. Therefore, research is being carried out into how the configuration of the heat exchanger affects the heat transfer, to see what the best configuration is. The literature was contradictory about the best configuration. So applied research needs to be carried out to see the effect of the configuration of the heat exchanger on the heat transfer.

Measurement setup

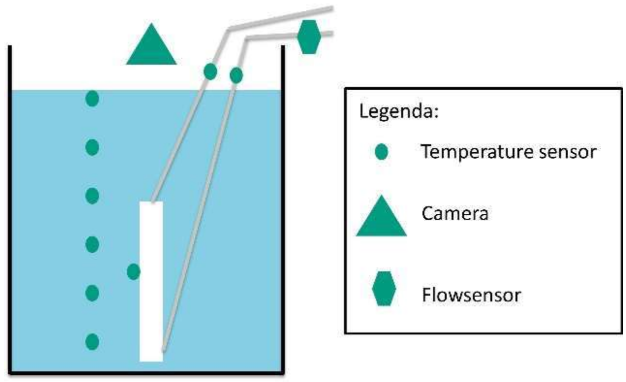

Figure 1: Schematic overview of test setup

The measurement setup and results are also documented in [2]. The heat exchanger is placed in a container and the container is insulated. In the set-up it is possible to place the heat exchanger horizontally, diagonally and vertically as well as vertically at the bottom. A schematic overview of the test setup is shown in Figure 1. In this Figure the white rectangle is the heat exchanger and the grey lines are the pipework. The pipework is connected to a chiller which cools down the cooling liquid, glycol, to -4 °C.

Results

Figure 2 shows the total extracted energy for cooling down from 4 °C to the freezing point. The measurements shown are spread out. Placing the heat exchanger vertically at the bottom seems to be slightly better. From a t-test it can be concluded that the measurements for the vertical at the bottom and the horizontal are less than 10 percent comparable.

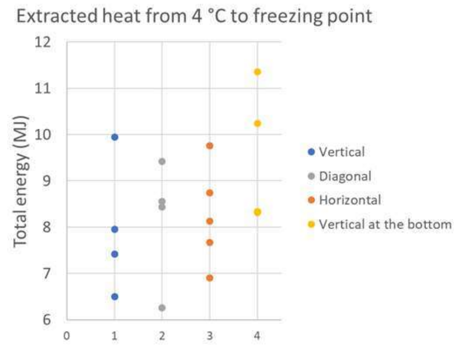

Figure 2: Extracted heat for different orientations of the heat exchanger

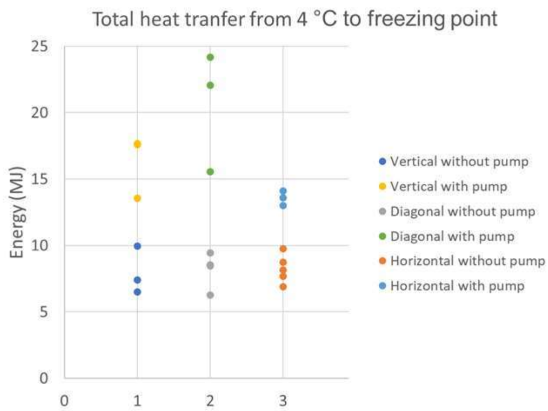

Figure 3: Total heat transfer from 4 °C to freezing point

When the water is mixed in the container, the total amount of energy extracted before ice formation is doubled for the different orientations. This is shown in Figure 3. Mixing the water increases the heat transfer coefficient of the heat exchanger and also increases the heat transfer from the environment. In addition, there is no stratification and therefore the whole container is cooled and not just the part that is at and above the heat exchanger. Figure 3 also shows that the diagonal orientation seems to have the highest heat transfer.

Discussion

From the results it is clear that more experiments need to be done to determine the best orientation is. The container was insulated, but it is still affected by the ambient temperatures. This may explain why there is a spread in the measured values for each orientation.

Conclusion

When water is mixed through the container, the diagonal orientation of the heat exchanger seems to have the best heat transfer. Circulating the water can double the amount of heat extracted. This is the case if the container is in a room temperature area. By placing the heat exchanger at the bottom, more water can be cooled. This increases the heat transfer as well.

References

[1] M.N. Buitink. J. Mathijsen, R.P. Van Leeuwen, 2021, SolarFreezer: Warmtepomp met thermische energieopslag, e-book Nationaal warmtecongres.
[2] M.N. Buitink, S.P.W. Hageman. I. Gebhardt, R.P. van Leeuwen, H. Gelten, 2023, Warmteoverdracht voor verschillende lamel oriëntaties en waterstromingen in de bufferzak.

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