MSc Thesis - Can a salt and magnetic liquid make the most energy-efficient heat pump?

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Type Project

Experimental

Project Description

The heating demand for the built environment in the Netherlands alone is expected to be 333 PJ of energy in 2030[1]. As of 2022, 82% of Dutch households still use natural gas for heating[2]. This is quite alarming for both the climate change and for the national energy security (despite the Groningen gas reserves). This demands an urgent need for an efficient heat pump.

The predominantly used heat pump technology is the vapour compression system which can reach up to 40 to 50% of the theoretical Carnot efficiency[3]. Magnetocaloric heat pump is an alternative, in which a magnetocaloric material is subjected to varying magnetic fields that results in temperature change. This can reach upto 60% of the Carnot efficiency[4]. However, it is expensive due to usage of high strength permanent magnet. To overcome this, Ionocaloric heat pump which uses electrical voltage in the order of 1 volts was proposed[5]. This is relatively economical and easy to obtain when compared with 1 tesla magnetic field requirements. However, the separation suffers from the high membrane resistance which is detrimental to its performance. Therefore, there is need for an heat pump with high energy efficiency with favourable operational requirements such as lower magnetic field and lower separation resistance.

To overcome the above mentioned bottlenecks, a heat pump system is envisioned that utilizes magnetic-ionic liquid with a suitable salt. The electrochemical field changes is used to alter the melting point of the salt, while a relatively low-strength magnetic field (0.2 tesla), instead of membranes, is used for separation. For this thesis, you are expected to develop an experimental test loop to achieve a temperature span of 5 K at room temperature.

What is expected from you?

- You have a background in one of the following - Mechanical Engineering, Chemical Engineering, Applied Physics, or SET. You may not have studied about this thesis topic in your course. But if you you are willing to learn, that is sufficient.
- Interest and curiosity to work in the lab with hands-on approach.

What can you expect?

- An eco-system in which you can apply your creativity and ideas in practice, test them, learn from it, and implement an improved version.
- An opportunity to work early on an efficient heat pump idea that has a good chance to be implemented in practice.

[1]Dutch Climate Agreement - h2ps://www.government.nl/binaries/government/documenten/reports/2019/06/28/climate-agreement/Climate+Agreement.pdf

[2]h2ps://opendata.cbs.nl//CBS/nl/dataset/84948NED/table

[3]Maier, Lena Maria, et al., CommunicaNons Physics 3.1 (2020): 186.

[4]4Chaudron et al., Proceedings of the Thermag VIII InternaNonal Conference on Caloric Cooling, 2018.

[5]8Lilley, Drew, and Ravi Prasher. "Ionocaloric refrigeraNon cycle." Science 378.6626 (2022): 1344-1348.

Supervision

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