Thermal modeling and efficiency analysis of an innovative heat engine

Introduction:

Due to space availability, North Holland has the potential of generating a significant amount of power production from PV especially during the summertime. But demand in this area is rather slim as compared to the potential capacity and the grid connection between North Holland and South Holland is thin therefore it is not possible to transfer this access power to South Holland where it can be utilized. The intermittency of solar power and the aforementioned supply-demand issue can be managed by employing seasonal heat storage systems which can facilitate the use of this access power within the region during the wintertime. In these systems, the access electricity from PV can be stored in the form of chemical bonds and when required it can be released to produce power.

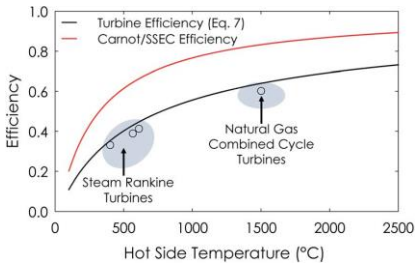

Fig.1 Comparison of estimated maximum efficiency for a turbomachinary and a solid state energy conversion (SSEC) device [1].

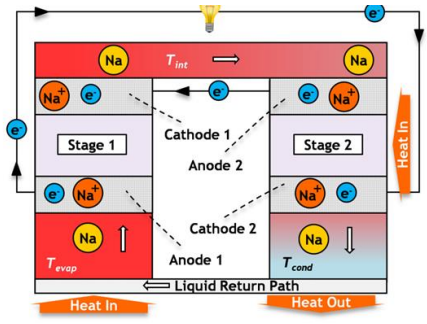

Fig.2 Schematic of thermally regenerative electrochemical heat engine using sodium as a working fluid [2]

Traditionally, turbomachinery systems are used for power production but they are more suitable for large scale applications due to large capital and operational costs of such systems. Another highly efficient power production pathway is to use solid-state energy conversion (SSEC) systems that can convert heat directly to electricity without moving parts. One such system is thermally regenerative electrochemical heat engines which typically utilize alkaline metals as a working fluid. These systems can work at high-temperatures because of not having any moving parts thereby can achieve higher efficiency as compared to the turbomachinery systems. The second important advantage is that they can utilize a constant temperature heat input, similar to the way an idealized Carnot cycle would operate.

Assignment:

This assignment includes the development of a thermal model for an innovative heat engine concept. The model will consider the various aspects of the proposed systems, including energy and power density, and various sources of irreversibility and their impact on efficiency. It will be used to perform parametric studies and optimization of the heat engine. The assignment also includes a cost analysis of the complete system. *The final assignment tasks will be defined after consultation with the student.*

Your background: We are looking for excellent master students having Mechanical Engineering or Sustainable Energy Technology background with a willingness to learn COMSOL and/or MATLAB.

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References:

1) Henry, Asegun, and Ravi Prasher. "The prospect of high temperature solid state energy conversion to reduce the cost of concentrated solar power." Energy & Environmental Science 7, no. 6 (2014): 1819-1828.
2) Limia, Alexander, Peter Kottke, Andrei G. Fedorov, and Shannon K. Yee. "Thermal modeling and efficiency of a dual-stage sodium heat engine." Applied Thermal Engineering 145 (2018): 603-609.