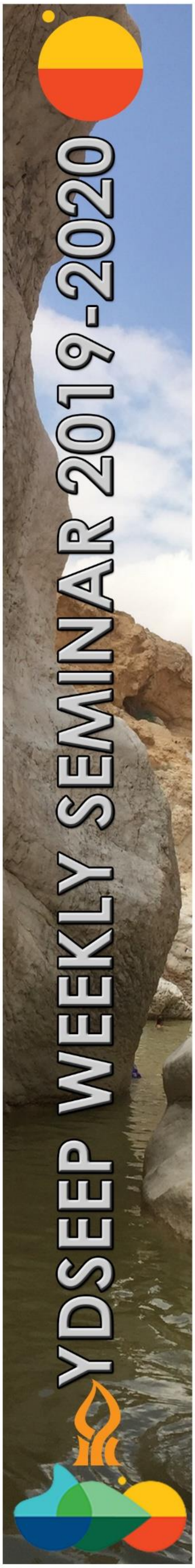

Ben-Gurion University of the Negev
Blaustein Institutes for Desert Research
The Swiss Institute for Dryland Environmental and Energy Research
Alexandre Yersin Department of Solar Energy and Environmental Physics

Acoustic energy conversion: recovering low-grade heat for various applications

Avshalom Offner
Nancy and Stephen Grand Technion Energy Programme
Technion

Abstract:
Low-temperature heat, abundantly available as industrial exhaust streams or non-concentrated solar radiation, is a largely underutilized energy source. Due to intrinsic irreversibilities, the efficiency of converting this heat to accessible power is low, requiring a robust, scalable, low-cost technology to face this challenge. In the present work we propose the use of thermoacoustic devices, i.e. heat engines employing a temperature difference to produce mechanical power through generation of high-intensity sound waves, for tapping this heat. Standard thermoacoustic systems typically operate under large temperature differences (> 200 K) and are therefore not suitable for this purpose. Various works over the past two decades suggested modifications to regular thermoacoustic systems, through which their temperature difference may be dramatically decreased, thus adapting them to waste-heat recovery purposes. These modifications, however, reduce the efficiency and increase system complexity (and cost).

The present work examines a different path towards meeting all the above criteria: we consider a gas mixture as the working fluid, containing a 'reactive' gas, able to exchange mass with a solid boundary, such that heat is primarily transferred at constant temperature, through latent heat. The vast amount of energy associated with the (nearly) reversible process of phase transition lowers the temperature difference in the system by leaving only a small fraction of the heat to be delivered through conduction and increase the temperature. In this manner, massive amounts of energy given at low temperature may be harnessed to produce acoustic power. A theoretical model accounting for this mass exchange was derived to investigate and capture the physical mechanisms of a mass-exchange thermoacoutic interaction; the results revealed not only the expected decrease in temperature difference, compared with a reference system involving no mass transfer, but also an increase in the system efficiency and generated acoustic power. Experimental setups were designed and constructed, demonstrating the first stable operation of a phase-change thermoacoustic engine, employing an air-water vapor gas mixture. The experimental results are in good agreement with the theoretical predictions, showing an increase in power production alongside a decrease in the temperature difference. The increase in efficiency and power generation suggests such systems may be cost-effective for low-grade heat recovery purposes.

Date & Location:

Tuesday, December 24, 2020, 11:00
Lecture room, Physics Building (ground floor)