Contribution ID: **350** Type: **Regular Oral (15m)**

Numerical modeling and design of the acoustic expander for cryogenic refrigeration

Thursday 25 July 2024 09:00 (15 minutes)

Cryogenic refrigerators can be broadly classified as either continuous flow machines or oscillating flow machines. The acoustic expander is a new hybrid approach that combines the best aspects of these two machines. Globally, the working fluid moves continuously through the recuperative heat exchanger of the cycle while locally the working fluid oscillates in the acoustic expander. This promising concept has been demonstrated experimentally through the use of reed-valves coupled to an acoustic resonator. This work develops a high-fidelity numerical model that captures non-linear acoustic effects for the future design and optimization of these acoustic expanders. The numerical model solves the fully compressible Navier-stokes equations for various 2D and 3D resonator geometries including both harmonic quarter wave resonators and non-harmonic Helmholtz resonators. The reed valve behavior is simplified using pressure-dependent boundary conditions that can be tuned to represent a variety of reed characteristics. The coupled reed-resonator system spontaneously oscillates at its natural resonance frequency and the numerical model predicts the resonator quality factor and isentropic expansion efficiency. We compare the results of the 2D/3D numerical model to a 1D model implemented in DeltaEC. Finally, the numerical model predictions are validated by experimental data. The acoustic expander unlocks new cryogenic cooling paradigms with applications to superconducting magnets and electronics, infrared imaging, quantum sensing, and cryogenic propellant management.

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.
This material is based upon work supported by the Department of the Air Force under Air Force Contract No. FA8702-15-D-0001. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of the Air Force.

Submitters Country

United States of America

Author: O'CONNOR, Nathaniel (MIT Lincoln Laboratory)

Co-authors: ADAMS, Jacob (MIT); Dr JONES, Matthew (MIT Lincoln Laboratory); Prof. BRISSON, John (MIT)

Presenter: O'CONNOR, Nathaniel (MIT Lincoln Laboratory)

Session Classification: Thu-Or13

Track Classification: Tracks ICEC 29 Geneva 2024: ICEC 03: Expanders, pumps, compressors, regenerators and other components