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Development and Analysis of a Novel Finned Compressor for Isothermal Compressed Air Energy Storage: From Modelling to Experimental Validation

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Considering the need for a reliable and environmentally friendly energy storage solution for addressing renewable energy intermittency issue and following the developments on Isothermal Compressed Air Energy Storage (I-CAES) systems, a new finned piston compressor which is characterized by increased heat transfer area and coefficient has been designed, analyzed, manufactured and experimentally tested. This compressor includes two sets of concentric annular fins with different diameters: the mobile fins are pushed into the space between the stationary fins through a driver shaft and compress the air trapped in the interconnecting annular chambers while keeping the air temperature close to ambient. Modeling of heat transfer and fluid flow in such a complicated geometry with a transient, non-linear, multi-layer, multi-dimensional nature can be best done by equivalent electric analogies with variable resistances and capacitors and employing a lumped method. Using bond graph representation method and based on a previously developed model for a classic reciprocating compressor, energy conversion has been modeled using a conjugate heat transfer and fluid flow model. Results of the simulation are presented and have been validated using an experimental test bench and to provide contrast to current technology, compared to a classic reciprocating compressor. The heat transfer along one cycle has increased in the finned compressor by 32 times compared to a classic piston compressor. The results also reveal that however the volumetric efficiency is decreased slightly in the finned compressor (8%), the exergetic efficiency has increased from 55.1% in a classic piston to 78.4% in the finned piston

References:

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Born in 1984 in Iran, Mahbod Heidari earned his Ph.D. in energy engineering from EPFL in Lausanne (Switzerland) and his M.Sc. degree from University of Manchester in energy systems. His research interests include energy storage, optimization of energy systems and modelling of thermo-fluid systems. During his PhD he worked on the development, analysis and experimental testing of a finned piston compressor, a new and promising machine, which can be used for Isothermal Compressed Air Energy Storage (ICAES). The topic of his postdoc research at University of Geneva is modelling, techno-economic analysis, and optimization of energy storage systems.