Modeling of active magnetic regenerators and experimental investigation of passive regenerators with oscillating flow - DTU Orbit (23/04/2019)

Modeling of active magnetic regenerators and experimental investigation of passive regenerators with oscillating flow

This thesis presents numerical modeling of active magnetic regenerator (AMR) and passive regenerator tests with oscillating flow. The work serves to investigate and improve the understanding of emerging concepts and technologies in the area of magnetic refrigeration. The discretization scheme of a one dimensional (1D) AMR model is improved for decreasing spurious temperature oscillations in the numerical solution. This transient AMR model is further modified for simulating tapered regenerators, heat loss through the housing wall and regenerators using mixed materials. Magnetocaloric materials (MCM) with a first or second order phase transition (FOPT or SOPT) exhibit different characteristics in isothermal entropy change $\Delta S_{iso}$, adiabatic temperature change $\Delta T_{ad}$, and temperature dependence of the magnetocaloric effect (MCE). A theoretical study quantifies the impact of these parameters, showing that all of them are equally important. Based on measured magnetocaloric properties of La(Fe,Mn, Si)$_{13}$H$_{y}$ and Gd, a thorough investigation on how to layer typical FOPT or SOPT materials is implemented. For those regenerators, the sensitivity to the working temperature and the Curie temperature variation is evaluated. A concept of mixing FOPT and SOPT materials is also investigated. Furthermore, the entropy production rates due to insufficient heat transfer, viscous dissipation and axial conduction, as well as the total entropy production rate, are calculated and compared for analyzing different loss mechanisms and optimizing AMRs. The impacts of the heat loss through the regenerator housing and the dead volume are also quantified. A multiparameter optimization reveals the optimal dimensions and operating parameters for different regenerator geometries. In order to evaluate different regenerator geometries, including the emerging epoxy bonded bed and different heat transfer fluids, a passive regenerator test apparatus is constructed and an experimental investigation is presented. The flow and heat transfer characteristics of different regenerators are estimated by presenting the measured and deduced indicators, including the pressure drop, friction factor, effectiveness, heating power and overall Nusselt number. Finally, based on the research in this thesis, the perspectives and some suggestions for the future work are given.

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