Numerical modelling and analysis of a room temperature magnetic refrigeration system - DTU Orbit (07/07/2019)

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This thesis presents a two-dimensional mathematical model of an Active Magnetic Regenerator (AMR) system which is used for magnetic refrigeration at room temperature. The purpose of the model is to simulate a laboratory-scale AMR constructed at Risø National Laboratory. The AMR model geometry comprises a regenerator made of parallel plates, which are separated by channels of a heat transfer fluid. The time-dependent model solves the momentum and continuity equations of the flow of the heat transfer fluid and the coupled energy equations of the heat transfer in the regenerator and the fluid. The AMR performs a cyclic process, and to simulate the AMR refrigeration cycle the model starts from an initial temperature distribution in the regenerator and fluid channel and takes time steps forward in time until the cyclical steady-state is obtained. The model can therefore be used to study both transient and steady-state phenomena. The AMR performance can be evaluated in terms of the no-load temperature span as well as the refrigeration capacity and the COP. The AMR model was verified extensively and it was concluded that the model has energy conservation and that the solution is independent of the chosen grid and time step. Initial results from the model showed significant temperature differences in both the regenerator and the fluid channel during the AMR cycle. This justifies the use of two-dimensional methods when an AMR with a parallel-plate regenerator is modelled. The model is flexible and was used to perform several parametric studies of the AMR performance for different design choices and operating conditions. The results of these studies are presented and the implications for optimal AMR operation are discussed. Finally, the AMR model was validated by comparing the model result to measurements from the experimental AMR constructed by Risø. The validation shows good agreement between the model and the experiments and it is possible to predict both the trends as well as the temperature span of the experimental AMR. In addition, the model can estimate the optimal operating conditions with good accuracy. The ability to provide good results of both the behavior and the performance of the experimental AMR shows that the developed model is a useful tool, which may be used for analysis, design and optimization of the laboratory AMR.

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