MAR15-2014-020832

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Modeling and design aspects of active caloric regenerators

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A cooling device based on a solid caloric material using, for example, the elastocaloric, magnetocaloric, barocaloric or electrocaloric effect has the potential to replace vapor-compression based systems for a variety of applications. Any caloric device using a solid refrigerant may benefit from using a regenerative cycle to increase the operating temperature span. This presentation shows how all active caloric regenerators can be modeled using similar techniques and how they are related to passive regenerator performance. The advantages and disadvantages of using a regenerative cycle are also discussed. The issue of hysteresis in caloric materials is investigated from a system/thermodynamic standpoint and the effects on cooling power and efficiency are quantified using a numerical model of an active regenerator using model caloric materials with assumed properties. The implementation in a working device will be discussed for elastocaloric and magnetocaloric cooling devices. It is shown that demagnetization effects for magnetocaloric systems and stress concentration effects in elastocaloric system reduce the overall effect in the regenerator and care must be taken in regenerator design for both technologies. Other loss mechanisms outside the regenerator such as heat leaks are also discussed. Finally, experimental results for active magnetic regenerative cooler are given for a range of operating conditions. The most recently published device uses a regenerator consisting of Gd and three alloys of GdY and has demonstrated a *COP* over 3.