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Material requirements for magnetic refrigeration applications

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Highlights

Investigation of the needed improvement in the properties of magnetocaloric materials

The requirements for non-magnetic properties are also discussed.

Comparison between the existing refrigerators and simulated magnetic ones

For demanding conditions and compact designs better materials are needed.

Abstract

A primary motivation underlying the research on room-temperature magnetic refrigeration is reaching energy efficiency levels beyond what is achievable with vapor-compression technology. However, the goal of building commercially viable magnetic refrigeration systems with high performance and competitive price has not been achieved yet. One of the obstacles to reach this goal is the inadequate properties of the currently existing magnetocaloric materials. In this article, the needed improvements in the properties of the magnetocaloric materials is investigated. Two existing vapor-compression refrigerators are used as reference for the required performance, and magnetic refrigerators are simulated using a numerical model. Apart from the requirements such as uniformity of transition temperature for each layer, small increment in transition temperature in adjacent layers, and mechanical strength of the materials, the study shows that for the investigated cases materials with adiabatic entropy change 2.35 times larger than the existing materials are needed to outperform vapor-compression systems.

Keywords: Magnetocaloric, Material, Magnetic, Refrigeration, Cooling.

Nomenclature:

a	specific surface area, ratio of surface area of particles to volume of bed (m^{-1})
a_1	field-dependent parameter in Eq. 16 ($\text{J kg}^{-1} \text{K}^{-1}$)
a_2	field-dependent parameter in Eq. 16 ($\text{J kg}^{-1} \text{K}^{-1}$)
A_c	cross section area of packed bed (m^2)
b_1	field-dependent parameter in Eq. 16 (K)

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