Exploration of Energy Efficient and Environmentally Friendly Magnetic Refrigeration Systems

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Abstract

Magnetic refrigeration is a highly efficient and environmentally friendly technology that could be used for next generation cryogenics, heating/cooling systems, and room temperature refrigeration [**].

For this project, an active magnetic regenerative (AMR) testing system was designed to study the best magnetic material candidate for room temperature magnetic refrigeration.

The AMR testing system included four repeated sequential steps: 1) Magnetization, 2) Hot Blow, 3) Demagnetization, and 4) Cold Blow. This system was used to evaluate an active regenerative porous bed made of gadolinium, Gd.

The resulting experimental data was used to develop a computational model that utilized both magnetic and thermodynamic principles.

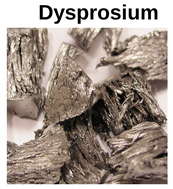
Why Magnetic Refrigeration?

(i) It does not use ozone depleting chemicals (CFCs), hazardous chemicals (NH3) or greenhouse gases (HCFCs and HFCs).
(ii) Higher efficiency than compressor-based techniques, e.g. the cooling efficiency in magnetic refrigerator working with gadolinium has been shown to reach 60% of the theoretical limit compared with only about 40% in the best gas-compression refrigerators.
(iii) The magnetic refrigerator can be built more compactly and generates much less noise.

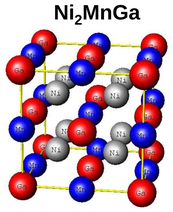
Refrigerant Materials

Pure Elements: Co, Ni, Dy
Alloy: MnAs, CrO_2, MnBi, Ni_2MnGa
Reference Magnetic Refrigerant: Gadolinium (T_{curie} =293K)

Dysprosium



Ni_2MnGa



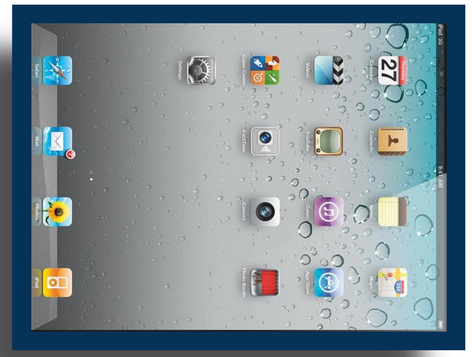
Nickel

Gd Turnings

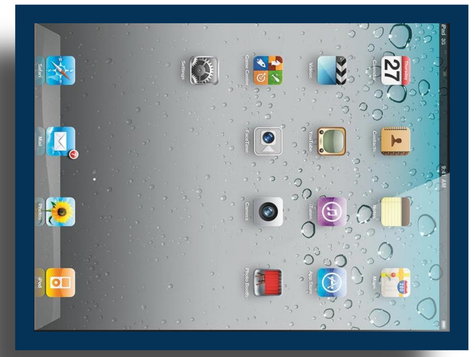
Bulk Gadolinium

Gd Powder

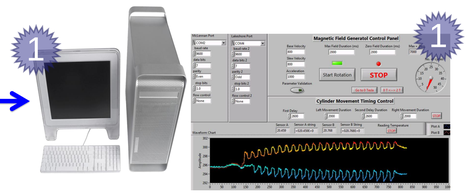
Conventional Refrigerator

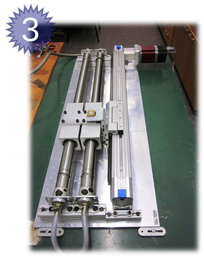


Magnetic Refrigerator

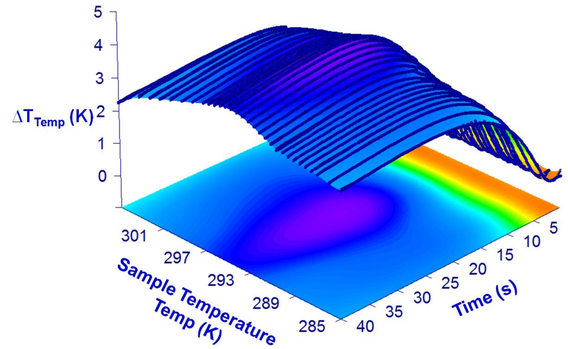


GWU Active Magnetic Refrigeration System

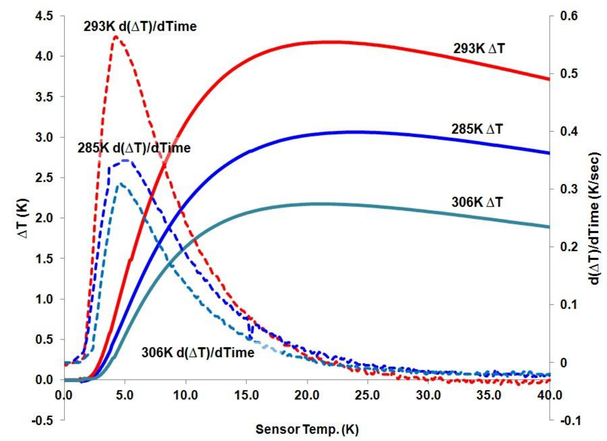




Experimental Results



3D surface plot of Gadolinium ΔT_{Temp} curve, ΔT_{Temp} as a function of Sample Temperature, Time and Applied Field.



Rate of MCE Temperature Change for Gd turnings sample

Future Works

New Patent Idea

- **Using the data collected from our newly invented temperature measurement system, we invented an idea for a magnetocaloric magnetic field sensor.**
- **When the magnetocaloric based sensor is exposed to the unknown ambient magnetic field, the sensor's rate of the temperature change will help determine the surrounding environment's magnetic field value. This sensor is computationally fast and accurate.**

References

***Please visit www.gwu.edu/~imr for reference listing**