OAK RIDGE NATIONAL LABORATORY FACT SHEET
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

MSSE Measurement Science and Systems Engineering Division

ROBOTICS AND ENERGETIC SYSTEMS GROUP RESG

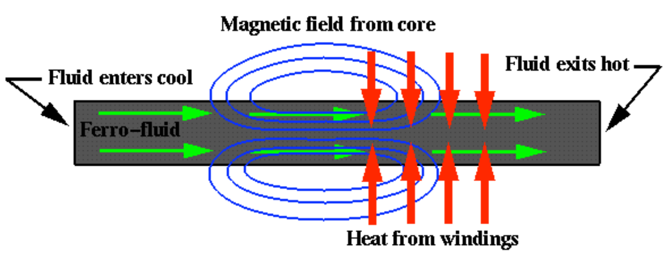
Magnetocaloric Cooling of Electric Machines

Existing Approach

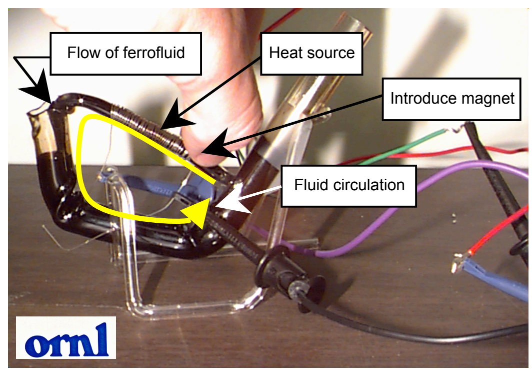
The performance and efficiency of electric machines (induction motors, generators, and transformers) is limited due to thermal constraints in the coils.[1] These constraints can be relaxed somewhat by circulating air through the air gaps in the machines. However, such approaches require the addition of pumping mechanisms and are limited due to the thermal conductivity of air.[2,3]

Oak Ridge National Laboratory's Approach

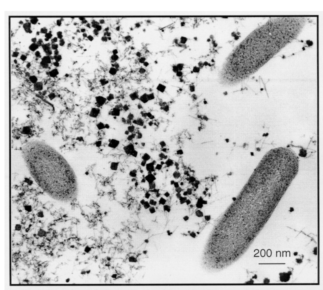
Oak Ridge National Laboratory's (ORNL) approach has been to cool electric machines by using ferrofluids as the cooling media. The goal is to exploit the thermal and magnetic characteristics of ferrofluids such that not only will the fluid circulate through the machine, but *existing thermal and magnetic fields in the motor will provide the energy needed for pumping the fluid*. The cooling mechanism will therefore require *no additional moving mechanical parts, pumps, or sensors. The behavior of the fluid will provide the method of pumping and cooling of the motor* (thus increasing the machine's potential energy density and efficiency). This basic principle can be extended to cooling any media that contains both thermal and magnetic field gradients. The fundamental challenge has been the synthesis of magnetic nanoparticles with targeted magnetic and thermal properties. ORNL's specific focus has been on both the chemical and biological synthesis of magnetic nanoparticles that exhibit targeted magnetic and thermal properties.



Basic principle.



Proof-of-principle demonstration.



ORNL's bacteria synthesizing magnetic nanoparticles.

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[1]Slocum, A., *Precision Machine Design*, Society of Manufacturing Engineers, 1992.
[2]Cambell, P., *Permanent Magnet Materials and Their Applications*, Cambridge University Press, 1994.
[3]Bangura, J. F., F. N. Isaac, N. A. Demerdash, A. A. Arkadan, "A Time-Stepping Coupled Finite Element-State Space Model for Induction Motor Drives, Part 2: Machine Performance Computation and Verification," *IEEE Power Engineering Society Transactions Papers*, July 1998.