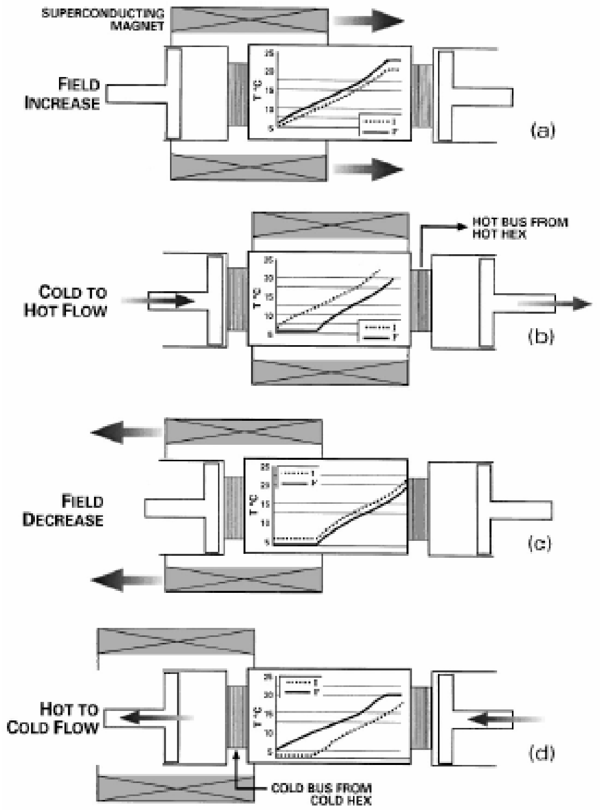
MAGNETIC REFRIGERATION

Description of Technology

A magnetic refrigeration cycle employs a solid-state magnetic material as the working refrigerant, and exploits the magnetocaloric effect (MCE), or the ability of a material to warm-up in the presence of a magnetic field and cool down when the field is removed. Heat absorption and heat rejection are facilitated by thermally linking the magnetic material with the cold source and hot sink respectively, using an environmentally benign heat transfer fluid such as water, anti-freeze mixture or a gas, depending on the operating temperature range. The forces involved in applying and removing the magnetic field provide the necessary net work input to the cycle for heat pumping from the source to the sink.



Active magnetic regeneration cycle (from Russek and Zimm, International Journal of Refrigeration, 29, 1366-1373, 2006.

Magnetization and demagnetization of a magnetic refrigerant can be viewed as analogous to compression and expansion in a vapour compression refrigeration cycle, but in contrast these magnetic processes are virtually loss-free and reversible for soft ferromagnetic materials. Further advantages associated with the solid-state nature of magnetic refrigerants are the absence of vapour pressure, resulting in zero ODP and zero GWP, and a large magnetic entropy density which is the key thermodynamic property determining the magnitude of the MCE. Magnetic refrigeration therefore offers the prospect of efficient, environmentally friendly and compact cooling.

State of development

Magnetic refrigeration technology for operating temperatures near to room temperature, including both magnetic materials and systems design, is under active development by several teams in North America, the Far East and Europe and a number of prototype systems (including both reciprocating and rotary designs) have been announced. Cooling capacities of prototypes are low, maximum reported to date is 540 W, with a COP of 1.8 at room temperature.

Potential application to the food sector

Considerable research and development is still required for the successful commercialisation of magnetic refrigeration systems. The most important challenge is the development of materials with high magnetocaloric effect, to reduce the size, weight and cost of the system. Other important areas of research are the development of effective methods of heat transfer between the refrigerant and secondary heat transfer fluid and overall thermal management and control.

Magnetic refrigeration has the potential for use across the whole refrigeration temperature range, down to cryogenic temperatures. It is anticipated that the first commercial applications will be for low capacity stationary and mobile refrigeration systems. Time to commercialisation is estimated to be greater than ten years.