MAGNETIC REFRIGERATION

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Introduction to Refrigeration

- **Refrigeration** is the process of removing heat from an enclosed space, or from a substance.
- The primary purpose of refrigeration is lowering the temperature of the enclosed space or substance and then maintaining that lower temperature.
Magnetic Refrigeration

- Magnetic refrigeration is a cooling technology based on the magneto caloric effect
- A strong magnetic field is applied to the refrigerant
- A heat sink then absorbs the heat released by the refrigerant
• Thermal contact with the heat sink is then broken so that the system is insulated, and the magnetic field is switched off.
• This increases the heat capacity of the refrigerant, thus decreasing its temperature below the temperature of the heat sink.
Principle of Magnetic refrigeration:

- Mgetto calorific effect is the basic principle on which the cooling is achieved.
- All magnets bears a property called Currie effect i.e. If a temperature of magnet is increased from lower to higher range at certain temperature magnet looses the magnetic field.
- Currie temperature. Depends on individual property of each material
As Energy input to the magnet is increased the orientation of the magnetic dipoles in a magnet starts loosing orientation. And vice versa at Currie temperature as magnet looses energy to the media it regains the property.

- Apply H spin align, $T$ increases
- Remove H spin randomized $T$ decreases

H = 0

H > 0


Gadolinium alloy heats up inside magnetic field and loses thermal energy by irradiation, so it exits the field cooler than when it entered.
Construction:

- Component Required-
  - Magnets
  - Hot heat exchange
  - Cold heat exchanger
  - Drive
  - Magneto caloric wheel
Thermo dynamic cycle

Magnetic refrigeration

Vapor cycle refrigeration
Steps of thermodynamic cycle -

- Adiabatic magnetization
- Isomagnetic enthalpic transfer
- Adiabatic demagnetization
- Isomagnetic entropic transfer
Adiabatic magnetization

- The increasing external magnetic field (+H) causes the magnetic dipoles of the atoms to align
- The net result is that the item heats up (T + ΔTad)
Isomagnetic enthalpic transfer

- This added heat can then be removed by a fluid like water or helium
- The magnetic field is held constant to prevent the dipoles from reabsorbing the heat
Adiabatic Demagnetization

- The substance is returned to another adiabatic (insulated) condition so the total entropy remains constant
- thermal energy causes the domains to overcome the field, and thus the sample cools
Isomagnetic entropic transfer

- The magnetic field is held constant to prevent the material from heating back up
- The material is placed in thermal contact with the environment being refrigerated
(a) Conventional vapour-compression refrigerator

- Condenser (heat rejection)
- Compressor
- Evaporator (heat absorption)
- Throttle (expansion)

(b) Magnetic refrigerator

- Heat rejection
- Adiabatic magnetisation
- Heat absorption
- Adiabatic demagnetisation

Process step 1:
- Compression/ Temperature increase
  - Magnetization/ Temperature increase

Process step 2:
- Extraction of heat/ Cooling
  - Extraction of heat/ Cooling

Process step 3:
- Expansion/ Temperature decrease
  - Demagnetization/ Temperature decrease

Process step 4:
- Injection of heat/ Heating
  - Injection of heat/ Heating
Working Materials

- Magneto caloric effect is an intrinsic property of magnetic solid.
- Ease of application and removal of magnetic effect is most desired property of material. It is individual characteristics and strongly depends on:
  - Curie temperature
  - Degree of freedom for magnetic dipoles during ordering and randomization of particles.
• The originally suggested refrigerant was a paramagnetic salt, such as cerium magnesium nitrate.
• Gadolinium and its alloys are the best material available today for magnetic refrigeration
Merits of Magnetic Refrigeration

- **Socio-Economic-**
  - MR do not use hazardous or environmentally damaging chemicals
  - Purchase cost may be high, but running costs are 20% less than the conventional chillers
  - Ozone depleting refrigerants are avoided in this system, hence it more eco-friendly
  - Competition in Global market, Research in this field provide the opportunity so that new industries can be set up
Technical-
- **High efficiency**- somewhat 60% more than vapour compression cycle
- **Compactness**- It is possible to achieve high energy density device, It is due to working substance is solid material(Gd) and not a Gas as in case of vapour compression cycle
- **Reliability**- Due to absence of gas, it reduces concern related to the emission into the atmosphere
- Energy conservation and reducing the energy costs are added advantage
- Energy consumption can be cut by upto 50%
- Lower maintenance cost
Thanking you
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