MAGNETIC REFRIGERATION

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CONTENTS:

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.

Methods of refrigeration

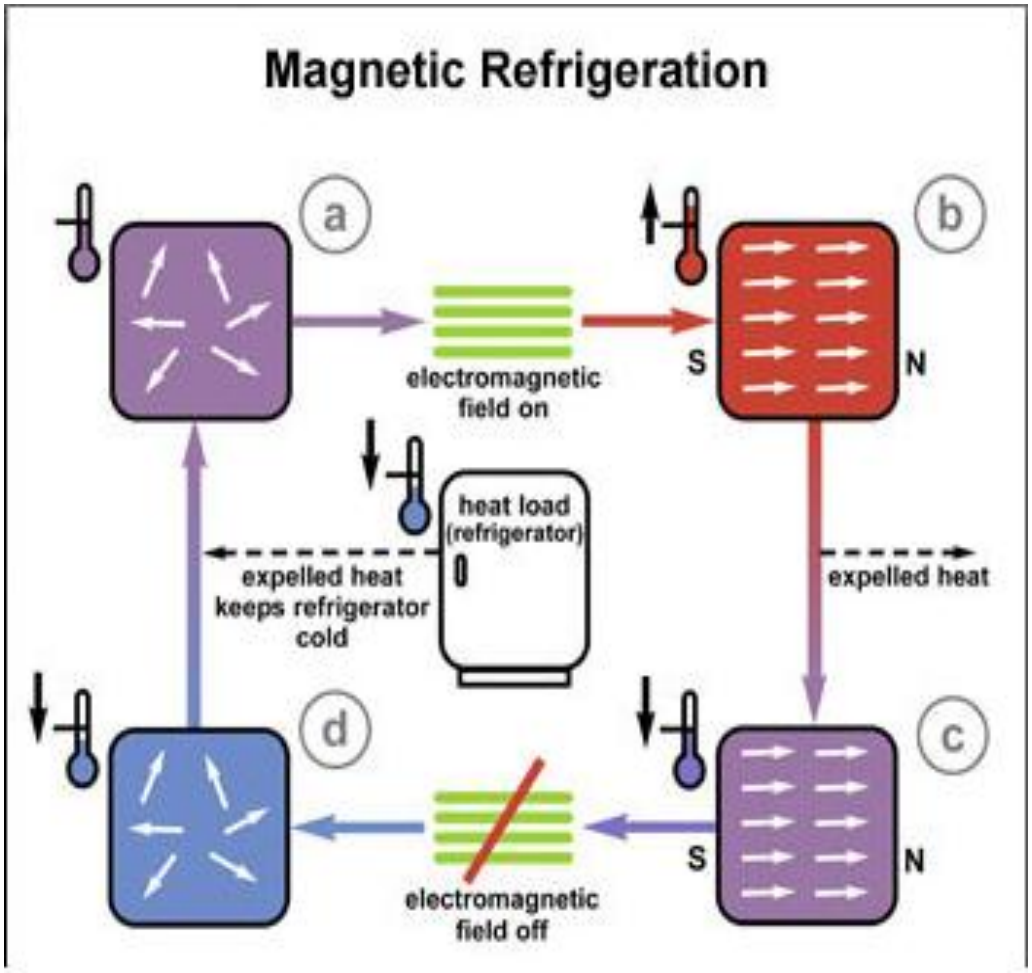
- Non-cyclic refrigeration
- Cyclic refrigeration
  - Vapor cycle
    - Vapor compression refrigeration
    - Vapor absorption refrigeration
  - Gas cycle
- Thermoelectric refrigeration
- Magnetic refrigeration
- Other methods

Principle of Magnetic refrigeration :

- Magneto 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 a versa at Currie temperature as magnet looses energy to the media it regains the property.

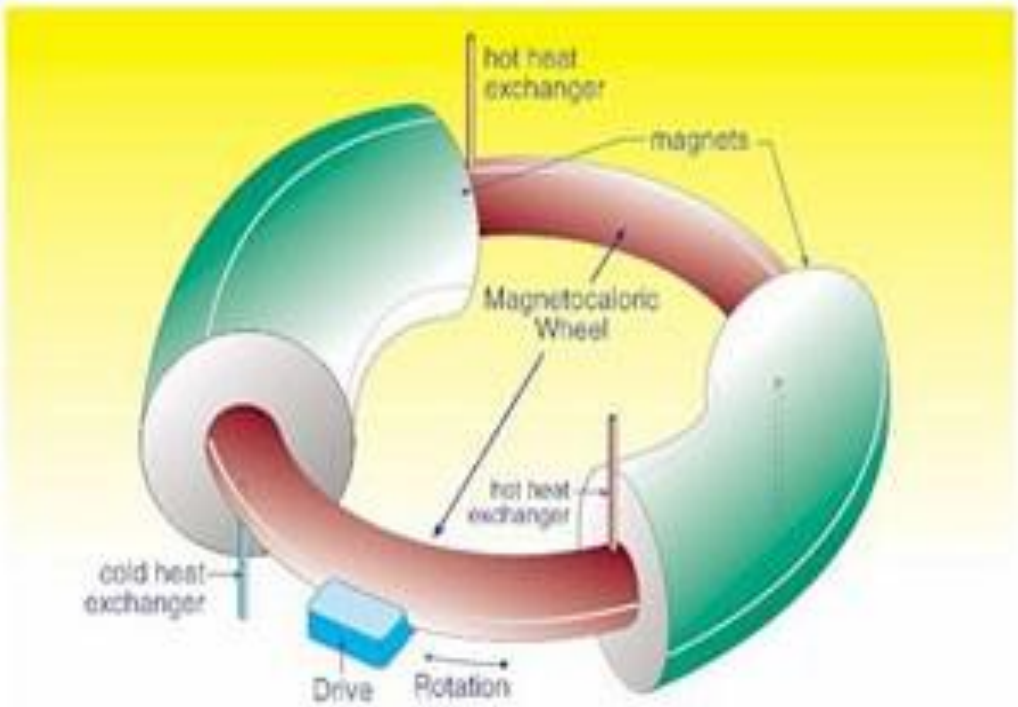
Magnetic refrigeration



- A magneto caloric material heats up when magnetized
- Then cools & demagnetize.
- Its temperature drop dramatically.

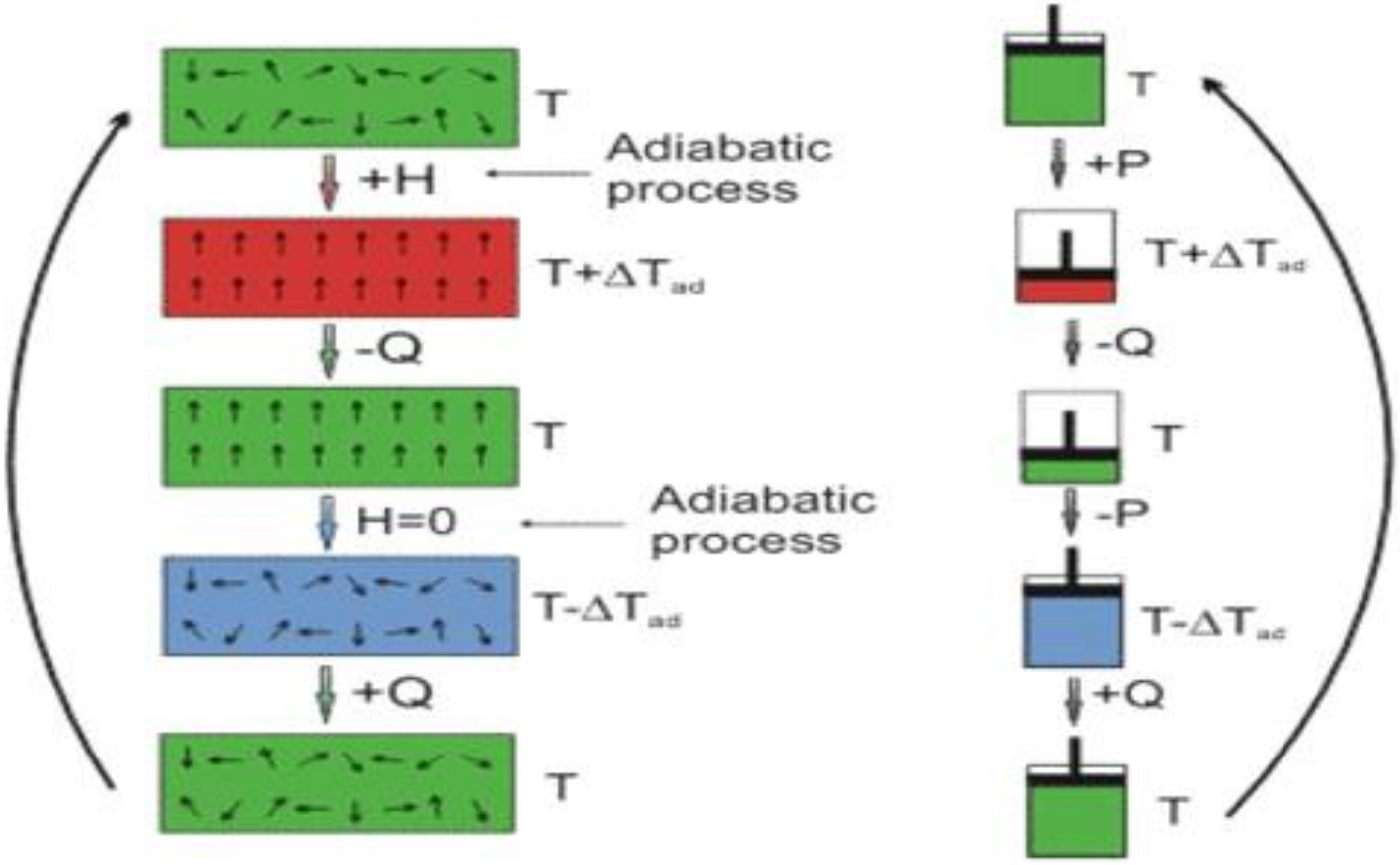
Components

1. Magnets
2. Hot heat exchanger
3. Cold heat exchanger
4. Drive
5. Magneto caloric wheel



An artist's rendition of a rotary magnetic refrigerator.

Thermo dynamic cycle



Magnetic refrigeration

Vapor cycle refrigeration

Steps of thermodynamic cycle

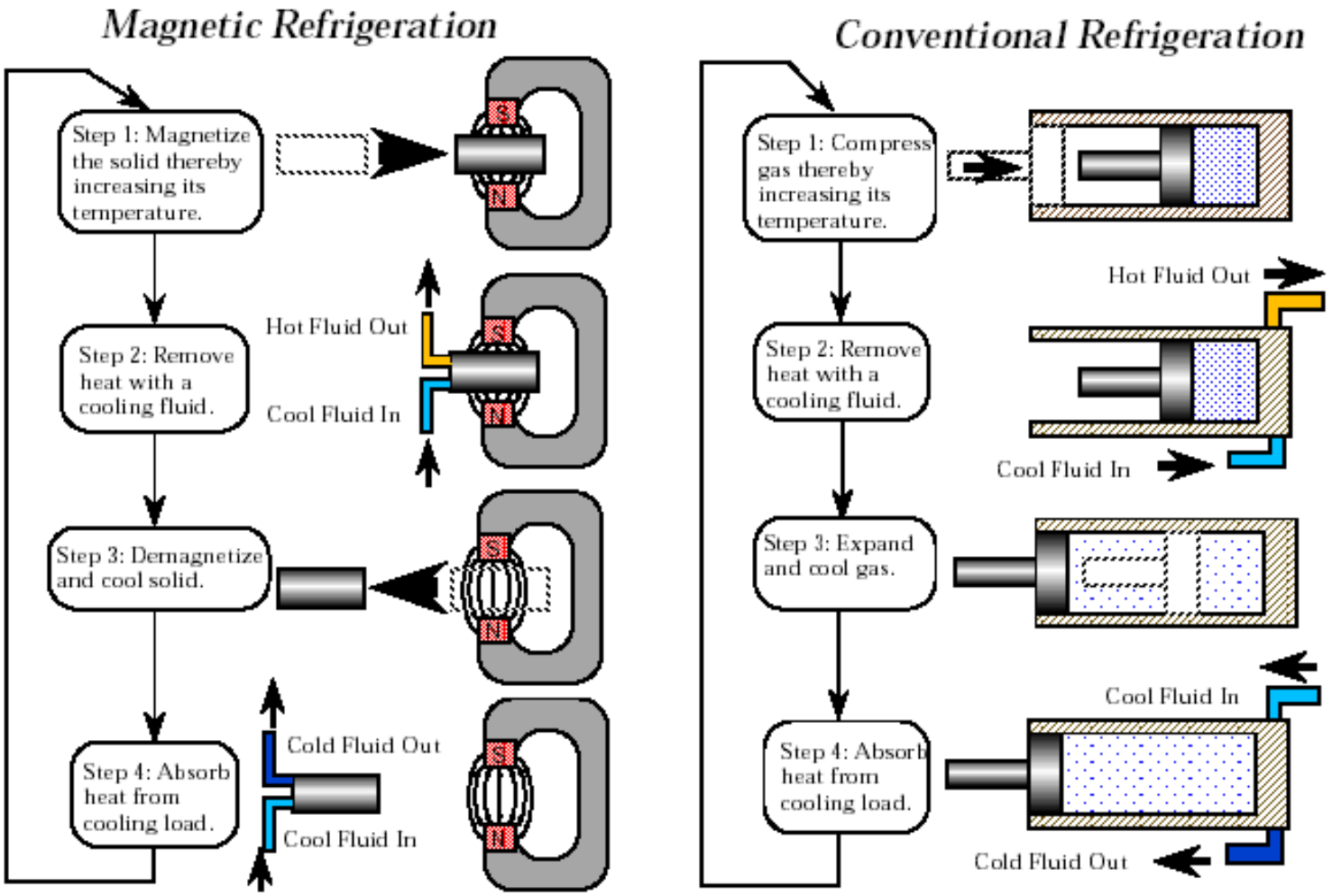
- Adiabatic magnetization
- Isomagnetic enthalpy transfer
- Adiabatic demagnetization
- Isomagnetic entropic transfer

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 particals.

- 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

Comparison B/w Magnetic Refrigeration & Conventional Refrigeration



Benefits

- Technical benefits

1. High Efficiency
2. Reduce operation cost
3. Compactness
4. Reliability

- Socio-Economic

1. Competition in global market
2. Low Capital Cost
3. Key Factor to new technologies

Advantages of Magnetic Refrigeration

- “Green” technology, no use of conventional refrigerants.
- Noiseless technology (no compressor). This is an advantage in certain contexts such as medical applications.
- Simple design of machines, e.g. rotary porous heat exchanger refrigerator.
- Low maintenance costs.

Disadvantages

- GMCE materials need to be developed to allow higher frequencies of rectilinear and rotary magnetic refrigerators.
- Permanent magnets have limited field strength. Electro magnets and superconducting magnets are (too) expensive.
- Temperature changes are limited. Multi-stage machines lose efficiency through the heat transfer between the stages.
- Protection of electronic components from magnetic fields is difficult.

Application

- Magnetic household refrigeration appliance
- Magnetic cooling & air-conditioning
- Central cooling systems
- Refrigeration in medicines
- Cooling in food industries, storage & transportation

Case Study

T.Utaki,T.Yamamoto & T.Numazava from **Osaka university**, Japan. Have constructed MR model based on multistage **Active Magnetic Refrigerative** (AMR) cycle.

The result of simulation, they showed that MR for hydrogen liquefaction is possible more than the use of convectional liquefaction method.

In general they have found that it is helpful to pre-cool hydrogen prior to liquefaction using liquid nitrogen or liquid nitrogen gas.

analyses with 3 case:

1. It is assumed that this system pre-cools the hydrogen from 300K-22Kusing 7-9 stages of AMRR.
2. In this case hydrogen is cooled from 300k-77k by LN and from 77K-22K by 3 stages of AMRR.
3. In this case supplied hydrogen is pre-cooled from 300K-120K by LNG and from 120K-22K by 5 stages of AMRR.

Best performance was achieved in case 2.

Conclusion

- Two advantages to using Magnetic Refrigeration over vapor compressed systems are no hazardous chemicals used and they can be up to 60% efficient.
- Magnetic refrigeration is a technology that has proven to be environmentally safe.
- Models have shown 25% efficiency improvement over vapor compression systems.

References

- **“Refrigeration and Air conditioning”** by Arora and Domkundwar
- **Lounasmaa**, **experimental principles and methods**, academic press
- A text book on **cryogenic engineering** by V.J.Johnson
- Wilkinson, Sophie L. **“Playing It Cool”** Science/Technology, April 2000

Thank you