MAGNETIC REFRIDGERATOR ITSP 2016

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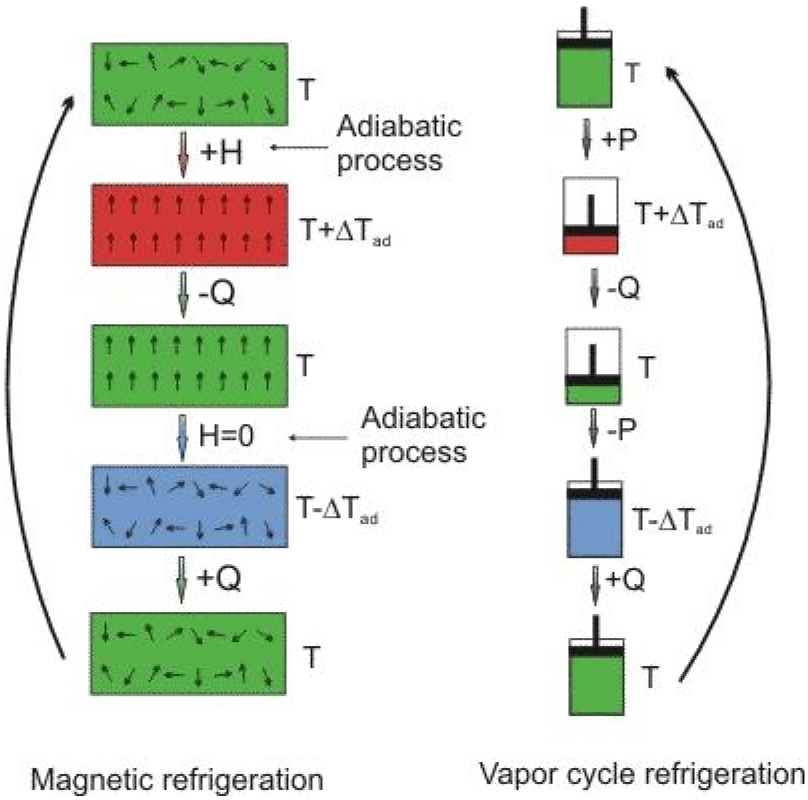
PRINCIPLE BEHIND MAGNETIC REFRIDGERATOR: MAGNETOCALORIC EFFECT

Magnetic refrigeration is a cooling technology based on the **magnetocaloric effect**. This technique can be used to attain extremely low temperatures, as well as the ranges used in common refrigerators. Compared to traditional gas-compression refrigeration, magnetic refrigeration is safer, quieter, more compact, has a higher cooling efficiency, and is more environmentally friendly because it does not use harmful, ozone-depleting coolant gases.

The effect was first observed by French physicist P. Weiss and Swiss physicist A. Piccard in 1917. The fundamental principle was suggested by P. Debye (1926) and W. Giauque (1927). The first working magnetic refrigerators were constructed by several groups beginning in 1933. Magnetic refrigeration was the first method developed for cooling below about 0.3K (a temperature attainable by He refrigeration, that is pumping on the He vapors).

Thermodynamic cycle



Analogy between magnetic refrigeration and vapor cycle or conventional refrigeration. *H* = externally applied magnetic field; *Q* = heat quantity; *P* = pressure; ΔT_{ad} = adiabatic temperature variation

The cycle is performed as a [refrigeration cycle]() that is analogous to the [Carnot refrigeration cycle](), but with increases and decreases in magnetic field strength instead of increases and decreases in pressure. It can be described at a starting point whereby the chosen working substance is introduced into a [magnetic field](), i.e., the magnetic flux density is increased. The working material is the refrigerant, and starts in thermal equilibrium with the refrigerated environment.

- ***Adiabatic magnetization:* A magnetocaloric substance is placed in an insulated environment. The increasing external magnetic field (+*H*) causes the magnetic dipoles of the atoms to align, thereby decreasing the material's** magnetic entropy and heat capacity. Since overall energy is not lost (yet) and therefore total entropy is not reduced (according to thermodynamic laws), the net result is that the substance is heated ($T + \Delta T_{ad}$).

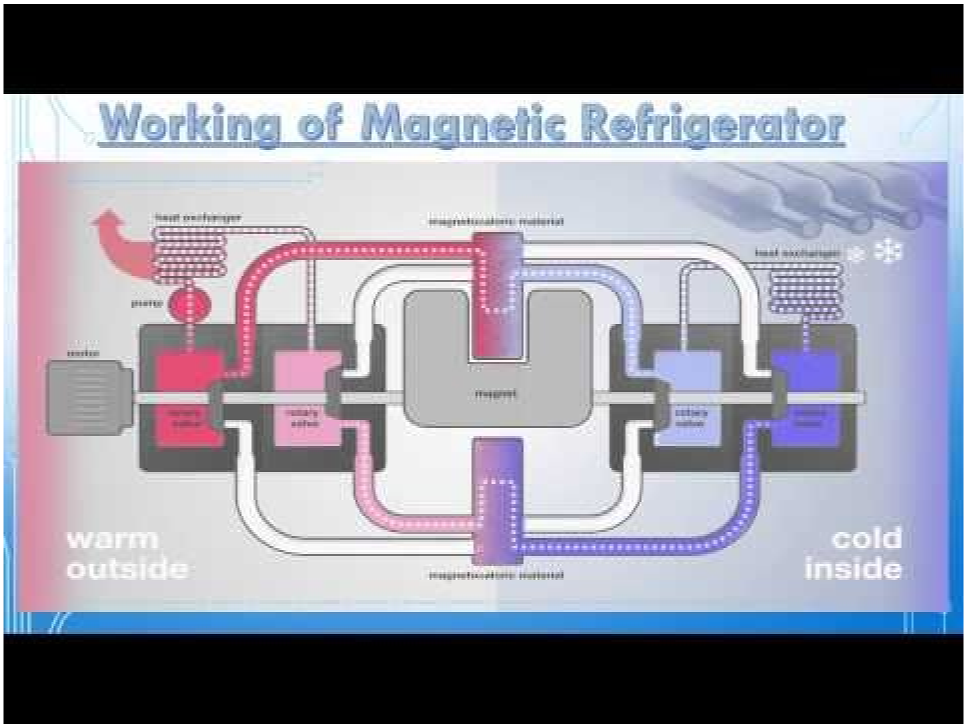
· *Isomagnetic enthalpic transfer:* This added heat can then be removed ($-Q$) by a fluid or gas — gaseous or liquid helium, for example. The magnetic field is held constant to prevent the dipoles from reabsorbing the heat. Once sufficiently cooled, the magnetocaloric substance and the coolant are separated (H=0).

· *Adiabatic demagnetization:* The substance is returned to another adiabatic (insulated) condition so the total entropy remains constant. However, this time the magnetic field is decreased, the thermal energy causes the magnetic moments to overcome the field, and thus the sample cools, i.e., an adiabatic temperature change. Energy (and entropy) transfers from thermal entropy to magnetic entropy, measuring the disorder of the magnetic dipoles.

· *Isomagnetic entropic transfer:* The magnetic field is held constant to prevent the material from reheating. The material is placed in thermal contact with the environment to be refrigerated. Because the working material is cooler than the refrigerated environment (by design), heat energy migrates into the working material ($+Q$).

Once the refrigerant and refrigerated environment are in thermal equilibrium, the cycle can restart.

ROUGH MODEL OF THE REFRIDGERATOR THAT WE HAVE IN OUR MIND:



MATERIALS REQUIRED:

1. Magnetocaloric substances like gadolinium or cadmium sulphate ,or cerium magnesium nitrate(if it is available in the institute, please allow us use it during our project as these materials are difficult to get and is very expensive)
2. Pump
3. Motor
4. Heat exchanger ducts
5. Chamber to be cooled
6. Electromagnet
7. Valves
8. Ducts
9. Ethanol+water mixture for heat exchange

Cost estimated is nearly 10,000 (Depends on the price of magneto caloric materials)

Time line:

1. Week 1: sufficient research works on this topics , making of the blue print of our machine, and acquiring parts.
2. Week 2: cutting and shaping of the parts according to specifications
3. Week 3: final assembly and testing
4. Week 4:buffer time