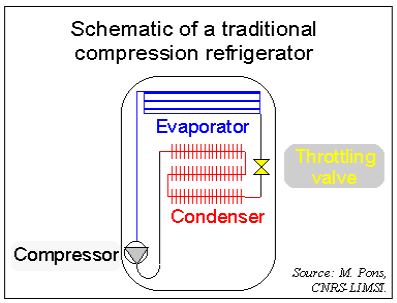
PRINCIPLE OF ADSORPTION CYCLES FOR REFRIGERATION OR HEAT PUMPING

Michel Pons

- **The operation of adsorption cycles for refrigeration can easily be compared to traditional compression cycles.**

Click on the icon, there on the right, and find a description of compression cycles for refrigeration

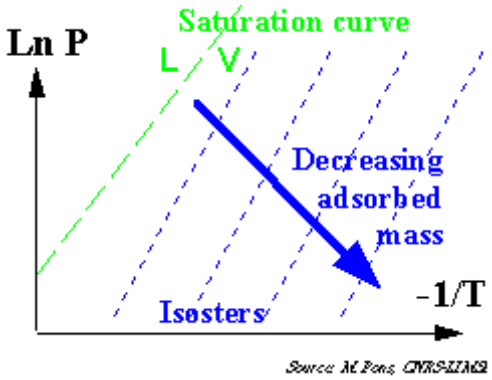


Principle of adsorption cycles for refrigeration

- **WHAT IS ADSORPTION?**

A relevant definition of the phenomenon of adsorption and a list of different adsorbents (Web site of the International Adsorption Society - IAS)

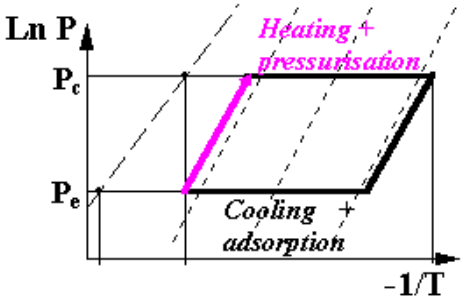
- **Let us just remind that adsorption is a reversible process by which a fluid molecule is fixed onto a solid matrix, typically a surface or a porous material. When the molecule is fixed, it looses some energy: adsorption is exothermic. Moreover, the thermodynamic equilibrium is divariant. This divariant equilibrium can be described by the set of isosters in the Clapeyron diagram (LnP vs -1/T).**



An adsorption cycle for refrigeration -or heat pumping- does not use any mechanical energy, but only heat energy. Moreover, this type of cycle basically is a four temperature discontinuous cycle.

An adsorption unit consists of one or several adsorbers plus a condenser plus an evaporator, connected to heat sources.
The adsorber -or system consisting of the adsorbers- exchanges heat with a heating system at high temperature -*HS*- and a cooling system at intermediate temperature -*CS*-, while the system consisting of the condenser plus evaporator exchanges heat with another heat sink at intermediate temperature (not necessarily the same temperature as the *CS*), and a heat source at low temperature. Vapour is transported between the adsorber(s) and the condenser+evaporator.

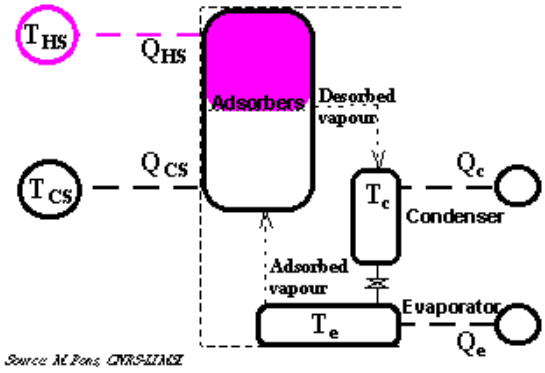
- **The cycle consist of four periods:**



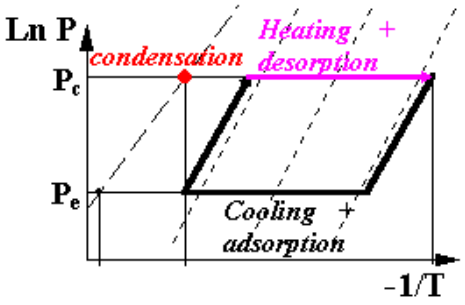
- **<u>1: HEATING AND PRESSURISATION</u>**

During this period, the adsorber receives heat while being closed.
The adsorbent temperature increases, which induces a pressure increase, from the evaporation pressure up to the condensation pressure.

This period is equivalent to the "compression" in compression cycles.

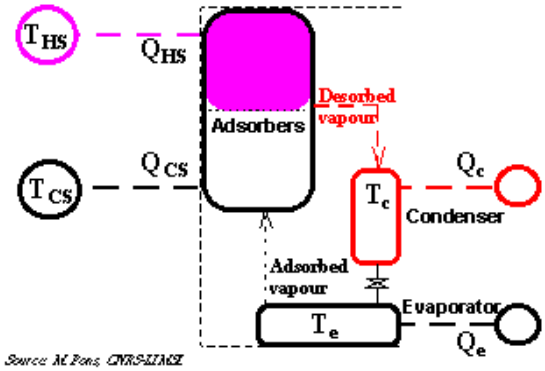


2: HEATING AND DESORPTION + CONDENSATION



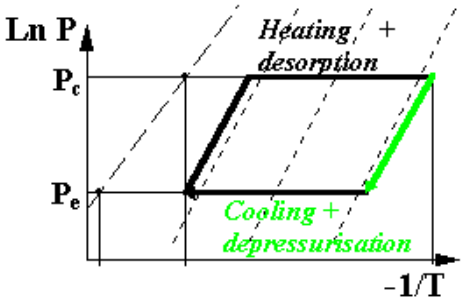
During this period, the adsorber continues receiving heat while being connected to the condenser, which now superimposes its pressure. The adsorbent temperature continues increasing, which induces desorption of vapour. This desorbed vapour is liquified in the condenser. The condensation heat is released to the second heat sink at intermediate temperature.

This period is equivalent to the "condensation" in compression cycles.



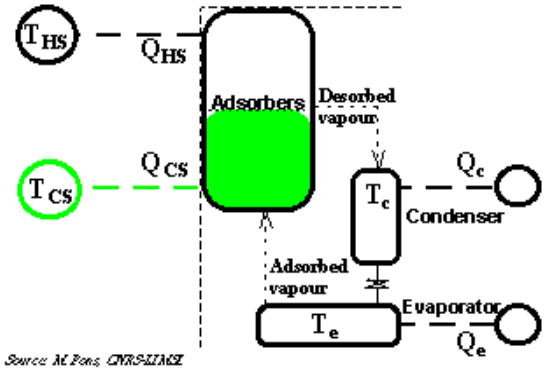
Source M.Pons CNRS-LIMSI

3: COOLING AND DEPRESSURISATION



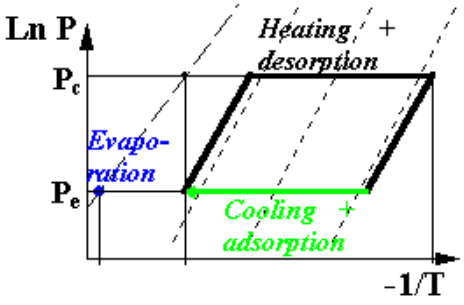
During this period, the adsorber releases heat while being closed.
The adsorbent temperature decreases, which induces the pressure decrease from the condensation pressure down to the evaporation pressure.

This period is equivalent to the "expansion" in compression cycles.



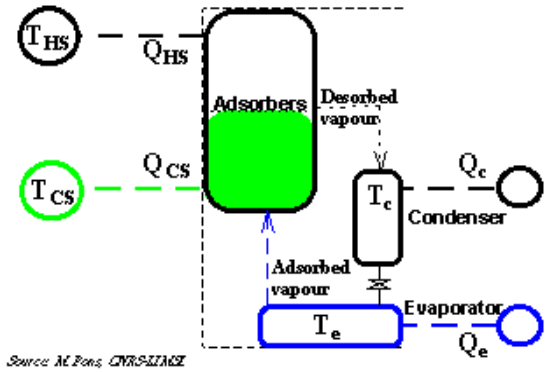
Source M.Pons CNRS-LIMSI

4: COOLING AND ADSORPTION + EVAPORATION



During this period, the adsorber continues releasing heat while being connected to the evaporator, which now superimposes its pressure.
The adsorbent temperature continues decreasing, which induces adsorption of vapour.
This adsorbed vapour is vaporised in the evaporator.
The evaporation heat is supplied by the heat source at low temperature.

This period is equivalent to the "evaporation" in compression cycles.



- **Basically, the cycle is intermittent because cold production is not continuous: cold production proceeds only during part of the cycle. When there are two adsorbers in the unit, they can be operated out of phase and the cold production is quasi-continuous.**
  - **When all the energy required for heating the adsorber(s) is supplied by the heat source, the cycle is termed *single effect cycle*.**
    Typically, for domestic refrigeration conditions, the coefficient of performance (COP) of single effect adsorption cycles lies around 0.3-0.4.
    When there are two adsorbers or more, other types of cycles can be processed.
  - **In *double effect cycles* or in *cycles with heat regeneration*, some heat is internally recovered between the adsorbers, which enhances the cycle performance.**

Source:

http://perso.limsi.fr/mpons/pricyc.htm