Factsheet

5 march 2009

Thermal sorption cooling

Through sorption processes, heat can be used for cooling. It can be coupled with waste heat or with solar collectors for cooling with low environmental impact. Electric power is used for pumps and fans; the electrical power consumption is generally less than 10% of traditional (mechanical) cooling. Compared to traditional cooling systems, these technologies result in low operational costs (energy), but require high investments.
A summary of various systems (based on an overview of RAEE, 2008):

Method	Closed cycle		Open cycle	
Name / Market available	**Adsorption chiller**	**Absorption chiller**	**Desiccant cooling**	**Close to market introduction**
Principle	Chilled water		Dehumidification of air and evaporative cooling	
Phase of sorbent	Solid	Liquid	Solid	Liquid
				
Typical material pairs	water - silica gel	water - lithium bromide ammonia - water	water - silica gel, water - lithium chloride	water - calcium chloride, water - lithium chloride
Typical cooling capacity (kW cold)	50 – 430 kW	15 kW – 5 MW	20 kW – 350 kW per module	
Typical COP	0, 5 – 0, 7	0, 6 – 0, 75 (Single effect)	0, 5 – >1	> 1
Driving temperature	60 – 90 °C	80 – 110 °C	45 – 95 °C	45 – 70 °C
Logical combination with solar collectors	Vacuum tubes, flat plate collectors	Vacuum tubes	Flat plate collectors, solar air collectors	Flat plate collectors, solar air collectors
Application	cooling water, min. 4°C	H_2O-LiBr: freezing NH_3-H_2O: min. 5°C	min. about 10°C	under study

Thermally driven chillers

The chillers are characterised by three temperature levels:

- A high temperature level that drives the process (supplied heat)
- A low temperature level produced by the process (cold generated)
- A medium temperature level that contains the reject heat. Closed cycle systems require cooling water for this (possibly supplied by a cooling tower). Lowering the cooling water temperature significantly contributes to the cooling efficiency.

Driving power (heat) can be (waste) heat from e.g. electricity production or solar heat.

Absorption cooling for refrigeration purposes

Closed cycle systems supply chilled water that can be used for refrigeration conditions. Cold distribution is realised through fluids such as water or glycol.
The process is driven by evaporating refrigerants (water or ammonia) through the heat supplied (section 1 in Figure 1). The refrigerant condensates in a cooled section (2). This process results in a highly concentrated refrigerant solution. This solution is pumped to the "refrigeration section" (3). Because of the high refrigerated concentration, part of it will evaporate here and condensate in a cooled lower concentration solution (4).

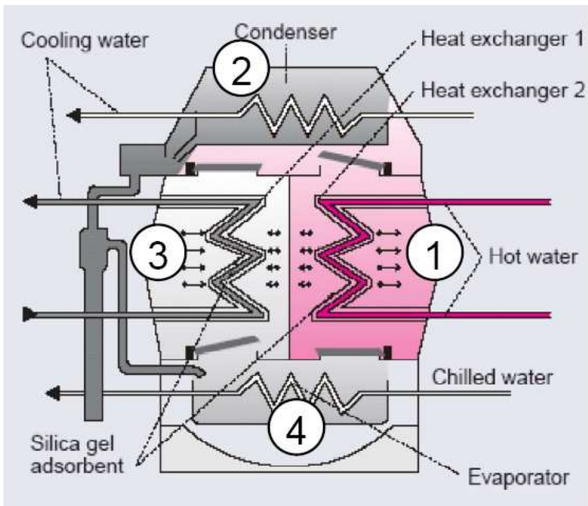

Figure 1. Absorption cooling process scheme (based on De Boer, 2005)

The evaporation in the "refrigeration section" provides the cooling effect. In order to keep the cyclic process going, the solution from section (4) is pumped to the hot section again.

Comfort cooling and dehumidification

Open systems supply cooled and dehumidified air. Driving force is evaporation and condensation of water on a desiccant (such as silica gel or zeolites). The process is explained with the following figure.

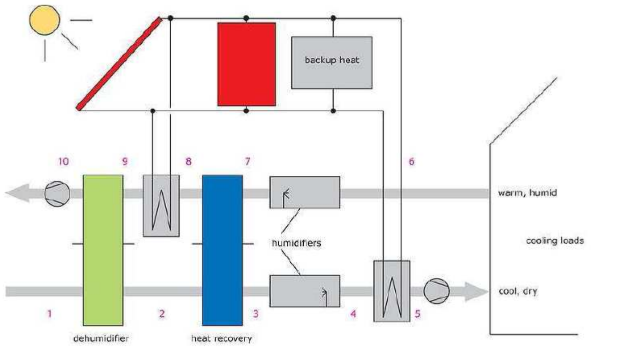

Figure 2. Desiccant cooling process scheme, using solar heat. (Solair-project, 2008).

Most common systems are desiccant cooling systems using a rotating dehumidification wheel with solid sorbent.
Warm and humid air enters the slowly rotating desiccant wheel and is dehumidified by adsorption of water (1-2). Since the air is heated up by the adsorption heat, a heat recovery wheel is passed (2- 3), resulting in a significant pre-cooling of the supply air stream. Subsequently, the air is humidified and thus further cooled by a controlled humidifier (3-4). The exhaust air stream of the rooms is humidified (6-7) close to the saturation point to exploit the full cooling potential in order to allow an effective heat recovery (7-8). Finally, the sorption wheel has to be regenerated (9-10) by applying heat in a comparatively low temperature range from 50℃- 75℃ and to allow a continuous operation of the dehumidification process.

This type of system (in combination with solar heat collectors) is quite common for cooling buildings in warm countries.

Financial considerations

The investments for sorption processes mainly depends on the cooling power required. The amounts are of comparable size for the various technologies.
Estimations of investments can be derived from Figure 3.

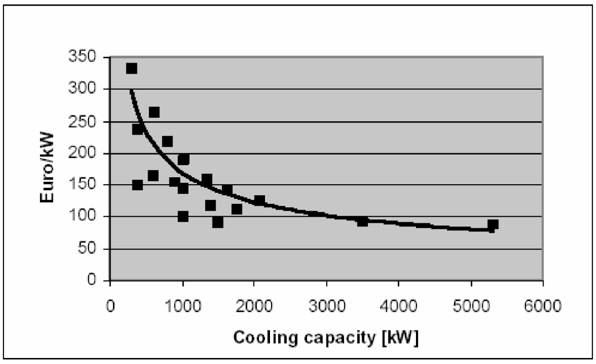

Figure 3. Estimated investments for single-effect sorption chillers (Vercampt, 2006)

Double-effect systems (with increased COP) require an additional investment of about €60 per kW. The investments are about 3 times higher than for traditional (compression) cooling systems. Feasibility of sorption chillers depends on:

- availability of free or inexpensive heat of sufficiently high temperature (possibly produced by solar collectors in hot countries).
- year-round variation of cooling need (return on high investments is most favourable if constant cooling is needed).

Practical financial feasibility will depend on external factors:

- availability (and price) of sufficiently high quality heat;
- availability of cooling water;
- continuity of availability of heat with respect to required continuity of cooling;
- existing system for cold distribution.

Typical example situations with favourable feasibility conditions:

- absorption refrigeration at food processing plants, using residual steam condensate heat.
- absorption refrigeration for chillers on fishing trawlers using waste heat from the diesel engine (existing);

Sources and further info

De Boer, R (2006).: Vaste stof-damp sorptiekoeling. *Verwarming en Ventilatie*, April 2005, pp. 302-307.
RAEE (2008): Rhônalpénergie-Environnement http://www.raee.org/climatisationsolaire/gb/solar.php
Solair-project (2008) www.solair-project.eu
Vercampt, S. (2006): *Warmte-kracht koppeling en trigeneratie.* Eindverhandeling, Universiteit Hasselt (Belgium).

Contact: *Jan Broeze*, AFSG Wageningen UR, phone +31.317.480147, e-mail jan.broeze@wur.nl
Sietze van der Sluis, TNO, Phone +31.88.8662206 email Sietze.vanderSluis@tno.nl
This renewable cooling research is executed with practical input by NVKL and financial support by the Dutch Ministry of Economic Affairs; program *Energie Onderzoek Subsidie: lange termijn (EOS-LT)*.