

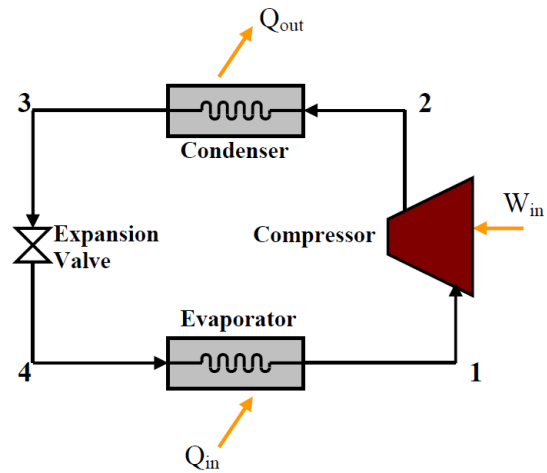
Introduction

Unlike vapour compression systems, which use electrically-driven compressors, sorption cooling technologies use a source of heat to produce cold. This characteristic makes sorption cooling machines a very useful sink of waste heat or solar energy. The term sorption cooling technologies encompasses both absorption and adsorption cooling. Of the two, absorption cooling is the most common.

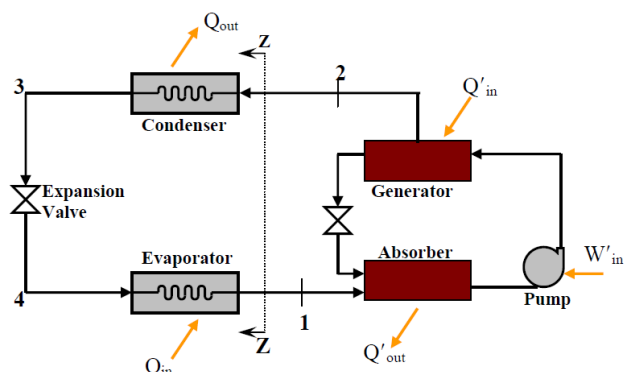
Interest in absorption cooling technology has varied since its introduction in the 19th century following variations in the cost of electricity and fossil fuel. Recently, the tightening of energy efficiency legislation and growth of decentralised energy systems, as well as environmental concerns over the use of Global Warming Potential refrigerants have led to increased efforts in sorption technology R&D. As a result, the range and efficiency of sorption machines available on the market has greatly increased.

Absorption Cycle

Absorption cycles are similar to vapour compression cycles; the main difference being that the compressor is replaced by a chemical cycle taking place between the absorber, pump, and regenerator. Basically, instead of compressing refrigerant vapour, the absorption cycle dissolves this vapour in a liquid (called the absorbent), pumps the solution to a higher pressure (with much less work input than required by a compressor) and then uses heat input to evaporate the refrigerant vapour out of the solution.



Basic vapour compression cycle



Basic absorption cooling cycle

This is of course a description of the basic cycle and actual systems are more complex and include additional components.

Technology

Two widespread absorption cycles currently in use are the lithium bromide (LiBr) cycle and the ammonia-water ($\text{NH}_3\text{H}_2\text{O}$) cycle. In the former, water acts as the refrigerant and LiBr as the absorbent. In the latter, the ammonia-water solution is the refrigerant and water is the absorbent. The LiBr cycle tends to be more common.

LiBr machines come as single-effect (single stage) or double-effect (two stage)

cycles. The double-effect machines are thermally more efficient but are more complex and require higher grade heat input. Triple effect machines have been in development offering even higher COP's.

COP's of absorption chillers are low. Single effect LiBr machines offer COP's of 0.65 ~ 0.7 and double-effect chillers can achieve COP's of about 1.2. The temperature of the heat source is the most important factor in the thermal efficiency of an absorption chiller. The higher the temperature of the heat source, the better the COP. Also, the efficiency of an absorption machine quickly deteriorates as soon as the temperature of the heat source drops below the design figure (for single-effect this is typically around 90°C)

Absorption chillers can be classified according to the form of heat input:

1. Direct-fired units combust fuel (typically natural gas) in an integral burner.
2. Indirect-fired units utilise steam or hot liquid which is supplied from an external source, typically a prime mover or solar array.
3. Bespoke machines which are fired by exhaust gases or a combination of heat sources. Those can be coupled directly to a prime mover reducing space requirements

Machines capable of simultaneous cooling and heating are also available on the market. Absorption chiller/heaters can eliminate the need for separate boilers reducing the cost and space requirements.

Characteristics

The advantages of absorption cooling machines are low electrical power requirements, fewer moving parts, quieter operation, and the use of low Global Warming Potential (GWP) refrigerants. Disadvantages include a high rate of heat rejection (1.75 – 2.5 kWh_r/kWh_r), limited

unit selection and support, large physical size and weight, and toxicity of ammonia absorbent.

Equipment

Depending on the technology, cooling capacities of absorption chillers range from 13 kW to 9.1 MW (<http://www.bchp.org/owner-equip.html> not all available in the UK). Smaller cooling capacities are currently available with adsorption cycles.

Larger units will usually be more efficient and will also include an integral vacuum pump. With smaller units, annual vacuum drawing may be necessary.

Cost

Depending on the unit size, the capital cost of single-effect absorption chillers is roughly 20-50% higher compared to an equivalent electric or engine-driven chiller. The cost will be still higher for direct fired units and for double- and triple-effect units.

Practical Tips for Implementation

Identify and resolve any pre-existing problems with a cooling system, heat rejection system, water treatment etc before installing an absorption chiller, or it may be unfairly blamed.

Select an absorption chiller for full load operation (by the incorporation of thermal stores if necessary) as COP will drop by up to 33% at part-load.

Consider VSD control of absorbent pump to improve the COP at low load.

Consider access and floor-loading (typical 2 MW Double-effect steam chiller 12.5 tonnes empty, 16.7 tonnes operating).

Ensure ambient of temperature of at least 5°C in chiller room to prevent crystallisation.

Crystallisation can be prevented if the following are considered:

- Avoid cooling water temperature colder than design by the use of mixing valves etc.
- Avoid sudden changes in cooling water temperature
- Ensure heat supply is completely shut-off when not required
- Provide a UPS to run the absorbent pump for 20 minutes after a power cut

Over-size external heat rejection if possible (N.B. required capacity is typically 50-100% bigger than an electric chiller to begin with) as reduced heat rejection capacity will severely restrict absorption chiller output just when it is

needed most and summer ambient temperatures are unlikely to fall in future.

Allow adequate time for commissioning – absorption chillers are not ‘Plug and Play’ and require 2 weeks to establish passivated internal coating after first charging with refrigerant and chemicals and after any subsequent opening to atmosphere.

Remember that a suitable chilling load is needed for commissioning.

Ensure operators are adequately trained in absorption chiller operation and in particular the conditions and transients likely to cause crystallisation.

This datasheet was produced by the CHP Group of the Chartered Institution of Building Services Engineers (CIBSE) to inform building professionals about all forms of CHP. To join or contact the CHP Group go to www.cibse.org/chp or contact CIBSE, 222 Balham High Road, London, SW12 9BS (020 8675 5211). Acknowledgements to Gregory Zdaniuk, Andrew Crafter and Huw Blackwell.