

Absorption refrigerator

An **absorption refrigerator** is a refrigerator that uses a heat source (e.g., solar, kerosene-fueled flame) to provide the energy needed to drive the cooling system. Absorption refrigerators are a popular alternative to regular compressor refrigerators where electricity is unreliable, costly, or unavailable, where noise from the compressor is problematic, or where surplus heat is available (e.g., from turbine exhausts or industrial processes, or from solar plants).

For example, absorption refrigerators powered by heat from the combustion of liquefied petroleum gas are often used for food storage in recreational vehicles. Absorptive refrigeration can also be used to air-condition buildings using the waste heat from a gas turbine or water heater. This use is very efficient, since the gas turbine produces electricity, hot water and air-conditioning (called Trigereneration).

Both absorption and compressor refrigerators use a refrigerant with a very low boiling point (less than 0 °F/−18 °C). In both types, when this refrigerant evaporates (boils), it takes some heat away with it, providing the cooling effect. The main difference between the two types is the way the refrigerant is changed from a gas back into a liquid so that the cycle can repeat. An absorption refrigerator changes the gas back into a liquid using a different method that needs only heat, and has no moving parts^[1]. The other difference between the two types is the refrigerant used. Compressor refrigerators typically use an HCFC or HFC, while absorption refrigerators typically use ammonia or water.

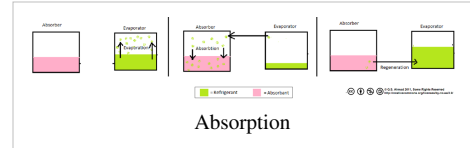
The standard for the absorption refrigerator is given by the ANSI/AHRI standard 560-2000^[2].

Principles

Absorptive refrigeration uses a source of heat to provide the energy needed to drive the cooling process.

The absorption cooling cycle can be described in three phases:

1. **Evaporation:** A liquid refrigerant evaporates in a low partial pressure environment, thus extracting heat from its surroundings – the refrigerator.
2. **Absorption:** The gaseous refrigerant is absorbed – dissolved into another liquid - reducing its partial pressure in the evaporator and allowing more liquid to evaporate.
3. **Regeneration:** The refrigerant-laden liquid is heated, causing the refrigerant to evaporate out. It is then condensed through a heat exchanger to replenish the supply of liquid refrigerant in the evaporator.



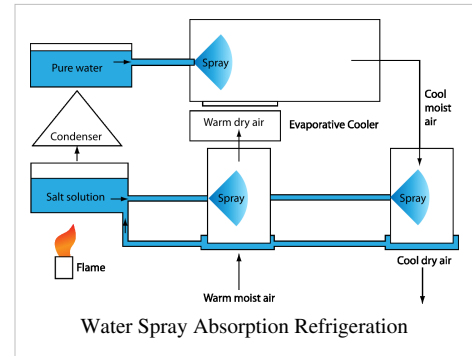
Simple salt and water system

A simple absorption refrigeration system common in large commercial plants uses a solution of lithium bromide salt and water. Water under low pressure is evaporated from the coils that are being chilled. The water is absorbed by a lithium bromide/water solution. The water is driven off the lithium bromide solution using heat.^[3]

Water spray absorption refrigeration

Another variant, depicted to the right, uses air, water, and a salt water solution. The intake of warm, moist air is passed through a sprayed solution of salt water. The spray lowers the humidity but does not significantly change the temperature. The less humid, warm air is then passed through an evaporative cooler, consisting of a spray of fresh water, which cools and re-humidifies the air. Humidity is removed from the cooled air with another spray of salt solution, providing the outlet of cool, dry air.

The salt solution is regenerated by heating it under low pressure, causing water to evaporate. The water evaporated from the salt solution is re-condensed, and rerouted back to the evaporative cooler.



Single pressure absorption refrigeration

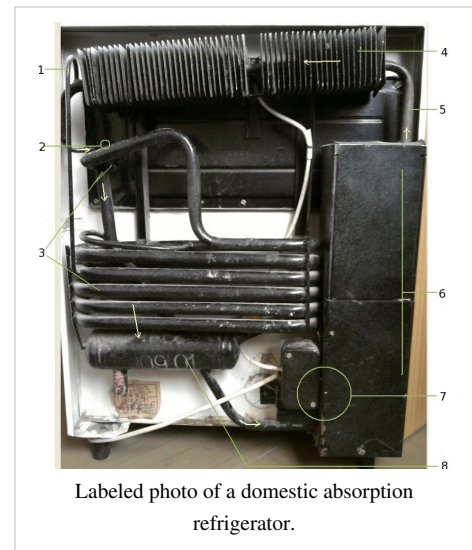
A single-pressure absorption refrigerator uses three substances: ammonia, hydrogen gas, and water. At standard atmospheric conditions, ammonia is a gas with a boiling point of -33°C , but a single-pressure absorption refrigerator is pressurised to the point where the ammonia is a liquid. The cycle is closed, with all hydrogen, water and ammonia collected and endlessly reused.

The cooling cycle starts with liquefied ammonia entering the evaporator at room temperature. The ammonia is mixed in the evaporator with hydrogen. The partial pressure of the hydrogen is used to regulate the total pressure, which in turn regulates the vapour pressure and thus the boiling point of the ammonia. The ammonia boils in the evaporator, providing the cooling required.

The next three steps exist to separate the gaseous ammonia and the hydrogen. First, in the absorber, the mixture of gasses enters the bottom of an uphill series of tubes, into which water is added at the top. The ammonia dissolves in the water, producing a mixture of ammonia solution and hydrogen. The hydrogen is collected at the top of the absorber, with the ammonia solution collected at the bottom.

The second step is to separate the ammonia and water. In the generator, heat is applied to the solution, to distill the ammonia from the water. Some water remains with the ammonia, in the form of vapour and bubbles. This is dried in the final separation step, called the separator, by passing it through an uphill series of twisted pipes with minor obstacles to pop the bubbles, allowing the collected water to drain back to the generator.

Finally the pure ammonia gas enters the condenser. In this heat exchanger, the hot ammonia gas is cooled to room temperature and hence condenses to a liquid, allowing the cycle to restart.



Labeled photo of a domestic absorption refrigerator.

History

Absorption cooling was invented by the French scientist Ferdinand Carré in 1858.^[4] The original design used water and sulfuric acid.

In 1922 Baltzar von Platen and Carl Munters, while they were still students at the Royal Institute of Technology in Stockholm, Sweden, enhanced the principle with a 3 fluids configuration. This "Platen-Munters" design can operate without a pump.

Commercial production began in 1923 by the newly formed company AB Arctic, which was bought by Electrolux in 1925. In the 60s the absorption refrigeration saw a renaissance due to the substantial demand for refrigerators for caravans. AB Electrolux established a subsidiary in the U.S, named Dometic Sales Corporation. The company marketed refrigerators for caravans under the **Dometic** brand. In 2001 Electrolux sold most of its Leisure Products line to the venture-capital company EQT which created Dometic as stand alone company.

In 1926 Albert Einstein and his former student Leó Szilárd proposed an alternative design known as Einstein refrigerator^[5].

In 2007, Adam Grosser presented his research of a new, very small, "intermittent absorption" refrigeration system for use in third world countries at the TED Conference. The refrigerator is a small unit placed over a campfire, that can later be used to cool 3 gallons of water to just above freezing for 24 hours in a 30 degree Celsius environment.^[6]

References

- [1] In comparison, a compressor refrigerator uses an electrically-powered compressor to increase the pressure on the gas, and then condenses the hot high pressure gas back to a liquid by heat exchange with a coolant (usually air). Once the high pressure gas has cooled and condensed into a liquid, it passes through an orifice which creates a pressure drop, which causes the liquid to evaporate. The evaporation process absorbs heat, and the temperature of the refrigerant drops to its boiling point at the (now) low pressure.
- [2] http://www.ahrinet.org/Content/FindaStandard_218.aspx?Listing_PK=150
- [3] Sapali, S. N. "Lithium Bromide Absorption Refrigeration System". *Textbook Of Refrigeration And Air-Conditioning*. New Delhi: PHI learning. p. 258. ISBN 9788120333604.
- [4] Eric Granryd & Björn Palm, Refrigerating engineering, Stockholm Royal Institute of Technology, 2005, see chap. 4-3
- [5] "US Patent 1781541" (<http://www.google.com/patents?q=1781541>). .
- [6] "Adam Grosser and his sustainable fridge" (<http://www.youtube.com/watch?v=HSdXqmnNCp0>). TED. . Retrieved 2010-04-18.

External links

- ANSI/AHRI Standard 560-2000 (http://www.ahrinet.org/Content/FindaStandard_218.aspx?Listing_PK=150).
- Absorption Heat Pumps (http://apps1.eere.energy.gov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12680) (EERE).
- Arizona Energy (http://www.arizonaenergy.org/AltEnergyClub/SMALL_AMMONIA_REFRIGERATOR.htm) Explanation with diagrams
- Design Analysis of the Einstein Refrigeration Cycle, Andrew Delano (1998) (http://www.me.gatech.edu/energy/andy_phd/). Retrieved September 13, 2005.
- How It Works, Details about the absorption system (<http://gasrefrigerators.com/howitworks>). Retrieved June 26, 2009.
- Ohio State University Center of Excellence in Absorption Technology: Theory of Heat Pump Operation (<http://rcl.eng.ohio-state.edu/~christ-r/ceat/theory/theory.html>)
- Air Conditioning Thermodynamics (http://www.arb.ca.gov/cc/ccms/documents/august_tsd/ac_thermo_august.pdf), published by the California EPA, Air Resources Board
- Thermally-Activated Machines Refrigeration Cycle (<http://www.northeastchp.org/nac/businesses/refrigeration.htm>): Northeast CHP Application Center at the University of Massachusetts Amherst and Pace University

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- Using Heat to Cool Buildings (<http://www.technologyreview.com/energy/37210/?nlid=4295>), MIT Technology Review

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