Evaporative cooling

Evaporative cooling is a physical phenomenon in which evaporation of a liquid, typically into surrounding air, cools an object or a liquid in contact with it. **Latent heat** describes the amount of heat that is needed to evaporate the liquid; this heat comes from the liquid itself and the surrounding gas and surfaces. When considering water evaporating into air, the **wet bulb temperature**, as compared to the air's **dry bulb temperature**, is a measure of the potential for evaporative cooling. The greater the difference between the two temperatures, the greater the evaporative cooling effect. When the temperatures are the same, no net evaporation of water in air occurs, thus there is no cooling effect.

The simplest example would be perspiration, or sweat, which the body secretes in order to cool itself. The amount of heat transfer depends on the evaporation rate, which in turn depends on the humidity of the air and its temperature, which is why you sweat more on hot, humid days.

Another, recent application of evaporative cooling is the "self-refrigerating" beverage can [1]. A separate compartment inside the can contains a desiccant and cooling liquid. Just before consumption, the desiccant comes into contact with the cooling liquid, inducing evaporation.

Evaporative cooling was in vogue for aircraft designs for some time in the late 1930s. In this case the system was used in order to reduce, or eliminate completely, the radiator which would otherwise create considerable drag. In these systems the water in the engine was kept under pressure with pumps, allowing it to heat to temperatures above 100 Celsius, as the actual boiling point is a function of the pressure. The super-heated water was then sprayed though a nozzle into an open tube, where it rapidly boiled and released its heat. The tubes could be placed under the skin of the aircraft, resulting in a zero-drag cooling system.

However these systems also had serious disadvantages. Since the amount of tubing needed to cool the water was large, the cooling system covered a significant portion of the plane even though it was hidden. This led to all sorts of added complexity and the systems were always terribly unreliable. In addition this large size meant it was very easy for it to be hit by enemy fire, and practically impossible to armor. British and US attempts to use the system turned to ethylene glycol instead. The Germans instead used streamlining and positioning of traditional radiators. Even its most ardent supporters, Heinkel's Günter brothers, eventually gave up on it in 1940.

Evaporative cooling was used in some automobiles, often as aftermarket accessories, until modern vapor-compression air-conditioning became widely available.

Evaporative cooling is a very common form of cooling buildings for thermal comfort since it is relatively cheap and requires less energy than many other forms of cooling. However evaporative cooling requires an abundant water source as an evaporate, and is only efficient when the relative humidity is low, restricting its effective use to dry climates. Evaporative coolers are colloquially referred to as *swamp coolers* in the U.S. In other places they are known as desert coolers.

Evaporative cooling is commonly used in cryogenic applications. The vapor above a reservoir of cryogenic liquid is pumped away, and the liquid continuously evaporates as long as the liquid's vapor pressure is significant. Evaporative cooling of ordinary helium forms a 1-K pot, which can cool to at least 1.2 K. Evaporative cooling of helium-3 can provide temperatures below 300 mK. Each of these techniques can be used to make cryocoolers, or as components of lower-temperature cryostats such as dilution refrigerators. As the temperature decreases, the vapor pressure of the liquid also falls, and cooling becomes less effective. This sets a lower limit to the temperature attainable with a given liquid.

This process has recently been observed to operate on a planetary scale on Pluto and acts as an Anti-Greenhouse Effect.

Evaporative cooling is also the last cooling step in order to reach the ultra-low temperatures required for Bose-Einstein Condensation (BEC). Here, so-called forced evaporative cooling is used to selectively remove high-energetic ("hot") atoms from an atom cloud until the remaining cloud is cooled below the BEC transition temperature. For a cloud of 1 million alkali atoms, this temperature is about 1μK.