Heat Pumps

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Heat pumps are realized through several physical effects, but they are classified depending on their applications (driving energy, source and sink of heat, or a heat pump which is basically a refrigeration machine). Refrigerators, air conditioners, and some heating systems are all common applications of heat pumps.

An easy way to imagine how a heat pump works is to imagine the heat in a given space - say the volume of a football (or soccerball). The air within the volume of the ball has say 100 units of heat. This air is then compressed to the size of ping pong ball (table tennis ball); it still contains the same 100 units of heat, but the heat is much more concentrated and thus the average heat per volume unit is much higher. The ping pong volume of heat is then moved from the heat source area to the target area that has a lower per volume concentration of heat. Since the heat of the ping pong ball volume is now a higher concentration than the surrounding heat, the heat is given off until the ping pong ball volume heat reaches the same concentration of heat as the surrounding area. The ping pong ball volume is then moved outside the target area back to the heat source area and allowed to expand. In expanding the volume of refrigerant in the ping-pong ball is expanded to the size of the football, and the heat energy per unit volume is now well below the 100 units enabling the expanded refrigerant to absorb heat from the surrounding area. The compressor unit creates the pressure difference which causes this cycle to endlessly repeat as long as the heat pump system is running.

When comparing the performance of heat pumps, it is best to avoid the word "efficiency", as it has many different meanings. The term coefficient of performance or COP is used to describe the ratio of heat output to electrical power consumption. A typical heat pump has a COP of about four, whereas a typical electric heater has a COP of one, indicating units of heat exchange performance per units of electrical power input (resistive electric heat being 100% efficient whereas heat pump heating offering up to 400% efficiency).

The COP of a heatpump is restricted by the second law of thermodynamics.

All temperatures T are measured in kelvins.

Commercial heat pump technologies are currently in a stage of rapid improvement: the COP for commercially available heat pumps has risen in the last 5 years from 3 to 4 and even (in a few cases) 5. As a result heat pumps are becoming popular choices for home-heating. Two common types of heat pumps for home heating are air-source and ground-source heat pumps depending on whether heat is transferred from the air or from the ground.

For an air-source heat pump its COP is limited by its need to pump the heat into the house from outside - and so they work less well in very cold climates where there is less heat density outside to pump in. Typically the COP decreases markedly once outside temperatures go below around -5 or -10 degrees Celsius, though this limit varies from one model to another.

Those buying an air-source heat pump should look closely at the heat pump's COP, at what outside temperature range that COP is effective for, at the cost of installation of the pump, at how much heat it can pump (measured in kilowatts), and at the noise generated (in decibels).

Because a ground-source heat pump draws heat from the ground (usually from groundwater), which below a depth of about 8 feet is at a relatively constant temperature year round, its COP is higher than for an air-source heat pump and its COP is constant year round. The penalty for this improved performance is that a ground-source heat pump is significantly more expensive to install than an air-source heat pump.

Heat pumps are also becoming more commonly used to heat swimming pools and to heat hot water for household use.

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