An electric compression heat pump consists of a compressor with a drive motor, a condenser, an expansion valve, and an evaporator. Its operation is based on a cyclical process of phase transition, which the working medium inside the pump undergoes. Ideally, this process can be divided into four steps, comprising compression, liquefaction, depressurisation, and evaporation.

The condensed working medium reaches the release valve, where it is depressurised (without doing any mechanical work). In this process, the temperature also decreases due to the work which needs to be performed in opposition to the molecular forces of attraction inside the working medium (Joule-Thomson effect). The enthalpy remains constant (\(h_3 = h_4\)). As it absorbs heat inside the evaporator, the working medium evaporates fully. This cools the surrounding reservoir. The heat absorbed per unit of mass is \(\Delta h_4 = h_4 - h_3\).

For the compression part of the cycle, the gaseous working medium is drawn in by the compressor and compressed without any change in entropy \(s_2 = s_1\) from \(p_1\) to \(p_2\) during which process the medium heats up (see Figs. 1 and 2). The temperature accordingly rises from \(T_1\) to \(T_2\). The mechanical compression work performed per unit of mass is \(\Delta w = h_2 - h_1\). Inside the condenser, the working medium cools considerably and condenses. The heat released as a result (excess heat and latent heat of condensation) per unit of mass is \(\Delta q_3 = h_3 - h_2\). It raises the temperature of the surrounding reservoir.

The condensed working medium is supplied to the hot water reservoir per time interval \(\Delta t\). Additional measurement of the temperature \(T_F\) provides an advanced insight into the processes taking place in the heat pump. \(T_F\) does not coincide with the temperature reading on the related manometer's temperature scale. This temperature scale is based on the vapour pressure curve for the working medium. The measurement therefore shows that the working medium before the expansion valve does not comprise a mixture of liquid and gas, but is entirely liquid.

For the expansion part of the cycle, the temperature also decreases due to the work which needs to be performed in opposition to the molecular forces of attraction inside the working medium (Joule-Thomson effect). The enthalpy remains constant (\(h_3 = h_4\)). As it absorbs heat inside the evaporator, the working medium evaporates fully. This cools the surrounding reservoir. The heat absorbed per unit of mass is \(\Delta h_4 = h_4 - h_3\).

A Mollier diagram of the working medium is often used to represent the cycle of a compression heat pump. This diagram plots the pressure \(p\) against the specific enthalpy \(h\) of the working medium (enthalpy is a measure of the working medium's heat content and generally rises with the pressure and gas content). Also specified are the isotherms (\(T = \text{constant}\)) and isentropes (\(h = \text{constant}\)) as well as the relative proportion by mass of the working medium in the liquid phase. The working medium condenses fully to the left of the vaporisation phase boundary line. The medium is present as superheated steam to the right of the condensation phase boundary and as a mixture of liquid and gas between the two lines. The two lines make contact at the critical point.

To depict the system in a Mollier diagram, the ideal cycle described above can be determined by measuring the pressures \(p_1\) and \(p_2\), respectively before and after the expansion valve, as well as the temperatures \(T_1\) and \(T_2\) respectively before the compressor and expansion valve.

The components of this experiment are connected via a copper pipe to form a closed system, and mounted on a base board. Thanks to the clarity of the set-up, it is easy to associate them with the sequence of phase changes taking place in the heat pump cycle. The evaporator and condenser are designed as coiled copper tubes and they are each immersed in a separate water bath which serves as a reservoir for determining absorbed or emitted heat. Two large manometers indicate the pressures on the refrigerant in the two heat exchangers. Two analog thermometers allow you to measure temperature in the two water baths. Temperature sensors with specially designed measuring terminals are used to register the temperatures in the copper tube before the compressor and the expansion valve.

The theoretical performance coefficient for an ideal cyclical process can be calculated from the specific enthalpies \(h_1\) and \(h_2\) and \(h_3\) and \(h_4\) read from a Mollier diagram:

1. Determining the enthalpies \(h_1\) and \(h_2\) of the ideal cyclical process and the quantity of heat \(\Delta q_3\) supplied to the hot water reservoir per time interval \(\Delta t\) makes it possible to estimate the mass flow of the working medium.

\[
\Delta q_3 = \Delta h_4 = h_4 - h_3
\]

\[
\text{mass flow} = \frac{\Delta q_3}{\Delta h_4}
\]

2. Determining the enthalpies \(h_1\) and \(h_2\) of the ideal cyclical process and the quantity of heat \(\Delta q_3\) supplied to the hot water reservoir per time interval \(\Delta t\) makes it possible to estimate the mass flow of the working medium.

\[
\text{mass flow} = \frac{\Delta q_3}{\Delta h_4}
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