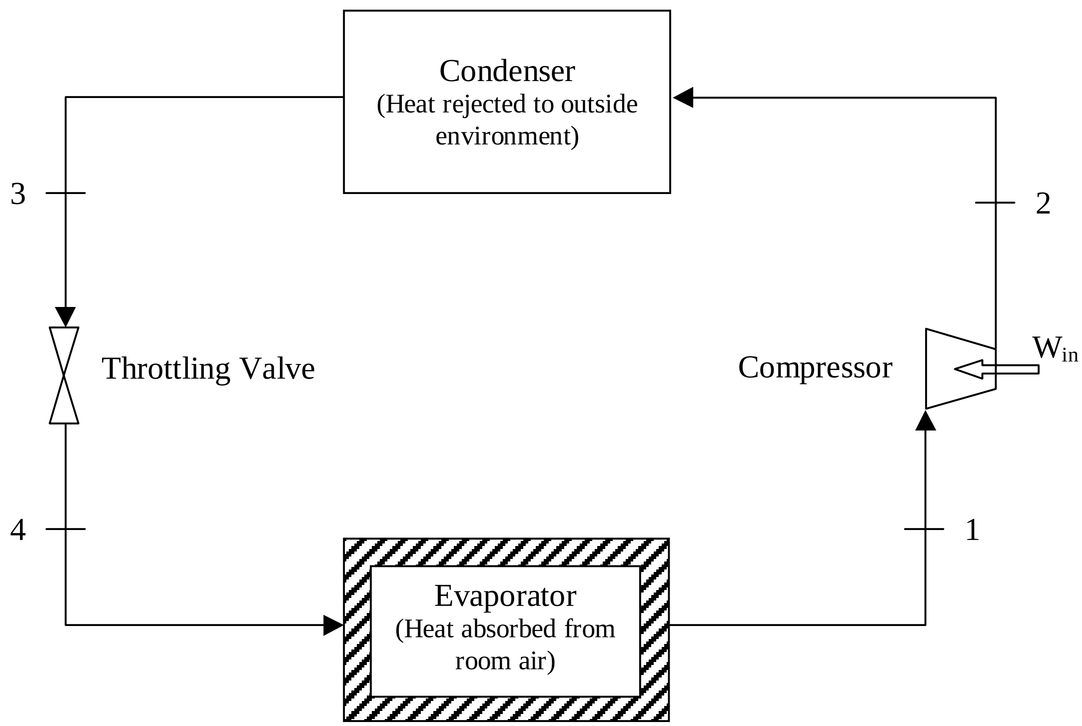
MEEG346 Thermal Laboratory

Laboratory Manual for Air Conditioner Experiment

The basic objective of an air conditioner is to remove heat from the room and discharge it to the outside environment. The same device can be run in reverse to serve as a heat pump; in this case, the AC absorbs heat from the outside environment and discharges it to the room.

The ideal vapor-compression refrigeration cycle is widely used for refrigerators, AC systems, and heat pumps. It is composed of 4 processes as shown in Figure 1.



1-2 Isentropic compression in the compressor
2-3 Heat rejection in the condenser coil (P = constant)
3-4 Expansion in the throttling valve
4-1 Heat absorption in the evaporator coil (P = constant)

Figure 1: The four steps in the ideal vapor-compression refrigeration cycle

It is important to recognize that the refrigerant does not simply flow through the devices described above, but in fact, experiences phase changes throughout the cycle. The refrigerant enters the compressor as a saturated vapor. During compression, its temperature increases to well above the surroundings. It enters the condenser as a super-heated vapor and leaves it as a saturated liquid. The phase change results due to heat loss from the refrigerant as it flows through the condenser. It should be noted that the temperature of the refrigerant at condenser exit could still exceed that of the environment.

Upon entering the throttling valve, the refrigerant experiences a pressure drop, which in turn lowers the temperature to well below that of the surroundings. It enters the evaporator as a low quality saturated mixture. The refrigerant absorbs heat from the room to complete the evaporation process. Now, it has again become a saturated vapor and is ready to re-enter the compressor to start the cycle over.

The cycle can be interpreted with the aid of a $T-s$ diagram shown below. The area under the curve 4-1 represents the heat absorbed inside the evaporator, and the area under the curve 2-3 represents the heat rejected in the condenser.

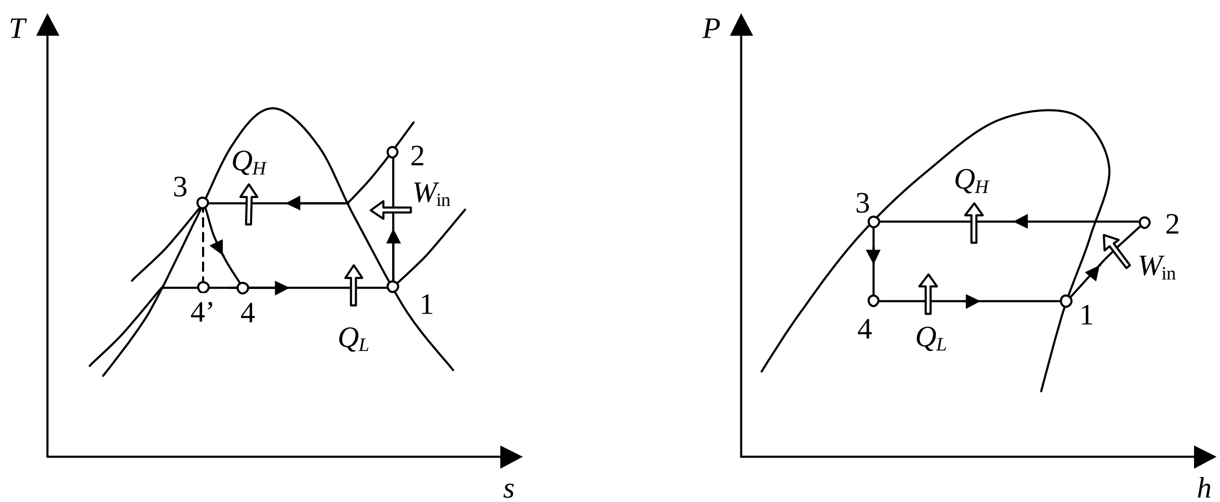


Figure 2: $T-s$ and $P-h$ diagrams for the ideal vapor-compression refrigeration cycle

Similarly, the $P-h$ diagram indicates that three of the four processes appear as straight lines, and the heat transfer in the evaporator and condenser is proportional to the lengths of the corresponding process curves.

Description of Parts

- Condenser/Evaporator
  In the window air conditioner, the condenser and evaporator are actually heat exchangers. All that can be seen of either one are U-shaped coils attached to the sides

on the front and back of the unit. One set of coils gets hot and the other cold, so be careful when touching them.

- Throttling Valve
  In this case, the throttling valve reduces the pressure of the refrigerant, by forcing the flow from a larger diameter tube to a smaller diameter tube. Ask the TA to point out its location.

- Compressor
  The compressor is the tall black cylinder that sits between the heat exchangers. It gets very hot during operation.

- Other
  The little black cylinder behind the compressor is a collector that has no effect on the thermodynamic/heat transfer processes and can be ignored. Two fans, both attached to the same motor, are used to move air over the heat exchanger coils. The motor is located next to the collector between the heat exchangers. A shield covers them for safety.

Sensors

Sensors are labeled with numbers. These numbers correspond to the LabVIEW program and to the figures in this manual.

- Pressure Sensors
  Four pressure sensors are placed throughout the air conditioner, one between each of the four devices (between compressor and condenser, etc.). They are silver, tubular shaped sensors with the OMEGA label on them. They measure pressure in volts (1 – 5 V, 1 V corresponding to 0 psi, and 5 V corresponding to 500 psi). They are connected to the data acquisition board with the blue wires.

- Thermocouples
  Four thermocouples located identically to the pressure sensors measure the temperature. The thermocouples are attached to the outside wall of the tubing. They are attached to the data acquisition board with copper wires. Their output (in volts) is converted by LabVIEW and displayed in °C.

- Mass Flow Sensor
  A turbine-type device (Flow Technology, Inc.) is used to read the volume flow rate of the coolant at the exit of the condenser when it has turned into a saturated liquid. The device has a digital display and the volume flow rate must be converted to $\dot{m}$ by multiplying with the correct density obtained from the $P - h$ chart.

- Watt Meter
  This clamps to the power cord of the air conditioner, which is connected to the outlet.

A digital read-out shows how much power the air conditioner is using. The TA will illustrate how to use the Watt Meter.

- LabVIEW Program

  Our LabVIEW program reads and converts voltage signals from each sensor to the respective units of measure, for example, pressure is converted from volts to psi, and temperature to Kelvin. Upto 16 channels can be read by the program. The LabVIEW program interfaces with two data acquisition terminals:

  1. A green board with linearized thermocouple modules (blue boxes):
     - Reads the first eight channels (0 – 7).
     - Reads the thermocouple outputs.
     - The thermocouples are labeled 1–4 and their respective channels are 0–3.
  2. A green screw terminal:
     - Reads the next eight channels (8–15).
     - Reads the pressure sensors and the relative humidity sensor.
     - The pressure sensors are labeled 1–4, and their respective channels are 8–11. The RH sensor is connected to channel 12.

  Be sure to verify the channel numbers *before* collecting data.