1. A cross-flow heat exchanger is used as a heat recovery device in a small house (both flows unmixed). Outdoor air enters into the other side and exhaust indoor air into the other side of the exchanger. Outdoor air heat capacity flow = exhaust air heat capacity flow. When the outdoor temperature is -20°C, the exhaust air is cooled from 20°C down to 3°C.
a) At what temperature does the outdoor air depart from the exchanger when the outdoor temperature is -10°C? At what temperature does the exhaust air depart from the exchanger?
b) As the outdoor temperature becomes warmer than -10°C, both of the airflows of are doubled. What are the temperatures in part a) when the outdoor temperature is -9°C, if the conductance is assumed to remain constant?
c) As years go by, the heat exchanger becomes dirty. The dirt accumulated on the surfaces diminishes the conductance of the heat exchanger. If the conductance has diminished as much as 10 %, what are the temperatures in part a) and b) (the heat capacity flows have not been changed)?

In reality, the water vapor in the exhaust air is more or less condensed in the exchanger. In this case the condension will be so small that it can be neglected, however.

2. The condension phenomenon is studied in a laboratory by using an arrangement where a thin metal plate separates two airflows, moving to opposite directions (picture below). The walls of the channels, where the airflows are, are insulated (except the metal plate).
A humid airflow flows into the upper channel at (25°C, φ = 45 %). The mass flow of the dry air contained by the humid airflow is $\dot{m}_i$ = 1 kg/s. The dry airflow, $\dot{m}$ = 1 kg/s, departs from the lower channel at 15°C.
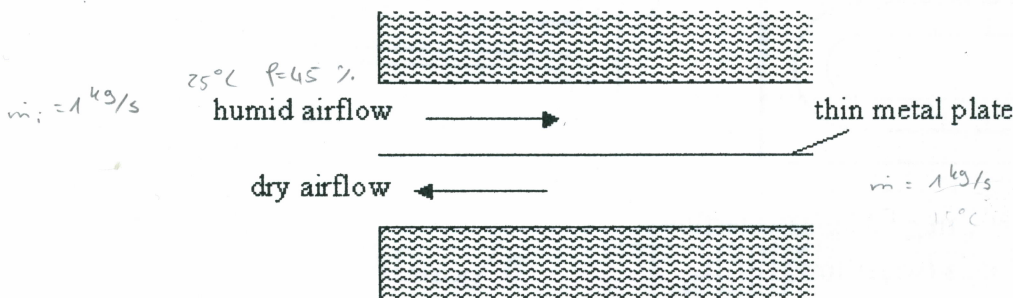
The velocities of both of the airflows are also equal and so it can be assumed that convective heat transfer coefficients are approximately the same on both surfaces of the plate.
What is the average temperature of the humid airflow at the point where water begins to condensate on the plate surface?

3. An evaporator/condenser of flowing film type is built of vertical brass tubes, tube size 22 mm/20 mm. The heat transfer power of one this kind of tube is 2 kW and on the outer surface of a tube there flows, at the rate of 2 kg/s, saturated water which evaporates into steam at 95 °C. The steam, which condenses inside in the tube, is at 100 °C. Calculate the length of one this kind of tube. (Brass is *messinki* in Finnish).