1. Ethylene glycol is heated from 25ºC to 40ºC at a rate of 2.5 kg/s in a horizontal copper tube (k=386 W/m.K) with an inner diameter of 2.0 cm and an outer diameter of 2.5 cm. A saturated vapor (T_g = 110ºC) condenses on the outside-tube surface with the heat transfer coefficient (in kW/m^2.K) given by $9.2/(T_g-T_w)^{0.25}$, where T_w is the average outside-tube wall temperature. What tube length must be used? Take the properties of ethylene glycol to be ρ=1109 kg/m^3, C_p = 2428 J/kg.K, k = 0.253 W/m.K, μ=0.01545 kg/m.s, and Pr=148.5.

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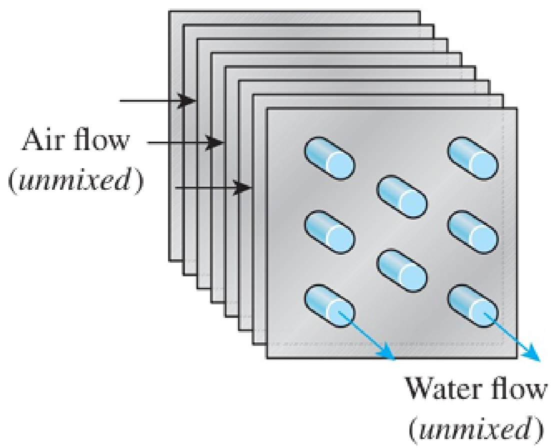
2. A single-pass cross-flow heat exchanger is used to cool jacket water (C_p = 1.0 Btu/lbm.ºF) of a diesel engine from 190ºF to 140ºF, using air (C_p = 0.245 Btu/lbm.ºF) with inlet temperature of 90ºF. Both air flow and water flow are unmixed. If the water and air mass flow rates are 92,000 lbm/h and 400,000 lbm/h, respectively, determine the log mean temperature difference for this heat exchanger.



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3. Saturated liquid benzene flowing at a rate of 5 kg/s is to be cooled from 75ºC to 45ºC by using a source of cold water (C_p = 4187 J/kg·K) flowing at 3.5 kg/s and 15ºC through a 20mm diameter tube of negligible wall thickness. The overall heat transfer coefficient of the heat exchanger is estimated to be 750 W/m^2·K. If the specific heat of the liquid benzene is 1839 J/kg·K and assuming that the capacity ratio and effectiveness remain the same, determine the heat exchanger surface area for the following four heat exchangers:
(a) parallel flow
(b) counter flow
(c) shell and tube heat exchanger with 2-shell passes and 40-tube passes
(d) cross-flow heat exchanger with one fluid mixed (liquid benzene) and other fluid unmixed (water).

4. During an experiment, a plate heat exchanger that is used to transfer heat from a hot-water stream to a cold-water stream is tested, and the following measurements are taken

	Hot Water Stream	Cold Water Stream
Inlet Temp. (ºC)	38.9	14.3
Outlet Temp. (ºC)	27.0	19.8
Volume Flow Rate (L/min)	2.5	4.5

The heat transfer area is calculated to be 0.0400 m^2.
(a) Calculate the rate of heat transfer to the cold water.
(b) Calculate the overall heat transfer coefficient.
(c) Determine if the heat exchanger is truly adiabatic. If not, determine the fraction of heat loss
and calculate the heat transfer efficiency.
(d) Determine the effectiveness and the NTU values of the heat exchanger.
Also, discuss if the measured values are reasonable.

5. A heat exchanger is to be selected to cool a hot liquid chemical at a specified rate to a specified temperature. Explain the steps involved in the selection process.

6. HEAT EXCHANGER DESIGN ANALYSIS

In an industrial facility, a countercurrent double pipe heat exchanger is used to heat the glycerin flowing at a rate of 1.5 kg/s from 10ºC to 50ºC by passing hot water at an inlet temperature of 120ºC. The hot water experiences a temperature drop of 50ºC as it flows through the heat exchanger. The overall heat transfer coefficient of the heat exchanger may be assumed to be 950 W/m^2K. A similar arrangement is to be installed at another location and it is proposed to use two small heat exchangers of the same surface area to be arranged in series instead of one single large heat exchanger. However, it is first required to compare the surface area of the two small heat exchangers against that of the single large heat exchanger, since the available space is a major constraint for the proposed design. The arrangement of the heat exchangers is as shown in figure. The water flow rate is split between the two heat exchangers such that 60% would go to the first heat exchanger and the remaining 40% would go to the second heat exchanger. The overall heat transfer coefficient of the two small heat exchangers is assumed to remain same as that of the large heat exchanger. As a design engineer, for both cases determine the heat exchanger (a) effectiveness, (b) NTU, (c) surface area, and (d) choice of the heat exchanger if the construction cost of the smaller heat exchangers is about 15% higher than a single large heat exchanger per unit surface area.