UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: August 2022

Module Number: ME8301 **Module Name: Heat Transfer (N/C)**

[Three Hours]

[Answer **all questions**, each question carries **10** marks]

Note: Clearly state any assumptions made in answering the questions.

Q1. a) Heat transfer applications and problems encountered in practice can be classified in to two groups. Briefly explain these two groups of problems with practical examples.

[4.0 Marks]

b) Briefly explain the four major regions of the boiling curve with the aid of sketches.

[6.0 Marks]

Q2. a) Consider a 1 m high, 1.2 m wide double pane window consisting of two layers of 3 mm thick glass having thermal conductivity of 0.78 W/m K separated by a 10 mm wide stagnant air space (thermal conductivity 0.026 W/m K). Determine the steady rate of heat transfer through this double pane window and the temperature of its inner surface for a day during which the room is maintained at 22 °C while the temperature of the outdoor is -10 °C. The convection heat transfer coefficients including the radiation effects of the inner and outer surfaces of the window are 10 and 40 W/m^2 K, respectively.

[5.0 Marks]

b) A 2 mm diameter and 7 m long electric wire is tightly wrapped by a 2 mm thick plastic cover whose thermal conductivity is 0.15 W/m K. Measurements indicate that an electrical current of 15 A passes through the wire and a voltage drop of 10 V exist along the wire. If the insulated wire is exposed to a medium at 28 °C with a heat transfer coefficient of 12 W/m^2 K, determine the temperature at the interface of the wire and the plastic cover in steady operation. Also determine the effect of reducing the thickness of the plastic cover to 1 mm, whether it will increase or decrease the interface temperature.

[5.0 Marks]

Q3. a) The forming section of a plastics plant puts out a continuous plastic sheet that is 4 ft wide and 0.04 in thick at a velocity of 30 ft/min. The temperature of the plastic sheet is 200 °F when it is exposed to the surrounding air, and a 2 ft long section of the plastic sheet is subjected to air flow at 80 °F at a velocity of 10 ft/s on both sides along its surfaces normal to the direction of motion of the sheet. Determine the followings.

i) The rate of heat transfer from the plastic sheet to air by forced convection in Btu/h.

ii) The temperature of the plastic sheet at the end of the cooling section.

Take the density and specific heat of the plastic sheet as 75 lbm/ft^3 and 0.4 Btu/lbm. °F, respectively. The Prandtl number, thermal conductivity, and kinematic viscosity of air at the film temperature of 140 °F and 1 atm are 0.7202, 0.01623 Btu/h. ft. °F, and 0.204 x 10^{-3} ft^2/s, respectively.

Note:

The Nusselt number of air for a flat plate is given to be,

and

[8.0 Marks]

b) Consider a hot baked potato. Will the potato cool faster or slower when we blow the warm air coming from our lungs on it instead of letting it cool naturally in the cooler air in the room? Briefly explain the answer.

[2.0 Marks]

Q4. a) Briefly explain the term "Fouling Factor" with **two** examples.

[3.0 Marks]

b) The condenser of a steam power plant operates at a pressure of 7.38 kPa. Steam at this pressure condenses on the outer surfaces of 12 horizontal tubes arranged in a rectangular array of 3 tubes high and 4 tubes wide through which cooling water circulates. The outer diameter of the pipes is 3 cm, and the outer surfaces of the tubes are maintained at 30 °C.

Here, take the saturation temperature of water vapor at 7.38 kPa, the latent heat of vapourisation of water, and the density of water vapour are 40 °C, 2407×10^3 J/kg, and 0.05 kg/m^3, respectively. The density, the specific heat at constant pressure, viscosity, and the thermal conductivity of liquid water at film temperature are 994 kg/m^3, 4178 J/kg K, 0.72×10^{-3} kg/m s, and 0.623 W/m K, respectively.

Using the formula given below, determine the rate of heat transfer to the cooling water circulating in the tubes.

The modified latent heat of vaporization (h_{fg}') and the heat transfer coefficient for condensation on a single horizontal tube (h) are given,

where,

g - gravitational acceleration

ρ_l, ρ_v - densities of the liquid and vapor, respectively

μ_l - viscosity of the liquid

h_{fg} - latent heat of vaporization

k_l - thermal conductivity of the liquid

T_s - surface temperature
T_{sat} - saturation temperature of the condensing fluid
c_{pl} - specific heat of the liquid
D - diameter of the tube.

[7.0 Marks]

Q5. a) Briefly explain the difference between the natural convection and the forced convection with practical examples.

[4.0 Marks]

b) Draw the graph of variation of the spectral blackbody emissive power with wavelength for different temperatures and discuss three observations that can be made from the graph.

[6.0 Marks]