

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

EXAMINATION PERIOD
APRIL 2022

CYFNOD ARHOLIADAU
EBRIL 2022

MODULE CODE:
ACMA5008 – THERMOFLUID AND CONTROL

TIME: 2 HOURS

ANSWER ALL QUESTIONS

Equipment or materials required,

- *Calculator*
- *Formulae Booklet 1 (General)*
- *Formulae Booklet 2 (Convection)*
- *Formulae Booklet 3 (Thermodynamics)*
- *Thermodynamics Tables*

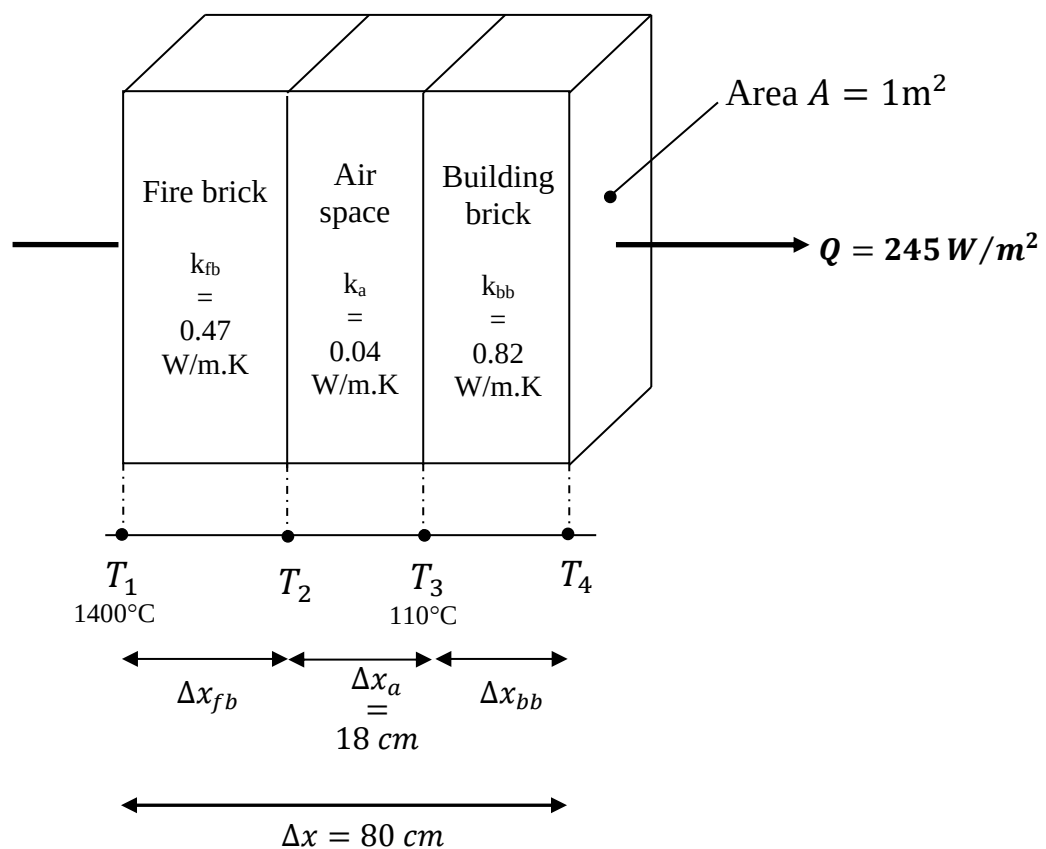
1. Question One: Heat Transfer Conduction (25 marks)

A composite furnace wall made of fire brick, an air space and an outside of building brick has a total width of 80 cm. The furnace wall temperature is 1400°C , the air space is 18 cm wide, and the temperature at the Air space – Building brick interface is 110°C . If the rate of heat transfer through the composite wall is 245 W/m^2 , and assuming,

- Thermal conductivity of the fire brick to be 0.47 W/m.K ,
- Thermal conductivity of the air to be 0.04 W/m.K ,
- Thermal conductivity of the building brick to be 0.82 W/m.K ,

- Calculate temperature T_2 at the Fire brick – Air interface. [8]
- Calculate the width of the fire brick layer. [8]
- Determine the width of the building brick layer. [4]
- Calculate temperature T_4 . [5]

Schematic:



2. Question Two: Heat Transfer, Convection + Radiation (25 marks)

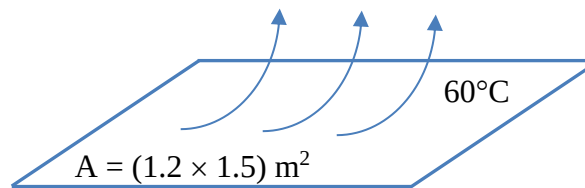
Calculate the total heat transfer by convection and radiation to air (from one side) at 20°C, from a horizontal rectangular plate 1.2 m wide and 1.5 m long maintained at 60°C at all points.

Consider the following,

- Quiescent conditions, that is no air velocity
- Significant length l = length of the wall = 1.5 m
- Ambient air pressure $P = 100.8 \text{ kPa}$
- $k = 0.0272 \text{ W/m.K}$
- $\mu = 0.019 \times 10^{-3} \text{ kg/m.s}$
- $c_p = 1.01 \text{ kJ/kg.K}$
- Surface emissivity of the plate covered with Black Epoxy Paint is 0.9

Schematic:

$$T_{air} = 20^\circ\text{C}$$



Notes:

- Air is considered as an ideal gas. The gas constant and specific heat values can be found in Table A-2.
- To determine the density ρ use the ideal gas equation where,

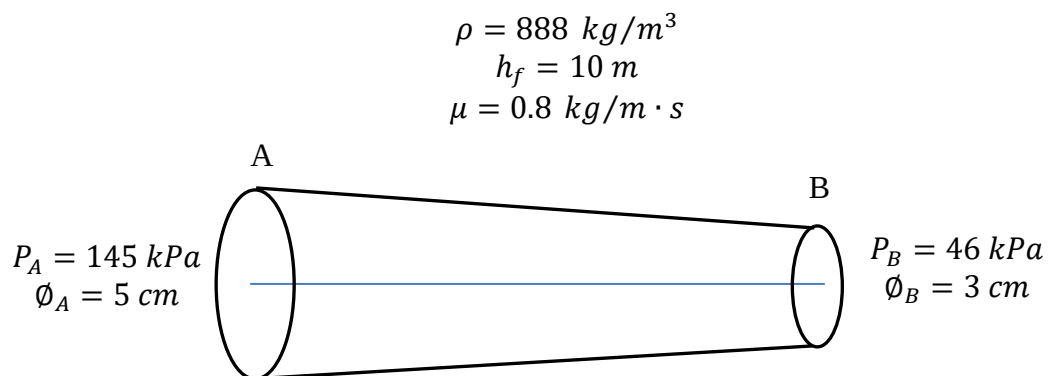
$$v = \frac{V}{m} = \frac{1}{\rho}$$

3. Question Three: Fluid Dynamics (25 marks)

Oil with a density $\rho = 888 \text{ kg/m}^3$ is flowing through a horizontal pipe. The pipe's pressure at section A and section B are measured to be 145 and 46 kPa, respectively. The pipe's diameter at section A and section B are 5 cm and 3 cm, respectively. Considering that the friction head is 10 m,

- a) Using the Continuity and Bernoulli equations, determine the velocity of oil at both sections A and B. [15]
- b) Using the Reynolds Number, determine if the flow is laminar through both sections, assuming a dynamic viscosity of $0.8 \text{ kg/m} \cdot \text{s}$ [10]

Schematic:

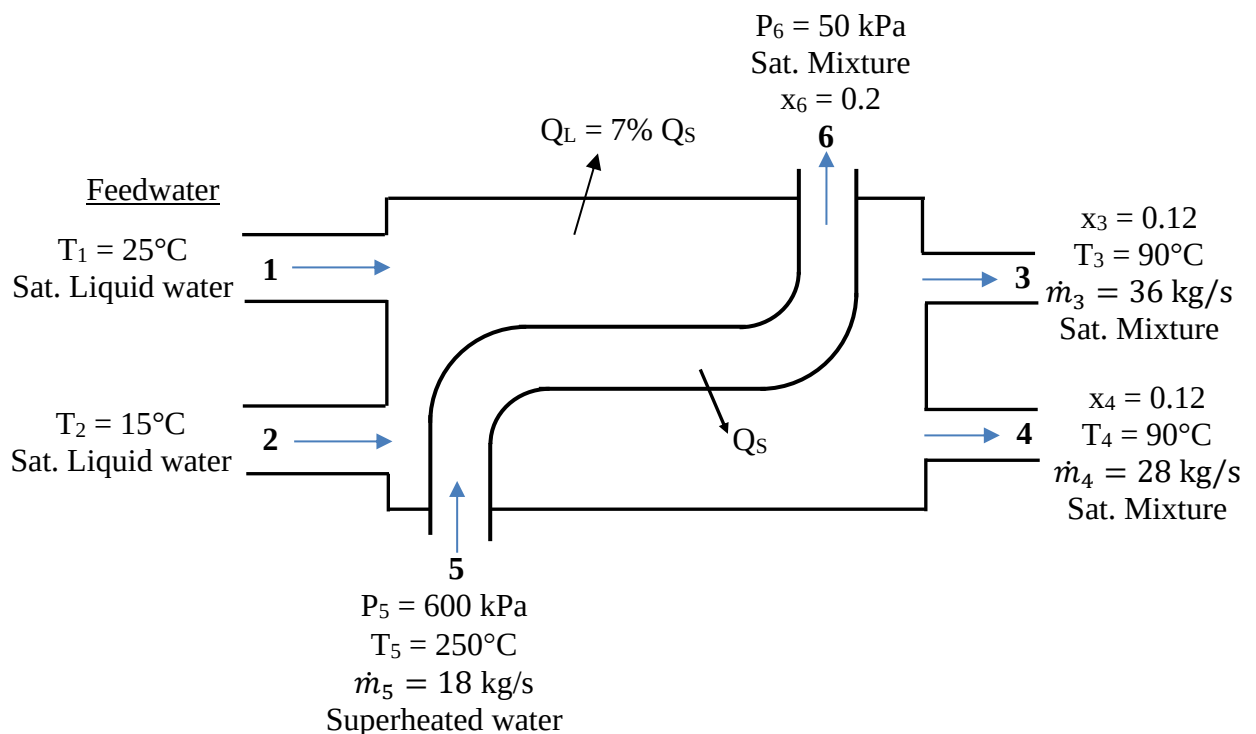


4. Question Four: Thermodynamics, Open System (25 marks)

In large steam power plants, the feedwater is frequently heated in closed feedwater heaters, which are basically heat exchangers, by steam extracted from the turbine at some stage. Steam enters the feedwater heater as superheated water at 600 kPa, 250°C and a mass flow rate of 18 kg/s, and leaves as saturated liquid-vapour mixture at 50 kPa and a quality of 20 percent. Feedwater enters the heater as saturated liquid with a temperature of 25°C through inlet 1, and as saturated liquid with a temperature of 15°C through inlet 2. Feedwater leaves as a saturated mixture with a quality of 12 percent at 90°C through both outlets 3 and 4. Feedwater exit the tank with a mass flow rate of 36 kg/s through outlet 3, and 28 kg/s through outlet 4. The heat losses from the outer surfaces of the heater are 7% of the heat given up by the steam.

- Dress a table of mass and energy balances for all possible systems. [9]
- Determine the heat transfer rate Q_s from the steam to the feedwater. [6]
- Determine the mass flow rates of the feedwater at both inlets 1 and 2. [10]

Schematic:



Assumptions:

- Steady-flow process.
- Kinetic and potential energy changes are negligible.
- There are no work interactions.

- The properties of saturated and superheated water can be found in Tables A-4, A-5, and A-6.
- In a saturated liquid-vapour mixture, the mass fraction of vapour is called the *quality* and is expressed as:

$$x = \frac{m_{vapour}}{m_{total}}$$

Quality may have values between 0 (saturated liquid) and 1 (saturated vapour). It has no meaning in the compressed liquid or superheated vapour regions. In the saturated mixture region, the average value of any intensive property y is determined from:

$$y = y_f + x \cdot y_{fg}$$

where f stands for saturated liquid, g for saturated vapour and y stands for v , u or h .

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