

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

EXAMINATION PERIOD
JANUARY 2022

CYFNOD ARHOLIADAU
IONAWR 2022

MODULE CODE:
ACMA5008 - THERMOFLUIDS AND CONTROL
ACMA5011 – THERMOFLUID MECHANICS

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*

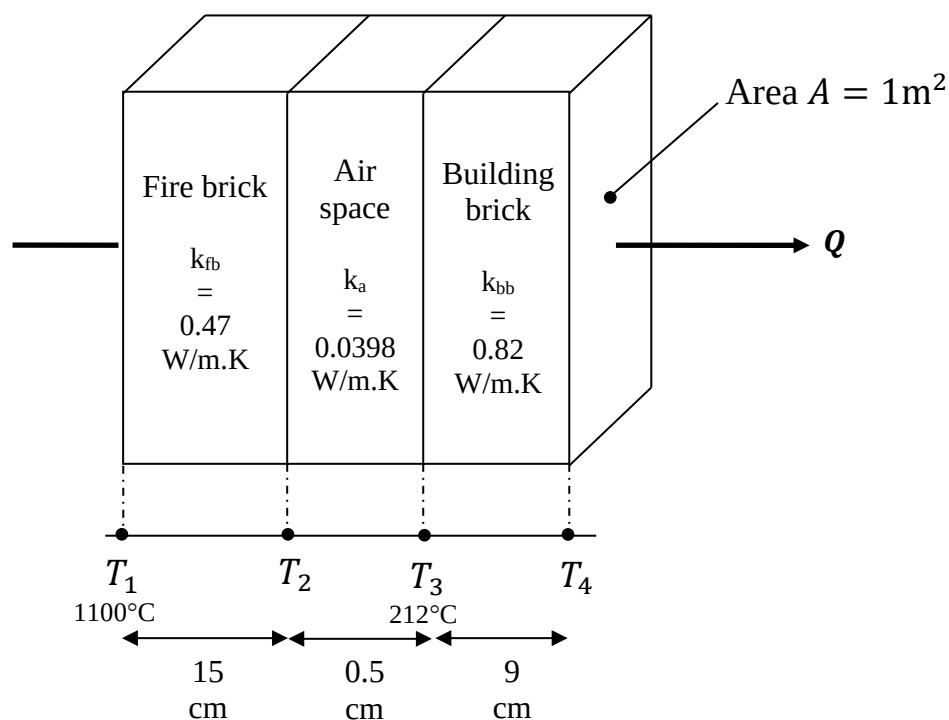
1. Question One: Heat Transfer Conduction (25 marks)

A composite furnace wall is made of fire brick, 15 cm thick, an air space, 0.5 cm thick, and an outside of building brick, 9 cm thick. The furnace wall temperature is 1100°C and the temperature at the Air space – Building brick interface is 212°C. Assuming,

- Thermal conductivity of the fire brick to be 0.47 W/m.K,
- Thermal conductivity of the building brick to be 0.82 W/m.K,
- Thermal conductivity of air to be 0.0398 W/m.K,
- Temperature T_3 of the wall at the Air space – Building brick boundary to be 212°C.

- Calculate the rate of heat transfer Q through the furnace wall. [13]
- Calculate temperature T_2 at the Fire brick – Air interface. [6]
- Calculate temperature T_4 . [6]

Schematic:



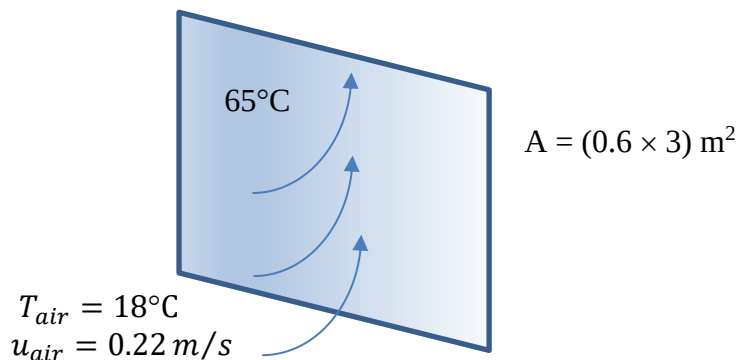
2. Question Two: Heat Transfer, Convection + Radiation (25 marks)

Calculate the total heat transfer by convection and radiation to air (from one side) at 18°C from a vertical plate 0.6 m tall and 3 m wide maintained at 65°C at all points.

Consider the following,

- Air velocity $u = 0.22\text{ m/s}$
- Significant length $l = \text{height of the wall} = 0.6\text{ m}$
- Ambient pressure of 101.3 kPa
- $k = 0.025\text{ W/m.K}$
- $Pr = 0.69$
- $\mu = 1.788 \times 10^{-5}\text{ kg/m.s}$
- Surface emissivity of the plate covered with Black Epoxy Paint is 0.89

Schematic:



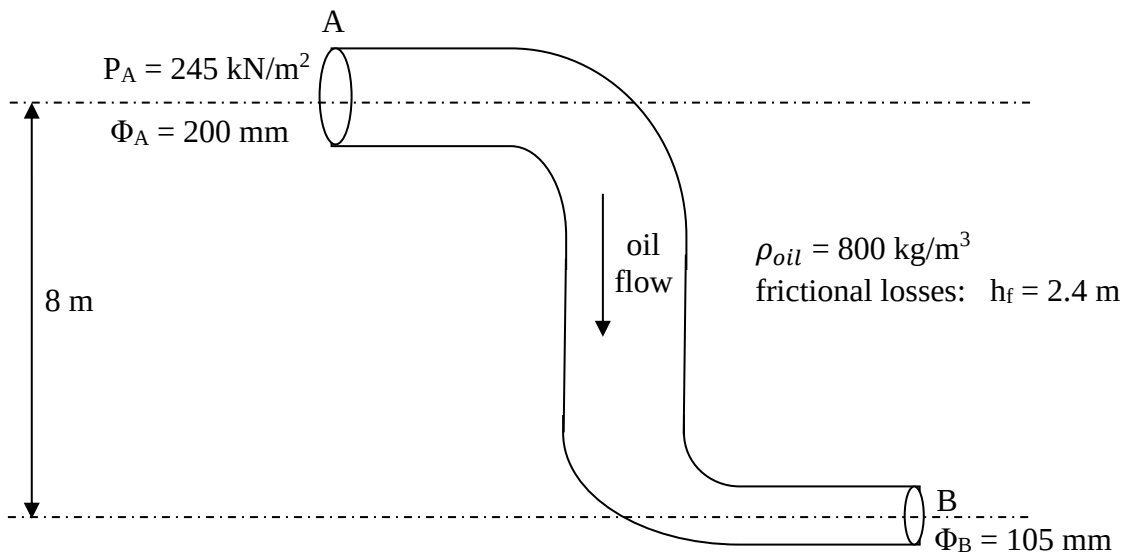
Notes:

- 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.

3. **Question Three:** Fluid Dynamics (25 marks)

The diameter of a pipe tapers gradually in the direction of oil flow as the level drops 8 m from point A to point B. The relative density of oil is 0.8. At A the gauge pressure is 245 kN/m^2 and the pipe diameter Φ_A is 200 mm; at B the diameter Φ_B is 105 mm. The frictional losses are equivalent to a head of 2.4 m of oil. Determine the pressure head at B when the flow rate is 63 kg/s .

Schematic:

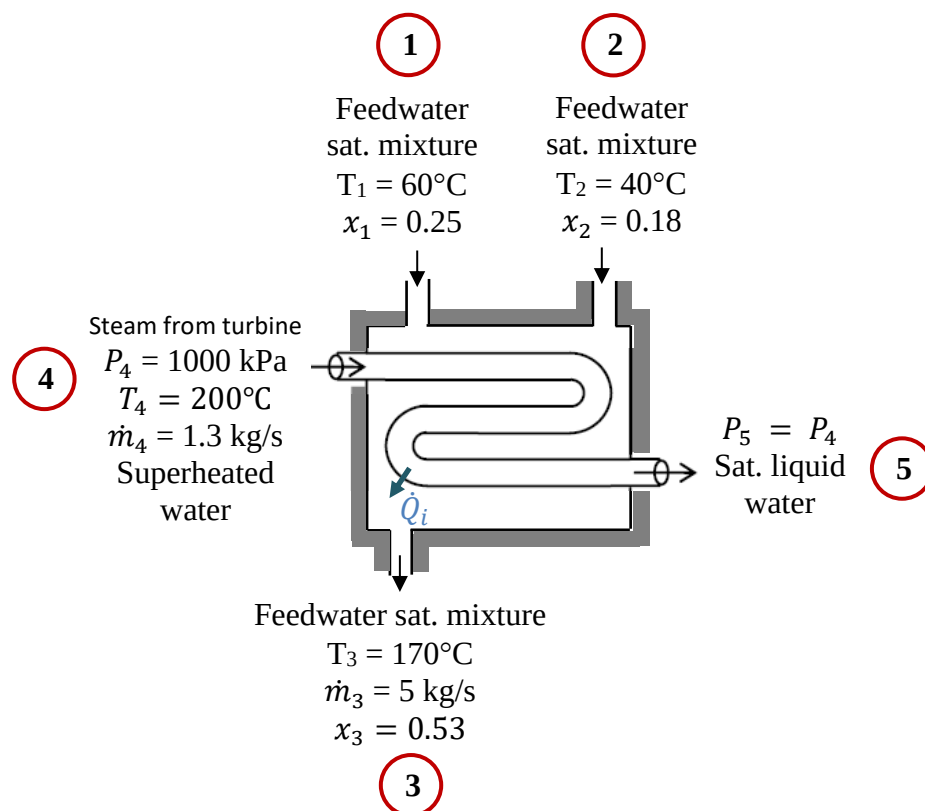


4. Question Four: Thermodynamics, Open System (25 marks)

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 at 10 bar, 200°C and a mass flow rate of 1.3 kg/s as superheated water and leaves as saturated liquid water at the same pressure. Feedwater enters the heater at 60°C and a quality of 25 percent through inlet 1, enters at 40°C and a quality of 18 percent through inlet 2, and leaves at 170°C with a quality of 53% and a mass flow rate of 5 kg/s. If there are no heat losses from the outer surfaces of the well-insulated heater,

- Express the mass and energy balances for all possible systems. [6]
- Calculate the heat transfer rate $\dot{Q}_i$ from the steam to the feedwater. [6]
- Calculate the mass flow rates of the feedwater at inlets 1 and 2. [13]

Schematic:



Notes:

- Steady-flow process.
- Kinetic and potential energy changes are negligible.
- There are no work interactions.
- The properties of steam and feedwater can be found in Tables A-4 through 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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