Ref. No.: Ex/PE/PE/H/T/414A/2024

B.E. Power Engineering, 4[rd] Year, 1[st] Semester Examination, 2024

Design and Analysis of Thermal Systems (Hons.)

Time: Three Hours **Full Marks: 100**

Group A: CO1 (30 Marks)

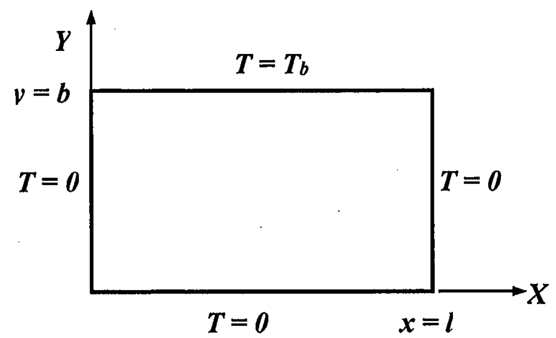
1. Answer the following questions briefly (any four questions)
   a) What is the difference between the design and analysis in a thermal system?
   b) Which factors drive new designs in Engineering Industries?
   c) Characteristics of thermal systems?
   d) What is modeling in the design of a thermal system?
   e) How is Modeling different from Simulation? **Marks: $4 \times 4 = 16$**
2. Design a shell and tube heat exchanger to sub-cool condensate from a methanol condenser from 95°C to 40°C. The flow rate of methanol is 100,000 kg/h. Water will be used as the coolant, with a temperature rise from 25°C to 40°C. **Marks: 14**

   OR

   In a reheat steam cycle, the initial steam pressure and the maximum temperature are 150 bar and 550°C, respectively. If the condenser pressure is 0.1 bar, the moisture at the condenser inlet is 15%, and assuming the ideal process, determine (a) the reheat pressure (b) the cycle efficiency, and (c) the steam rate (SSC). **Marks: 14**

Group B: CO2 (20 Marks)

3. A two-dimensional rectangular plate is subjected to the boundary conditions as shown in the figure below. Derive an expression for the steady-state temperature distribution $T(x, y)$ across the plate



OR

Considered a fin having a 'Triangular' profile and it ends up to a point. The length of the fin is 'L', the thickness is 't', and the width is 'b'. The fin material has a thermal conductivity k, while the convective heat transfer coefficient at the surface of the fin is h. The fin is attached to a base wall having temperature T_b. From the energy balance across a small element in the fin, develop the governing equation for heat transfer through the fin and write down the boundary conditions.

If a modified Bessel equation in the form of $\frac{d^2y}{dx^2}+\frac{1}{x}\frac{dy}{dx}-y=0$ has a general solution as, $y=C_1I_0(x)+C_2K_0(x)$, where $I_0(x)$ and $K_0(x)$ are the modified zero-order Bessel functions of

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the first and second kind, respectively, show that the temperature distribution along the fin can be expressed as,

$$\frac{T-T_\infty}{T_b-T_\infty}=\frac{I_0(2B\sqrt{x})}{I_0(2B\sqrt{L})}$$; assuming $z=2B\sqrt{x}$ **Marks: = 20**

Group C: CO3 (30 Marks)

4. Answer the following questions briefly
   a) What do you understand by the externally irreversible and internally irreversible Rankine cycle? What is the penalty due to irreversibility? Describe using a T-S diagram.
   b) Elaborate on the concept of exergy and economics in analyzing thermodynamic system performances **Marks: 2 × 5 = 10**
5. What is fin? State their applications. Briefly describe about the fin effectiveness and fin efficiency. Elaborate on the criteria for optimum design of a finned surface.
   Marks: 2 + 8 + 10 = 20

OR

Steam at 20 bar, 360°C is expanded in a steam turbine to 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water into the boiler. (a) Assuming an ideal process, find the network and the cycle efficiency per kg of steam. (b) If the turbine and the pump each have 80% efficiency, find the % of reduction in the network and cycle efficiency. **Marks: 20**

Group D: CO4 (20 Marks)

6. Answer all the questions (any four questions)
   a) Why numerical methods are more applicable for designing a thermal system?
   b) Define LMTD for a heat exchanger. State their physical significance. Why correction factor is imposed for a heat exchanger analysis?
   c) State the design aspect of a finned heat exchanger. When application of fin is advantageous?
   d) What is a burner for a pulverized-fuel-fired boiler? Describe the Functions of a Burner.
   e) Elaborate on the furnace exit gas temperature and their impacts on the design.
   Marks: 4 × 5 = 20