National Program on Technology Enhanced Learning
IIT Madras

Design and Optimization of Energy Systems
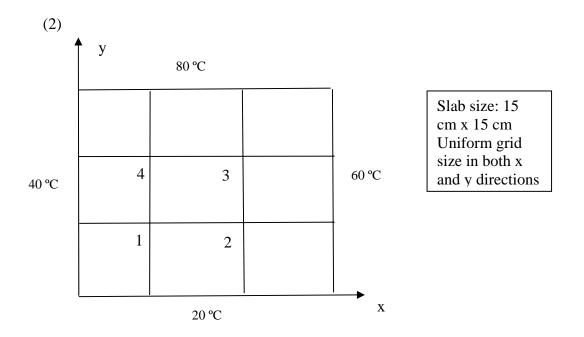
Self Assesment Test 1

Duration: 50 min

Max. Marks: 40

1. Make suitable assumptions wherever required with justification
2. Make reasonable assumptions of any missing data

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(1) Steam at the rate of 0.12 kg/s, at a temperature of T_s, bled from a turbine, is used to heat feed water in a closed feed water heater. Feed water at 80 °C flowing at the rate of 3 kg/s enters the heater. The U value for the feed water heater 1500W/m^2 K. The area of the exchanger (heater) is 9.2 m^2.

The latent heat of vaporization of steam is given by h_g= (2530- 3.79T_s) kJ/kg where T_s is the temperature at which steam condenses in °C (which is also the same as the temperature at which steam is bled assuming no heat losses along the way).

(1) Set up the energy balance equations for the steam side and the water side.
(2) Write down the expression for the heat duty of the feed water heater.
(3) Identify the relationship between (1) and (2)
(4) Using information from (1) (2) and (3) and the method of successive substitution, determine the outlet temperature of the feed water (T_0) and the condensing temperature of steam T_s.
(5) Start with an initial guess of T_o= 130 °C and perform at least 4 iterations.

(18)

(2)

y

80 ℃

40 ℃

4	3	
1	2	

60 ℃

Slab size: 15 cm x 15 cm Uniform grid size in both x and y directions

20 ℃

x

Two dimensional, steady state conduction in a square slab with constant thermal conductivity, k = 50 W/m K and a uniform internal heat generation of q_v= 1 x 10^6 W/m^3 is to be numerically simulated. The details along with the boundary conditions are given in the figure. For simplicity as well for demonstration purposes, the number of grid points is intentionally kept small for this problem.

(a) Identify the equation that governs the temperature distribution (T (x, y)) for the given problem.   (1)

(b) Using the Gauss-Seidel method, estimate T_1,T_2, T_3 and T_4. Start with an initial guess of 50 ℃ for all the four temperatures. *Do at least 7 iterations*.   (10)

(c) What is the approximate center temperature? What would have been your crude guess of the centre temperature? Are these two in agreement?   (3)

(3) The specific volume of saturated water vapor (v_g) varies with temperature (T) as shown in the Table given below

T, °C	v_g, m^3/kg
30	32.90
50	12.04
80	3.409

Using Lagrange interpolation polynomial of order2, determine the specific volume of saturated water vapour at 60 °C. Compare this with the estimate obtained using a linear interpolation and comment on the results.   (8)

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