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I SEM. M.Tech. (ADVANCED THERMAL POWER AND ENERGY SYSTEMS) DEGREE END SEMESTER EXAMINATIONS NOV-DEC 2015

SUBJECT: DESIGN OF THERMAL SYSTEMS (MME-545)
REVISED CREDIT SYSTEM

Time: 3 Hours. MAX.MARKS: 50

Instructions to Candidates:
- Answer **ANY FIVE FULL** questions.
- Missing data, if any, may be suitably assumed.

1A) Explain the different steps involved in the design and optimization procedure of any thermal system. (04)

1B) Three materials A, B and C of varying thicknesses are available for combining into a building wall. The characteristics and costs of the materials are

Material	Thermal resistance, per cm thickness	Load bearing capacity, per cm	Cost per cm in dollars
A	30	7	8
B	20	2	4
C	10	6	3

Total thermal resistance of the wall must be 120 or greater and the total load bearing capacity must be 42 or greater. Minimum cost wall is sought. Use the simplex algorithm to determine the optimum thickness of each material. (06)

2A) What is NTU? Explain the significance of NTU for heat exchanger design. Show that effectiveness of a counter flow heat exchanger can be expressed as a function of two dimension less groups $\frac{UA}{W_{min}}$ and $\frac{W_{min}}{W_2}$

Where U is the overall heat transfer coefficient, W is the heat capacity of the liquids. (04)

2B) A hydraulic power system must provide 300 W of power and cost can be expressed as a function of volume flow rate Q (m^3/s)and pressure build up ΔP as cost $=1200Q^{0.4}\sqrt{10+(\Delta P\times 10^{-4})}$ dollars. Using

geometrical programming for constrained optimization find the minimum cost, pressure build up and volume flow rate required. (06)

3A) What is information flow diagram? Explain the significance.

Write the information flow diagram for a non-regenerative gas turbine system. Also discuss the flow of information between the different parts. (04)

3B) Total pressure drop from point 1 to point 5 in the multi branch duct system in the figure 3B is to be 500 Pa. Table below presents the costs for various duct sizes in each of the section as a function of the pressure drop in the section. Use dynamic programming to determine the pressure drop in each section resulting in the minimum total cost of the system.

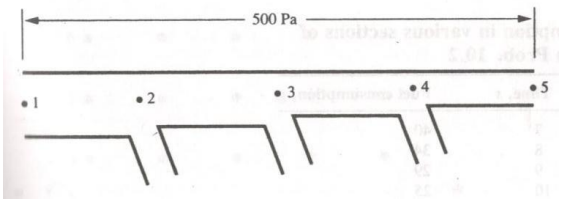

Figure 3B

Section	Pressure drop (Pa)	Cost (dollars)
1-2	50 100 15 200	256 222 205 193
2-3	50 100 15 200	210 180 166 157
3-4	50 100 15 200	149 135 125 117
4-5	50 100 15 200	106 93 86 81

(06)

4A) With relevant equations explain principle of use of Hemstitching search method to solve constrained optimization problems (04)

4B) An experimental study is performed in a plastic screw extruder along with a die to determine the relationship between mass flow rate m and

the pressure difference P. The relationship for the die is found to be (06)

$m = 0.5P^{0.5}$ and the screw extruder is $P = 2 + 3.5m^{1.4} - 5m^{2.2}$. Simulate the system using Newton Raphson's method assuming initial guess of m = P = 0.25.

5A) Pressure drop in a circular pipe of diameter 2 cm varies according to the equation P $= Km^a$ where P is the pressure drop (Pa), m is the mass flow rate (kg/s), K and a are the constants. Table below shows the experimental pressure drops obtained for different flow cases. Obtain the best fit to the given data and obtain the pressure drop for a Reynolds's number 5750. Consider dynamic viscosity of the fluid as 0.8933×10^{-3} kg/m-s.

Reynolds' number	3500	4000	4500	5000	5500	6000	6500
Pressure drop in Pa (p)	502	528	593	708	876	1092	1411

(05)

5B) A power plant system needs a machinery for a suitable operation. Two types A and B are available. The applicable costs are given as

particulars	A (Rs)	B (Rs)
Initial cost	20000	30000
Annual maintenance cost	4000	2000
Refurbishing cost at the end of 4 years	3000	0
Annual saving	500	1000
Salvage value	500	3000
Annual tax	1250	1370

Useful life is 8 years for A and 6 years for B. Rate of interest is 9% compounded quarterly. Using annual cost method, determine which is a better acquisition? (05)

6A) Newly harvested grain has a high moisture content and must be dried to prevent spoilage. Drying can be achieved by warming the air and blowing it through a bed of grains. The total cost of drying includes

Heating cost =0.002QΔT and the blower operating cost= $2.6 \times 10^{-9} Q^3$ where Q is the air quantity delivered through the bed (m^3/m^2 of bed area), ΔT is the rise in temperature (°C) through the heater. Value of Q and ΔT also influence time required for drying of the grain according to the equation

Drying time = $\frac{80 \times 10^6}{Q^2 \, \Delta T}$ days. Using constrained Lagrange multiplier method for optimization compute the minimum operating cost, value

of Q and ΔT that will achieve adequate drying in 60 days. (05)

6B) A cylindrical storage tank is to be designed for storing hot water from a solar energy collection system. The volume is given as 2 m^3 and the surface area is to be minimized in order to minimize the heat loss to the environment. Solve the above method by using unconstrained Fibonacci search method and determine the optimal dimensions. Assume n = 5. and uncertainty interval for the radius of the tank can be taken between 0.1 m to 1.5 m. (05)