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m. E. (Mechanical) with Thermal Engineering Sem-II

**BHARTIYA VIDYA BHAVAN'S
SARDAR PATEL COLLEGE OF ENGINEERING**

[An Autonomous Institution Affiliated to University of Mumbai]

MUNSHI NAGAR, ANDHERI(WEST), MUMBAI-400 058

END SEMESTER EXAMINATION APRIL/MAY 2014

CLASS/SEM: M.E.(Thermal Engineering)/II

TOTAL MARKS:100

SUBJECT: AIR CONDITIONING SYSTEM DESIGN

DURATION: 4 HOURS

MASTER

1. Answer any Five questions out of Seven questions.
2. Figures to the right indicate full marks.
3. Assume suitable data and justify your assumption.
4. Use of refrigeration tables, steam table and psychrometric chart is permitted.

Q 1(a) The DBT and WBT of atmospheric air are 35°C and 23°C respectively when the barometer reads 1.00125. Determine without using psychrometric chart, calculate (i) Specific humidity (ii) Relative humidity (iii) Dew point temperature (iv) Density of air and (v) enthalpy of mixture per kg of dry air. [10]

(b) Explain different types of duct layout patterns of duct arrangement systems for distribution of air from air-handling equipment to the air supply openings in the room. [10]

Q.2 The following data was collected to design an air-conditioning system for restaurant in Mumbai.

Outside conditions ----- 34°C DBT and 28°C WBT

Inside design conditions --- 24°C DBT and 50% RH

Solar heat gain through walls, roof and floor ----- 270 kW.

Solar heat gain through glass ----- 253 kW

Occupants -----25

Latent heat gain per person ----6 kW

Sensible heat gain per person----- 5 kW

Internal lighting load ----- 15 lamps of 100 watts capacity each and 10 florescent tubes of 80 Watts each.

Sensible heat gain from other sources -----667 kW

Infiltrated air ----- $14\text{ m}^3/\text{min}$

If 40% fresh air and 60% re-circulated air are mixed and passed through the conditioner coil then find the followings

- (i) Amount of total air in m^3/min .
- (ii) Dew-point temperature of the coil.
- (iii) The condition of supply air to the room.
- (iv) The capacity of the conditioner in tons of refrigeration.

[20]

Q.3(a) Write a note on the following with sketch. (Any Four)

[20]

- (i) Window air-conditioner.
- (ii) Split air-conditioner.

m. E. (Mechanical) with Thermal Engineering Sem-IV
 Air Conditioning System Design 07/05/2014

(iii) Direct expansion system.

(iv) All-water system.

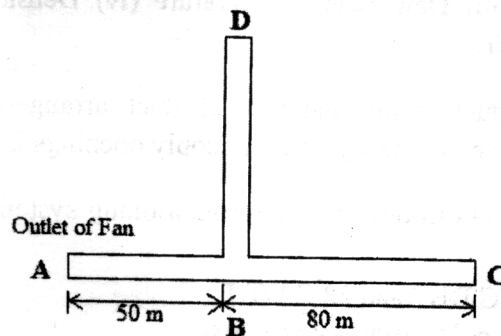
(v) All air system

(vi) Air water system.

Q.4(a) What are important methods adopted for noise control in air conditioning systems? [10]

(b) Draw different prefabricated attenuators and explain their use in noise reduction in pipes and ducts. [10]

Q.5(a) A duct 1.5m x 1m in size carrying conditioned air runs 50 m from the fan outlet. Then it divides into two parts each of 80 m in length and 1.5m x 1 m in cross section as shown in figure. If the air discharge at the point C is 1600 m³/min, determine the quantity discharged at the point D and the static pressure at the outlet of the fan. Calculate the duct friction loss by using following formula: $H_f = (4fL/D_e) * (V/242.1)^2$ where D_e is the equivalent diameter of the duct and f (friction factor) = 0.005. [08]



(b) Describe briefly any four methods of humidity control in air conditioning. [12]

Q.6(a) Air flowing at rate of 100 m³/min at 40°C DBT and 50% relative humidity is mixed with another stream flowing at the rate of 20 m³/min at 26°C DBT and 50% relative humidity. The mixture flows over a cooling coil whose apparatus dew point temperature is 10°C and by-pass factor is 0.2. Find DBT and relative humidity of air leaving the coil. If this air is supplied to an air-conditioned room where DBT of 26°C and relative humidity of 50% are maintained, estimate:

(i) Room sensible heat factor

(ii) Cooling load capacity of coil in TR. [14]

(b) Describe equal friction loss method and static regain method of duct design. [06]

Q.7(a) What are the major difficulties experienced in air-conditioning a car? [05]

(b) Explain in detail with neat sketch any one of the followings: [15]

(i) Railway air-conditioning

(ii) Marine air-conditioning

(iii) Automobile air-conditioning

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SARDAR PATEL COLLEGE OF ENGINEERING

(An Autonomous Institution Affiliated to University of Mumbai)

MASTER

END SEMESTER EXAMINATION, MAY 2014

Total Marks: 100

Duration: 4 Hours

ME(Thermal Engg.) Sem - II

SUBJECT: Computational Fluid Dynamics

- Attempt any FIVE questions out of seven questions.
- Answers to all sub questions should be grouped together.
- Figures to the right indicate full marks.
- Make suitable assumption with proper explanation.

- (i) With suitable examples, explain following terms 10
a. Physical Model, b. Mathematical Model and c. Numerical Model
 - (ii) What is model validation? State its significance in numerical computation.
 - Discuss the fundamental conservation law required for the analysis of a thermo-fluid system. Listing all assumptions, derive general form of momentum conservation equation. 10
- Discuss about different approach of investigating a thermo-fluid problem. Tabulate merits and demerits associated with each approach. 10
 - Solve following set of equation using: 10

$$5x_1 + 2x_2 + x_3 = 8$$

$$x_1 + 2x_2 + x_3 = 4$$

$$x_1 + x_2 + 3x_3 = 5$$
 - Gauss Elimination method
 - LU decomposition method
- Mention fundamental thermal and flow boundary conditions and explain them. Discuss image point and polynomial fitting method of treating convective boundary condition 10
 - Transform the following differential equations into equivalent integral form. For each equation identify transient term, volumetric source term, convective term and diffusive term. 10
 - Linear convective equation $\frac{\partial T}{\partial t} + c \frac{\partial T}{\partial x} = 0$ where $c > 0$ is a constant
 - One dimension heat equation $\frac{\partial T}{\partial t} = a^2 \frac{\partial^2 T}{\partial x^2} + f(x)$
 - Three dimension heat equation $\frac{\partial T}{\partial t} = \nabla^2 T + g(x)$
 - One dimensional Poisson equation $\nabla^2 T = g(x)$
 - One dimensional Burgers equation $\frac{\partial T}{\partial t} + u \frac{\partial T}{\partial x} = \mu \frac{\partial^2 T}{\partial x^2} + f(x)$ where $\mu > 0$ is a constant
- What is up-winding? Discuss about its need in numerical computation? Explain different techniques of up-winding with suitable sketch of cells. 10

05/05/2014

m. E. (Thermal Engineering) Sem-II Computational Fluid Dynamics

- b) A 5cm long straight fin of circular cross section (dia. 1mm) of insulated tip is used for dissipating heat from a base body maintained at constant temperature 400°C. If the fin is suddenly exposed to an ambient temperature: 25°C and h : 50 W/m²K. 10
- Write governing equation and BCs,
 - Using FVM discretize the equation,
 - Calculate temperature at equally spaced 6 points along the fin at 4 different time step level for a good convergence
 - Plot temperature variation at all time steps.
- (Take thermal diffusivity α for the material as 10⁻⁵ m²/s).
- 5 a) Discuss different approach of modeling transient heat transfer. Identify stability issues for one dimension transient heat conduction with convection using finite volume method. 10
- b) Discuss and explain following terms: 10
- Over and under relaxation
 - Diagonal dominance
 - Role eigen values in solution of linear algebraic equations
 - Time step
6. a) Discuss about the application and scope of the computational fluid dynamics in thermal engineering. 5
- b) The rectangular plate (thermal conductivity = 25 W/mK) has dimensions 24cm by 40cm and is 1cm thick. Boundary conditions are as shown in figure. Neglecting the heat flow in the direction normal to the plane assuming steady state condition, 15
- The diagram shows a rectangular plate with the following boundary conditions:
 - Top edge: $T = 300^\circ\text{C}$
 - Right edge: $h = 40 \text{ W/m}^2\text{K}$, $T_\infty = 25^\circ\text{C}$
 - Bottom edge: $q = 3000 \text{ W/m}^2$
 - Left edge: Insulated (indicated by a hatched line)
- Develop a mathematical model in integral form.
 - Assuming 4 horizontal and 3 vertical mesh, write discretized equation for all cells based FVM.
- Obtain steady state solution using point by point method with proper initial guess.
- Tabulate result.
7. a) Mention different flow solvers and explain the procedure of SIMPLE algorithm? For a 2D incompressible flow derive pressure correction equation? 10
- b) Solve, $\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2}$, subjected to initial condition $u = \sin \pi x$ at $t = 0$ for $0 \leq x \leq 1$ and boundary condition $u = 0$ at $x=0$ and $x=1$ for $t > 0$. 10
- Consider 6 grid points in the computational domain; calculate values of variable at 6 time levels using explicit method. Show results in tabular form.

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RE- EXAMINATION June 2014

Total Marks: 100

Duration: 4 Hours

ME (Thermal Engineering) SEM: II

COMPUTATIONAL FLUID DYNAMICS

- Attempt any FIVE questions out of seven questions.
- Answers to all sub questions should be grouped together.
- Figures to the right indicate full marks.

1. Consider steady state heat conduction with heat generation. Both face A and B are maintained at constant temperatures. Data: Wall thickness $L = 2\text{cm}$, Constant thermal conductivity $k = 5 \text{ W/m}^2 \cdot \text{K}$, $T_A = T_B = 100^\circ\text{C}$, Volumetric heat generation $q = 500 \text{ kW/m}^3$.
(a) Write the governing equation in both differential and integral form and mathematically represent appropriate boundary condition.
(b) Discretize the computational domain in 5 equal parts and write finite volume based nodal equation.
(c) Find nodal temperature by a direct method and compare it with a converged iterative solution. 20
2. a) What is Reynolds Transport Theorem. Write down the governing equations in integral form and explain the physical meaning of each term in the equation 10
b) Solve the following system of equations using LU decomposition method 10
$$\begin{aligned} 5x_1 + 2x_2 + x_3 &= 12 \\ x_1 + 4x_2 + 2x_3 &= 15 \\ x_1 + 2x_2 + 5x_3 &= 20 \end{aligned}$$
and compare the result with Jordan iterative method.
3. a) What is turbulence? Explain important properties of turbulence. What is turbulence modeling? Give the list of predictive methods to explain turbulence phenomenon. Explain any two of them. 10
b) What is system modeling and simulation? Explain following terms with appropriate examples: (a) Physical model, (b) Mathematical model, and (c) Numerical model 10
What do you understand by model validation?
4. a) How CFD does helps in designing of a thermal system? Explain steps and procedure of CFD analysis of an engineering problem. List its advantages and disadvantages. 10
b) What do you understand by ADI scheme? Discuss a case where using ADI would be beneficial compared to other schemes. Write the discretized form of the equation using this concept for the case considered for discussion. 10
5. a) What do you understand by numerical analysis? How numerical analysis of flow problem analysis does differ from thermal diffusion problem? Explain in detail. 10
b) Explain the steps to solve flow problems using SIMPLE algorithm and derive 10

Page 1

M-ET M) Mech Thermal Engg. Sem II Comp. Fluid Dyna-
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pressure correction equation for 2D incompressible fluid flow.
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6. a) Discuss numerical modeling of one dimensional transient convection-diffusion heat transfer with known velocity field. 10
- (a) Develop governing equation from a generalized energy equation.
 - (b) Discretizing with finite volume approach, develop convergence and stability restrictions arising due central difference interpolation of convective term.
 - (c) Suggest two methods to avoid convergence and stability restrictions.
- A large steel plate ($k = 50 \text{ W/mK}$) with a thickness of 0.05 m . One side of it is maintained at a constant temperature of 900°C and other side is covered by ceramic plate ($k = 0.5 \text{ W/mK}$) with a thickness of 0.08 m . The ceramic plate exposed to an ambient temperature 25°C with a convective heat transfer coefficient $50 \text{ W/m}^2\text{K}$. 10
- b) The internal heat transfer coefficient at the steel ceramic plate interface is $500 \text{ W/m}^2\text{K}$.
Develop finite difference equation and calculate temperature distribution in the steel and ceramic plate.
- 7 a) Why special treatment is needed for numerical discretization of convective terms present in transport equations. List several scheme designed for this purpose? 10
- b) For monotonic convergence of one dimensional convection-diffusion problem, prove that the stability is limited by Peclet number if CDS is used to treat convective terms. Find the restriction imposed. 10

Page 2

M. E. mechanical with Thermal Engineering Sem-II

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END SEM-EXAMINATION, MAY 2014

21b
29/4/14
MASTER

SEM / CLASS: SEM II / M. E. (THERMAL ENGG.)

TOTAL MARKS: 100

SUBJECT: DESIGN OF HEAT EXCHANGER

TIME: 04 HRS

- Use of HMT Data Book and DATA Book Xerox are allowed.
- Attempt any Five questions out of seven questions.
- Answers to all sub questions should be grouped together.
- All questions carry equal marks.
- Make suitable assumptions with proper explanations.

Q.1. A heat exchanger is to be designed to heat raw water by the use of condensed water at 70°C and 0.2 bar, which will flow in the shell side with a mass flow rate of 14 kg/s. The heat will be transferred to 9 kg/s of city water coming from supply at 15°C. A single shell and two tube passes is preferable. A fouling resistance of $1.76 \times 10^{-4} \text{ m}^2 \cdot \text{K/W}$ is suggested and the surface over design should not be over 35%. A maximum coolant velocity of 1.5 m/s is suggested to prevent erosion. A maximum tube length of 5 m is required because of space limitations. The tube material is carbon steel ($K = 60 \text{ W/m.K}$). Raw water will flow inside of $\frac{3}{4}$ inch straight tubes (90 mm OD and 16 mm ID). Tubes are laid out on a square pitch with a pitch ratio of 1.25. The baffle spacing is approximated by 0.6 of shell diameter, and the baffle cut is set to 25%. The permissible maximum pressure drop on shell side is 5 psi. The raw water outlet temperature should not be less than 50°C. The selection depends on the closest number of tubes in the TEMA table. Select the number of tube from table for a 2-Pshell and tube heat exchanger. Note that heat duty is fixed, so the heat exchanger length and pressure drops for both streams are to be calculated.

Take properties of shell side fluid and tubes side fluid at T_b from properties table.

Use Mc Adams correlation for shell side heat transfer coefficient:

$$Nu = (h_o D_e) / k = 0.36 (D_e G_s / \mu)^{0.55} (Pr)^{0.33} (\mu_b / \mu_w)^{0.14} \text{ for } 2 \times 10^3 < Re_s < 10^6$$

Use correlation for tube side heat transfer coefficient:

$$Nu_b = \frac{(f/2) (Re - 1000) Pr}{1 + 12.7 (f/2)^{1/2} (Pr^{2/3} - 1)}$$

$$f = [1.58 \ln(Re) - 3.28]^{-2}$$

$$\text{Use shell side pressure drop } (\Delta P)_s = \frac{f G_s^2 (N_b + 1) D_s}{2 \rho D_e \phi_s}$$

$$f = \exp [0.576 - 0.19 \ln(Re_s)]$$

$$\text{Use tube side pressure drop } = (\Delta P)_t = [4f (LN_p/d_i) + 4N_p] (\rho u_m^2 / 2)$$

Calculate shell side and tube side heat transfer coefficient. Also calculate pressure drop on both shell side and tube side fluids. And check the value of surface over design for a given heat exchanger.

m. E. mechanical with Thermal Engineering Sem-II
 Design of Heat Exchanger 29/04/2014

Q.2. The objective of design of a **finned double-pipe heat exchanger** is to design an oil cooler with sea water. Engine oil at a rate of 3 kg/s will be cooled from 65°C to 50°C by sea water at 20°C. The sea water outlet temperature is 30°C, and it flows through the inner tube.

The following design data are selected:

Length of hairpin = 4.5 m, Annulus nominal diameter = 2 inch, Nominal diameter of the inner tube = ¾ inch, Fin height = 12.7 mm, Fin thickness = 0.9 mm, Number of fins per tube = 30, Material throughout = carbon steel ($K = 60 \text{ W/m.K}$), Number of tubes inside the annulus = 1. Select the nominal diameter of the inner tube ¾ inch schedule 40 (OD = 26.67 mm and ID = 20.93 mm),

The properties of fluids are:

	Annulus fluid (Oil)	Tube-side fluid (Sea Water)
Density, kg/m^3	885.27	1013.4
Specific heat, J/kg.K	1902	4.004
Viscosity, kg/m.s	0.075	9.64×10^{-4}
Thermal conductivity, W/m.k	0.1442	0.639
Prandtl number, Pr	1050	6.29

Use correlation for inner tube:

$$f = [1.58 \ln(\text{Re}) - 3.28]^2$$

$$\text{Nu}_b = \frac{(f/2)(\text{Re}_b)(\text{Pr}_b)}{1.07 + 12.7(f/2)^{1/2}(\text{Pr}_b^{2/3} - 1)}$$

Use correlation for Annulus tube:

$$\text{Nu}_b = 1.86 \left[\text{Re}_b \text{Pr}_b \frac{D_h}{L} \right]^{1/3} \left(\frac{\mu_b}{\mu_w} \right)^{0.14}$$

$$\text{For } [\text{Re Pr} (D_h/L)]^{0.33} \times (\mu_b/\mu_w)^{0.14} \geq 2$$

Assume fouling resistance for engine oil = $1.76 \times 10^{-4} \text{ m}^2.\text{K/W}$ and for sea water = $0.088 \times 10^{-3} \text{ m}^2.\text{K/W}$ and **Calculate:** 1) Surface area of heat exchanger, 2) Number of hairpins, 3) Pressure drops and pumping power for both streams.

Q.3. A) What are the advantages and disadvantages of the principal types of shell and tube construction? Why are baffles used in shell and tube heat exchanger? Where are fins used? What are the types of fins that are used in heat exchangers?

B) What are the main selection criteria of a shell and tube heat exchanger? What are the different assumptions to be considered during design of heat exchangers? Explain shell types used (any four) in shell and tube heat exchanger?

Q.4. A) State the different factors to be considered for selection of number of tubes within the shell. How do you calculate equivalent diameter of shell for square pitch layout and triangular pitch layout of shell and tube heat exchanger? How are five different streams (A, B, C, E, & F) identified by Bell-Delaware method?

B) How is the allocation of fluids to shell and tube side decided? What is tube pitch? What factors decide the pitch in a particular case? What are the different tube layout angles?

m. E. mechanical with Thermal Engineering Sem-III
Design of Heat Exchanger 29/04/2014.

Q.5. A Gasketed-plate heat exchanger will be used for heating city water ($R_{fc} = 0.00006 \text{ m}^2 \cdot \text{k/W}$) using the wastewater ($R_{fh} = 0.00006 \text{ m}^2 \cdot \text{k/W}$) available at 90°C . The vertical distance between the ports (L_v) of the plate is 1.60 m and the width of the plate (L_w) is 0.50 m with a gap between the plates (b) of 6 mm. The enlargement factor (ϕ) is given by the manufacturer as 1.17 and the chevron angle (β) is 50° . The plates are made of titanium ($k = 20 \text{ W/m.k}$) with a thickness (t) of 0.6 mm. The port diameter (D_p) is 150 mm. The cold water enters the plate heat exchanger at 15°C and leaves at 45°C at a rate 6 kg/s and it will be heated by the hot water available at 90°C , flowing at a rate of 12 kg/s. Considering single pass arrangements for both streams. Consider total number of plates (N_t) = 100, Total effective area = 100 m^2 .

Use correlation as:

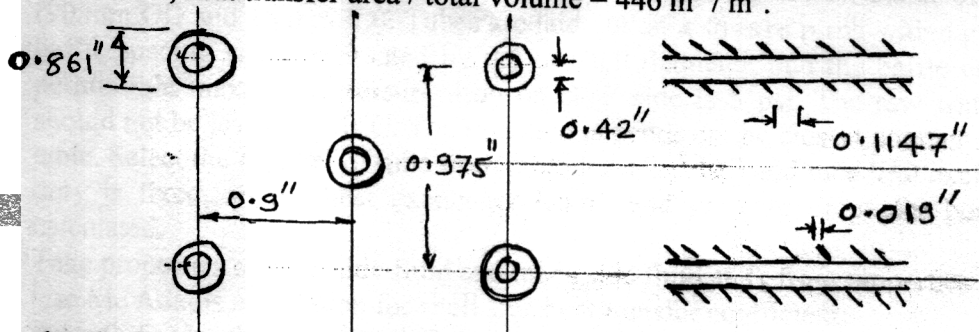
$$Nu = (hD_h/k) = 0.3 (Re)^{0.663} (Pr)^{0.333} (\mu_b/\mu_w)^{0.17}$$

Take friction coefficient for hot and cold fluids as $f = (1.441)/(Re)^{0.206}$

The maximum permissible pressure drop is 50 psi. Collect the properties of both water from property table.

List the result in Table and compare the results. Calculate the pressure drop for both streams.

Q.6. A) Air enters the core of a finned-tube heat exchanger as shown in figure at 1 atm and 25°C . Surface CF-8.72, tube OD = 1.07 cm, fin pitch = 3.43/cm, fin thickness = 0.048 cm, fin area / total area = 0.876, air passage hydraulic diameter = $D_h = 0.443 \text{ cm}$, free-flow area / frontal area, $\sigma = 0.494$, heat transfer area / total volume = $446 \text{ m}^2 / \text{m}^3$.



The air flows at a rate of 1500 kg/h perpendicular to the tubes and exits with a mean temperature of 120°C . The core is 0.5 m long with a 0.25 m^2 frontal area. Calculate the total pressure drop between the air inlet and outlet and the average heat transfer coefficient on the air side.

Take air densities at the inlet (25°C) and outlet temperature (120°C) from properties table.

Also find properties of air at bulk mean temperature from property table.

Take $f = 0.006$ and colburn modulus = 0.0167 from TEMA at that Reynold number.

B) What are the uses of longitudinal and impingement baffles? State the advantages and limitations of Gasketed plate heat exchangers. State the applications of compact heat exchangers.

Q.7. A) Cooling water is circulated through an induction heating coil made of copper tube having 6 mm external and 4.5 mm internal diameters. The coil diameter is 100 mm. The internal wall temperature of the coil is 80°C . The inlet temperature of water is 20°C and the outlet temperature is 65°C . The velocity of water is 1.5 m/sec. Determine the heat transfer coefficient from tube wall to water and the rate of heat transfer per meter length of pipe. If the coil has 10 turns, calculate the total heat removed by the water.

Find Properties of water at 42.5°C from property table of water.

M.E. mechanical with Thermal Engineering Sem-II

Design of Heat Exchanger

29/04/2014

$Re_{cr1} = [(16.4) / (d/R)^{1/2}]$ for $d/R \geq 8 \times 10^{-4}$ For $Re_f < Re_{cr1}$ the flow is laminar & there is no secondary circulation. Nusselt No. for laminar flow: $Nu = 3.66$

If Re_f is between Re_{cr1} & Re_{cr2} , i.e. $Re_{cr1} < Re_f < Re_{cr2}$, there is secondary circulation &

$$Re_{cr2} = 18500 [d / (2R)]^{0.28}$$

If $Re_f > Re_{cr2}$ then flow is turbulent: $Nu = 0.023 Re^{0.8} \times Pr^{0.4}$ and heat transfer coefficient can be calculated by correction factor: $h_{corr} = \epsilon h_c$ where $\epsilon = [1 + 1.8(d/R)]$

- B) 1) State the objectives of design of compact heat exchanger.
2) Explain the effects of fouling on heat transfer, pressure drop of heat exchanger.
3) State the different types of fouling.
4) State the different methods of cleaning of heat exchanger.

BHARATIYA VIDYA BHAVAN'S
SARDAR PATEL COLLEGE OF ENGINEERING
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RE-EXAMINATION, MAY-JUNE 2014

SEM / CLASS: SEM II / M. E. (THERMAL ENGG.)

TOTAL MARKS: 100

SUBJECT: DESIGN OF HEAT EXCHANGER

TIME: 04 HRS

m.e (16) with Thermal Enng. Sem II

MASTER

- Use of HMT Data Book and HEAT EXCHANGER DESIGN DATA BOOK are allowed.
- Attempt any Five questions out of seven questions.
- Answers to all sub questions should be grouped together.
- All questions carry equal marks.
- Make suitable assumptions with proper explanations.

Q.1. Cold water will be heated by a waste water stream. The cold water with a flow rate of 140 kg/s enters the gasketed-plate heat exchanger at 22°C and will be heated to 42°C. The waste water has the same flow rate entering at 65°C and leaving at 45°C. The maximum permissible pressure drop for each stream is 50 psi.

Process Specifications:

	Hot Fluid (waste water)	Cold fluid (cooling water)
Total fouling resistance (m ² K/W)	0.00005	0
Specific heat (J/kg.K)	4183	4178
Viscosity (Ns/m ²)	5.09 x 10 ⁻⁴	7.66 x 10 ⁻⁴
Thermal conductivity (W/mK)	0.645	0.617
Density (kg/m ³)	985	995
Pr. No.	3.31	5.19

Constructional Data:

Plate material	SS304
Plate thickness (mm)	0.6
Chevron angle (degree)	45
Total number of plates	105
Enlargement factor (Φ)	1.25
Number of passes	One pass/one pass
Total effective area (m ²)	110
All port diameters (mm)	200
Compressed plate pack length L _c (m)	0.38
Horizontal port distance L _h (m)	0.43
Effective channel width L _w (m)	0.63
Thermal conductivity of Plate material (W/mK)	17.5

Use correlation for hot and cold fluids as: $Nu = \frac{hD_h}{K} = 0.3 (Re)^{0.663} (Pr)^{0.333} \left[\frac{\mu_b}{\mu_w} \right]^{0.17}$

Take friction coefficient for hot and cold fluids as: $f = \frac{1.441}{Re^{0.206}}$

List the result in Table and compare the results. Calculate the pressure drop for both streams. Do the performance, heat transfer and pressure drop analysis of above heat exchanger?

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Q.2 A heat exchanger is to be designed to heat raw water by the use of condensed water at 67°C and 0.2 bar, which will flow in the shell side with a mass flow rate of 50,000 kg/hr. The heat will be transferred to 30,000 kg/hr of city water coming from supply at 17°C. A **single shell and two tube passes is preferable**. A fouling resistance of $1.76 \times 10^{-4} \text{ m}^2 \cdot \text{K/W}$ is suggested and the surface over design should not be over 40%. A maximum coolant velocity of 1.5 m/s is suggested to prevent erosion. A maximum tube length of 5 m is required because of space limitations. The tube material is carbon steel ($K = 60 \text{ W/m.K}$). Raw water will flow inside of $\frac{3}{4}$ inch straight tubes (19 mm OD and 16 mm ID). Tubes are laid out on a **square pitch** with a pitch ratio of 1.25. The baffle spacing can be taken as 0.4 to 0.6 of shell diameter, and the baffle cut is set to 25%. The permissible maximum pressure drop on shell side is 5 psi. The raw water outlet temperature should not be less than 40°C.

Perform the preliminary analysis. For preliminary analysis, correlations are not required. Assume heat transfer coefficient for shell side and tube side as 5000 and 4000 $\text{W/m}^2 \cdot \text{K}$ respectively. Take properties of shell side fluid and tubes side fluid at T_b from property table.

Q.3. Distilled water with a flow rate of 50 kg/s enters a baffled shell and tube heat exchanger at 32°C and leaves at 22°C. Heat will be transferred to 150 kg/s of raw water coming from a supply at 20°C. Design a heat exchanger for this purpose.

A **single shell and single tube pass is preferable**. The tube diameter is $\frac{3}{4}$ inch (19 mm OD with 16 mm ID) and tubes are laid out on a 1 inch square pitch. Use the baffle spacing of 0.5 m. A maximum length of the heat exchanger of 8 m is required because of space limitations. The tube material is 0.5Cr-alloy ($K = 42.3 \text{ W/m.K}$). Assume a total fouling resistance of $1.76 \times 10^{-4} \text{ m}^2 \cdot \text{K/W}$. Note that surface over design should not exceed 30%. The maximum flow velocity through the tube is also suggested to be 2 m/s to prevent erosion.

Perform thermal analysis of the heat exchanger by Kern Method. Take properties of shell side fluid and tubes side fluid at T_b from property table.

Use correlation for shell side heat transfer coefficient as: $Nu = \frac{h_o D_e}{K} = 0.36 (Re)^{0.663} (Pr)^{0.333}$

Use correlation for tube side heat transfer coefficient as:

$$Nu = \frac{\frac{f}{2} Re Pr}{1.07 + 12.7 \sqrt{\frac{f}{2} (Pr^{\frac{2}{3}} - 1)}} \quad \text{and} \quad f = [1.58 \ln(Re) - 3.28]^{-2}$$

Use correlation for pressure drops on the shell side and tube side respectively:

$$(\Delta P)_S = \frac{f G_s^2 (N_b - 1) D_s}{2 \rho D_c \phi_s} \quad \text{and} \quad (\Delta P)_t = \frac{4 f L N_p G_t^2}{d_i 2 \rho}$$

Q.4. (A) Air at atmospheric pressure flows across a staggered tube bank consisting of 8 rows of tubes in the flow direction. The tube diameter is 1 cm, longitudinal spacing and transversal spacing of two consecutive tubes are $X_l = 1.5 \text{ cm}$ and $X_t = 2.54 \text{ cm}$. The upstream velocity $U_\infty = 6 \text{ m/s}$ and upstream temperature $T_\infty = 20^\circ \text{C}$. If the surface temperature of the tube is 180°C , find the average heat transfer coefficient for the tube bank. Take properties of air at inlet

M. E. M. with Thermal Engg. Sem II Design of Heat

temperature of 20°C from property table. For $n = 8$ rows, take $C_n = 0.98$, Also take μ_w from ~~exchanger~~ property table at wall temperature.

Average Nu at bulk temperature for $Re = 1000$ to 2×10^5 .

$$\overline{Nu} = 0.35 C_n Re^{0.6} Pr^{0.36} \left(\frac{Pr_b}{Pr_w} \right)^{0.25} \left(\frac{x_t}{x_l} \right)^{0.2} \quad (15)$$

(B) What are the advantages and disadvantages of gasketed-plate heat exchanger? (05)

Q.5. (A) Determine the total heat transfer coefficient at 30 cm from the inlet of a heat exchanger where engine oil flows through tubes with an inner diameter of 1.27 cm. Oil flows with a velocity of 0.5 m/s and at a local bulk temperature of 30°C. While the local wall temperature is 60°C.

Properties of engine oil at bulk temperature of 30°C as:

$$\rho = 882.3 \frac{kg}{m^3}, \quad C_p = 1922 \text{ J/kgK}, \quad \mu = 0.416 \frac{Ns}{m^2}, \quad K = 0.144 \text{ W/mK}, \quad Pr = 5550,$$

$$\text{At } T_w = 60^\circ C, \quad \mu_w = 0.074 \frac{Ns}{m^2}$$

Use correlation as:

$$Nu = 1.86 (Re.Pr)^{0.333} \left[\frac{d_i}{L} \right]^{0.333} \left[\frac{\mu_b}{\mu_w} \right]^{0.14} \quad (10)$$

(B) What are the different classification of heat exchangers and explain each type in brief. What are the different factors to be considered in the design of heat exchangers? (10)

Q.6 (A). Explain the Inline tube bank geometry with neat sketch with proper notations. Explain different kinds of baffles for shell-side fluid. (10)

(B) Explain the following terms: (10)

(i) Effect of Turbulence (ii) Friction Factor (iii) Pressure Loss (iv) Recuperators

Q. 7 (A) Explain heat exchanger design methodology with flow diagram. Explain gas-to-gas heat exchangers and its applications. (10)

(B) Explain the effects of pressure drops, LMTD, Fouling factors and overall heat transfer coefficient on design of heat exchanger. (10)

Page 13

Qib
215/14

Bhartiya Vidya Bhavan's

Sardar Patel College of Engineering

An Autonomous Institution Affiliated to Mumbai University

End Semester Exam

Academic year: 2013-14

SEM – II

Class: M.E. Mechanical (Thermal Engineering)

Total Marks: 100

Subject: Experimental Analysis & Instrumentation

Duration: 4 hrs

- Attempt Any Five questions out of Seven questions
- Figures to right indicate full marks
- Assume suitable data if necessary
- Answers to sub questions should be grouped together.

MASTER

-
- Q. 1 (a) Explain different types of inputs in measurement system with example? 10 m
- (b) Write short notes on: 10 m
- i. Ramp
 - ii. Parabolic
 - iii. Impulse inputs
- Q.2. (a) Explain construction and working resistive type of instrument for angular displacement measurement? 10 m
- (b) A circuit was tuned for resonance by eight different students, and the values of resonant frequency in kHz were recorded as 532, 548, 543, 535, 546, 531, 543 and 536. Calculate: 10 m
- (i) The Arithmetic Mean
 - (ii) Average Deviation
 - (iii) Standard Deviation assuming finite number of readings are taken?
 - (iv) Variance
- Q.3 (a) Explain working of any one type of Tachogenerators? 10 m
- (b) Explain construction and working of any one accelerometer? State its advantages and disadvantages? 10 m
- Q.4. (a) Explain construction and working of any one elastic pressure transducer? 10 m
- (b) Explain construction and working of Mcleod Gauge for vacuum measurement? 10 m

m. E. mechanical (Thermal Engineering)
Experimental Analysis & Instrumentation.

02/05/2014.

Q.5. (a) Explain working of Resistance Temperature Detectors? State material requirements for Resistive wire used in RTDs? 10 m

(b) Explain any one method for measuring Thermal conductivity? 10 m

Q.6. (a) Explain why temperature compensation is required for a strain gauge? 10 m
Explain any one type of temperature compensation technique with adjacent gauge?

(b) Explain working of Laser Doppler Anemometer? State its advantages over Rotameter? 10 m

Q.7. (a) Explain working of any one type of instrument for Humidity measurement? 10 m

(b) Explain how Data Acquisition system is essential for today's instrumentation of laboratory and industrial applications? 10 m

20/11/4

EXAM

Sardar Patel College of Engineering

(An Autonomous Institute affiliated to University of Mumbai)

M.E. (Thermal Engg.)

SEM - II

Duration: 4 Hrs

Marks: 100

SUBJECT: PIPING ENGINEERING

M.E (Thermal Engg) with Thermal Engg Sem II

NOTE: Attempt any five questions.

Assume suitable data wherever necessary.

Figures to the right indicate full marks.

Draw neat sketches wherever required.

Q.1 a) Explain the role of a piping engineer in the

06

- i) Installation of a new plant. ii) operation of an existing plant.
- b) Calculate maximum allowable pressure for a 90° miter bend for 3-cut and also state your recommendations for the design pressure.

14

Data:

Outside diameter	= 812 mm
Nominal Thickness	= 8 mm
Corrosion allowance	= 1.5 mm
Allowable stress	= 105 N/mm ²
Design Pressure	= 0.6 N/mm ²
Joint Efficiency	= 0.85

Q.2 a) State and explain with neat sketches different ways of joining pipes. Also write when each one is used.

12

b) Distinguish between Male and Female type flange and Tongue and Groove type flange with simple sketch. Explain when each of the flange type is useful.

04

c) List the documents that are required to be furnished by the other departments to a piping department.

04

Q.3 a) The following data refers to a header & branch pipe connection:

14

Nominal diameter of header pipe (Schedule 40)	= 6"
Outer diameter of header pipe	= 168.3 mm
Minimum thickness of header pipe	= 7.11 mm
Nominal diameter of branch pipe (Schedule 40)	= 4"
Outer diameter of branch pipe	= 114.3 mm
Minimum thickness of branch pipe	= 6.02 mm
Design pressure	= 400 psig
Design Temperature	= 250°C
Corrosion allowance	= 1.5 mm

Pigea

M. E (M) with Thermal Engg Sem II Piping Engg. 20/6/14

Allowable stress for ASTM A53 Grade B at design temperature = 104 N/mm^2

(For both Header & Branch pipe)

Design a suitable reinforcing pad if it is to be made from a plate of equal quality to that of the pipe material. Assume Machining tolerance 12.5% and $Y = 0.4$.

- b) What are the basic considerations of piping layout? 06
- Q.4 a) Find the optimum diameter of pipe for Steam at 120°C , 2 atm. Pressure, 400 kg/hr and 15 m/s velocity. 05
- b) Draw neat functional diagram, explain the working, and write advantages, limitations and applications of gate valve. 10
- c) Write note on cathodic protection of piping. 05
- Q.5 a) Write notes on the following codes/standards (Any two) 10
- i) IBR. ii) Gas cylinder rules. iii) ASME -B31.1 & B31.3
- b) Explain the following types of supports with neat sketches (Any two): 10
- i) Welded shoe support ii) hanger support iii) Roller support
- Q.6 a) Write notes on: 10
- i) Heat Exchanger piping. ii) Piping Isometrics
- b) Draw a neat schematic diagram. Write objective, and write what P&ID should contain and what it should not contain. 10
- Q.7 Write notes on (Any Four): 20
- i) Plot plan
- ii) Traced piping
- iii) Role of computers in piping
- iv) Stress intensification factor for piping joint
- v) Piping for pumps

Page 2

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09/05/14

Sardar Patel College of Engineering

(An Autonomous Institute affiliated to University of Mumbai)

M.E. (Thermal Engg.)

SEM - II

Duration: 4 Hrs

Marks: 100

SUBJECT: PIPING ENGINEERING

m. e. pm) with Thermal Engg.
Sem II

NOTE: Attempt any five questions.

Assume suitable data wherever necessary.

Figures to the right indicate full marks.

Draw neat sketches wherever required.

MASTER

- Q.1 a) What are the inputs received and outputs given by piping Engineer? 08
- b) What are the methods of welding used for piping fabrication? Explain with neat sketches any four of them briefly. 12
- Q.2 a) The following data refers to a 4 piece miter bend: 10
- | | |
|--------------------------|----------|
| Plate thickness | = 0.322" |
| Nominal diameter of pipe | = 8" |
| Outer diameter of pipe | = 8.626" |
| Miter angle | = 15° |
| Miter spacing | = 6.5" |
- (i) Check for miter spacing, whether closely spaced or widely spaced.
- (ii) Calculate Stress Intensification Factor.
- (iii) Calculate Flexibility Factor.
- b) A water pump has to deliver water from a reservoir at a rate of 200 m³/hr at 20°C through an ERW pipe of NB 200mm to an overhead tank at 10m height. The pipe length is supposed to be 60m, one non return valve & a gate valve each, and four 90°formed bends with a radius of 2d, The pump center is 1m above the water level of the reservoir. Calculate the total pressure head at the pump & the power required for pumping. Assume (i) pump efficiency as 70% (ii) $\lambda=0.028$ and (iii) Coefficient of resistance for fittings as 0.8 for NRV, 3.6 for Gate valve and 0.14 for each 90°bend. 10
- Q.3 a) The following data refers to a header & branch pipe connection: 14
- | | |
|---|------------|
| Nominal diameter of header pipe (Schedule 40) | = 150 mm |
| Outer diameter of header pipe | = 168.3 mm |
| Minimum thickness of header pipe | = 7.11 mm |
| Nominal diameter of branch pipe (Schedule 20) | = 80 mm |
| Outer diameter of branch pipe | = 88.9 mm |
| Minimum thickness of branch pipe | = 5.49 mm |

M. E. (Mechanical) with Thermal Engineering Sem-II
Piping Engineering 29/05/2014.

Design pressure = 0.6 N/mm²

Design Temperature = 150°C

Corrosion allowance = 1.5 mm

Allowable stress for ASTM A53 Grade B at design temperature = 120 N/mm²

(For both Header & Branch pipe)

Thickness of reinforcing pad (If required) = 6 mm

Design a suitable reinforcing pad if it is to be made from a plate of equal quality to that of the pipe material. Assume $Y = 0.4$.

b) Write note on role of computers in piping 06

Q.4 a) Find the optimum diameter of pipe for CO₂ at 120 °C, 3 atm. Pressure, 500 kg/hr and 12 m/s velocity. 05

b) Draw neat functional diagram, explain the working, and write advantages, limitations and applications of Butterfly valve. 10

c) Calculate the safe working pressure & pipe wall thickness for a 100mm dia. Schedule 80 butt welded pipe, safe working stress for carbon steel at working temp. 100°C is 50 N/mm². 05

Q.5 a) Write notes on the following codes/standards (Any two)

i) SMPV rules ii) IBR iii) ASME -B31.1 & B31.3 10

b) Write notes on: 10

i) Plot plan. ii) Piping Isometrics

Q.6 a) Explain the following types of supports with neat sketches (Any two): 10

i) Hanger support ii) Anchor support iii) Roller support

b) Draw a neat schematic diagram, write objective, and write what PFD should contain and what it should not contain. 10

Q.7 Write notes on (Any Four): 20

i) Heat Exchanger piping

ii) Ferrous materials of construction of pipes

iii) Non-ferrous materials of construction of pipes

iv) Piping for pumps

v) Piping for compressor