ME (Mech / Thermal Engg). Sem-II. Lib 27/04/15

Design of Heat Exchange

BHARATIYA VIDYA BHAVAN'S

SARDAR PATEL COLLEGE OF ENGINEERING

[An Autonomous Institution Affiliated to University of Mumbai]

END SEM EXAMINATION, APRIL-MAY2015

SEM / CLASS: SEM II/M. E. (THERMAL ENGG.) **TOTAL MARKS: 100**

SUBJECT: DESIGN OF HEAT EXCHANGER **TIME: 04 HRS**

Master file

- Use of HMTData Book and HEAT EXCHANGER DESIGN DATA BOOK are allowed.
- **Question No. 1 is compulsory.**
- Attempt **any Four questions** out of remaining sixquestions.
- Answers to all sub questions should be grouped together.
- All questions carry equal marks.
- Make suitable assumptions with proper explanations.

Q.1.Answer the following questions (any five)

a) Write short notes on Spiral plate heat exchangers.

b) Why are baffles used in shell and tube heat exchangers?

c) What are the advantages and the limitations of Gasketed plate heat exchangers?

d) What do you mean by fouling resistance, cleanliness factor, and percent over surface?

e) State and explain the parallel and series arrangements of (Hairpins) double pipe heat exchangers.

f) What is Bell Delaware method of shell and tube heat exchangers?

Q. 2. Coldwaterwill 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 beheated to 42°C. The waste water has the same flow rate entering at 65°Cand 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^2K/W)	0.00005	0
Specific heat (J/kg.K)	4183	4178
Viscosity (Ns/m^2)	5.09×10^{-4}	7.66×10^{-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

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Design of Heat Exchanger. 27/4/15

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?

Q.3. 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 to30,000 kg/hr of city water coming from supply at 17°C. **A single shell and two tube passes is preferable.** A fouling resistance of 1.76×10^{-4} $m^2.K/W$ 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 5m is required because of space limitations. The tube material is carbon steel (K=60W/m.K). Raw water will flow inside of ¾ inch straight tubes (19mm OD and 16mm 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 W/m^2K respectively. Take properties of shell side fluid and tubes side fluid at T_b from property table.

Q.4.(A) Water at the rate of 3.783 kg/s is heated from 38 to 55°C in a shell and tube heat exchanger. On the shell side one pass is used with water as the heating fluid, 1.9 kg/s, entering the exchanger at 93°C. The overall heat transfer coefficient is 1420 W/m^2K and the average water velocity in the 1.9 cm diameter tubes is 0.37 m/s. Because of space limitations the tube length must not be longer than 2.5 meter. Calculate the number of tube passes, the number of tubes per pass, and the length of tubes, consistent with this restriction.
Use heat transfer data book to calculate correction factor.

(B) Considera piping circuit of a heat exchanger. In the circuit there are four 90° elbows, three close pattern returns bends, two check valves (clearway swing type), two angle valves (with no obstruction in flat type seat), and three gate valves (conventional wedge type); the valves are fully open. The straight part of the circuit pipe is 150 m, and water at 50°C flows with a velocity of 4m/s. the pressure drop through the heat exchanger is 12 kPa. Normal pipe size is 2 inch. Take equivalent lengths of fittings are as follows:
Elbow 30, return bends 50, check valves 50, angle valves 145, and gate valves 13.
Calculate:

1. The total pressure drop in the system
2. The mass flow rate
3. Pumping power if isentropic efficiency is 80%.

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Q.5. (A) Cooling water is circulated through an induction heating coilmade 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.
$Re_{cr1} = [(16.4) / (d/R)^{1/2}]$ 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 Ref 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: $h_{corr} = \varepsilon\, h_c$ where $\varepsilon = [1 + 1.8(d / R)]$

(B) 1. What are the basic requirements of heat exchangers? Explain in brief.

2. What are the basic components of shell and tube heat exchangers? State the functions of each component.

Q. 6. (A) What are the rating and sizing of the shell and tube heat exchangers? What are the input parameters for rating problems and sizing problems?

(B) What is maldistribution? State and explain problems that occur due to maldistribution? What are the causes of maldistribution?

Q. 7 (A) State and explain the assumptions used in basic design methods of heat exchangers. State the different heat exchanger design calculations.

(B) 1. Explain the variable overall heat transfer coefficient. How it is different from constantoverall heat transfer coefficient?

2. Explain the meaning and functions of following shell types (TEMA):
E-shell, F-shell, J-shell, G-shell, H-shell

MEC(Mech / thermal Engee), 29/4/15.
Experimental Analysis & Instrumentation.

Lib 29.4.15.

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End-Sem

CLASS/SEM: **M.E. (Mech) Sem II** (Thermal Engg) | Total Marks: **100**

SUBJECT: **Experimental Analysis and Instrumentation** | Duration: **4 Hour**

Date: **29th April 2015**

Master

- Question **1** is compulsory
- Solve any **4** from **2** to **7**
- Assume suitable data if necessary.

Q.	Description	Split Marks	Total Marks
1.	a. A wheatstone bridge requires a change of 5Ω in the variable resistance arm of the bridge to produce change of 50 mV in output voltage. Determine the sensitivity and the scale factor.	(1)	(20)
	b. The dead zone in a certain pyrometer is 0.2 % of span. The range of 500 °C to 1000 °C. What minimum temperature change is required before that change is detected by pyrometer?	(1)	
	c. Draw graphs for (Diagrams should be labelled properly)		
	i. Step input	(1.5)	
	ii. Ramp input	(1.5)	
	iii. Parabolic input	(1.5)	
	iv. Impulse input	(1.5)	
	d. Mention types of filters and draw ideal characteristic diagrams for them (Diagrams should be labelled properly).	(6)	
	e. Answer following	(4)	
	i. The output of transducer is always electrical (True or False)		
	ii. Which one detects very small change in temperature (Thermistor / Thermocouple / Resistance thermometer)		
	iii. The strain gauge with negative gauge factor will increase the resistance offered by strain gauge in compressive loading (True or False)		
	iv. For an OPAMP circuit operating as voltage follower input voltage signal is given to which input end.		

Page (1)

	f. A Saybolt viscometer is used for measurement of viscosity of a motor oil. The time recorded for 60 ml drainage is 183 s. Calculate the kinematic viscosity. In the expression to calculate kinematic viscosity using the method the first constant has value 0.22×10^{-6} and the second constant in the expression is 179×10^{-6}	(2)	
2.	a. Explain parallel plate capacitive transducer i. Principle ii. Diagram iii. Equation (with all symbols explained and with units) iv. Working b. In a wheatstone bridge three out of four resistors have value 120 Ω. The strain gauge attached to a structure to measure strain, forms the fourth resistance of this bridge. The resistance of strain gauge before being strained is 120 Ω. The strain gauge has gauge factor of 2. When tensile load is applied on the structure the resulting strain is 5 micro-strain. If the applied battery voltage is 6 V, i. What is open circuit voltage when no tensile load is applied on the structure ii. What is the change in the resistance of the strain gauge due to tensile loading iii. What is the change in open circuit voltage due to change in the resistance of the strain gauge iv. Calculate the sensitivity of bridge v. If the output of the bridge is connected to a meter with 4 kΩ resistance how much current would flow through meter when tensile load is applied on the structure	 (2) (2) (2) (2) (3) (2) (2) (2) (3)	(20)
3.	a. Describe working and application of linear variable differential transformer (LVDT) for displacement measurement with diagram. • Diagrams explaining working • Working b. Explain procedure for the estimation of thermal conductivity of solids using guarded hot plate apparatus. • Draw neat properly labelled schematic diagram • Explain working with appropriate expressions with all symbols explained c. Explain Knudsen gauge for vacuum measurement with diagram i. Draw diagram ii. Explain Working iii. Advantages in comparison to other methods	 (4) (3) (3) (4) (2) (2) (2)	(20)

4.	a. For the following data set of 8 elements : 6, 8, 4, 3, 5, 7, 4, 3, Calculate		(20)
	i. mean,	(1)	
	ii. variance and	(2)	
	iii. standard deviation	(1)	
	b. Explain procedure for the estimation of the viscosity using falling piston viscometer	(5)	
	c. A photoelectric tachometer attached to a shaft with gear mounted on it. Tachometer gets signal from this gear with 120 teeth. The gating period is 10^5 μs. The shaft rotates at 1200 rpm speed. What is will be the signal count of tachometer for given gating period.	(3)	
	d. Explain DC Tachometer generator		
	i. Draw properly labelled diagram	(2)	
	ii. Explain Construction and working	(3)	
	e. Explain working of thermistors (Only principle and working, no diagram needed)	(3)	
5.	a. Explain velocity measurement using Pitot tube		(20)
	i. Draw diagram	(3)	
	ii. Derive expression	(3)	
	c. The differential pressure across an orifice in an airline is measured by a simple water manometer. The manometer registers a differential head of 100 mm of water when the flow rate in the line is 10000 m^3/h of air density of 2 kg/m^3. A proposal is made to use the same installation to measure the rate of flow of water in the line, using mercury in place of water in the manometer. Estimate the difference in the level of the mercury in the two sides of the manometer which would be obtained for a flow rate of 2000 m^3/h of water. Assume coefficient of discharge remains the same and no compression of air. The density of mercury is 13600 kg/m^3.	(5)	
	c. Explain working of constant temperature hot wire anemometer		
	i. Draw diagram	(2)	
	ii. Explain working	(2)	
	iii. Derive expression with all symbols explained	(3)	
	iv. Draw characteristic diagram	(2)	
6.	a. Define following term with reference to experimental measurements		(20)
	i. Scale range and scale span (Give example)	(3)	
	ii. Drift (Define all types of drifts with appropriate diagrams)	(6)	
	iii. Repeatability and Reproducibility	(2)	
	b. A second order system with a mass of 8×10^{-3} kg and stiffness of 1000 N/m.		
	i. Calculate the natural frequency of the system.	(2)	
	ii. Determine the damping constant to just prevent overshoot in	(2)	

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Experimental Analysis & Instrumentation

	response to a step input force iii. Calculate the frequency of damped oscillations if damping ratio is reduced to 0.6 c. Derive expression for combined error for the output which is multiplication of two quantities.	(2) (3) (6)	
7.	a. The dynamic viscosity of liquid water at 20 °C is 1.01×10-3 Ns/m2 and the density is 1000 kg/m^3. The tube through which it flows is 1 mm diameter and the Reynolds number is 500. Find suitable length for the tube. The differential pressure is about 50 kPa. b. Derive expression for bridge sensitivity for voltage sensitive Wheatstone bridge. c. A moving coil voltmeter has a uniform scale with 200 divisions, the full scale reading is 200 V and 1/5 of scale division can be estimated with a fair degree of certainty. Determine the resolution of the instrument in in volt. d. The resistance of a circuit is found by measuring current flowing and the power fed into the circuit. Find the combined relative limiting error in the measurement of resistance if the relative limiting error in the power and the current are ± 1.5 % and ± 1.0 % respectively. $R = P/I^2$, where R is resistance, P is power and I is current i. Derive expression ii. Calculate combined error	(6) (6) (2) (4) (2)	(20)

MEC(Mech / Thermal Engg), Sem-II. Lib
Computational Fluid Dynamics. 02.05.15.

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SARDAR PATEL COLLEGE OF ENGINEERING

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END SEMESTER EXAMINATION, MAY 2015

Total Marks: 100 (Mech) Duration: 4 Hours

MTech (Thermal) 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.

Master

1. a) What is checker board problem in numerical implementation of flow problem? In context to this issue discuss the terms: Collocated mesh, Staggered mesh, and Semi-staggered mesh. **10**

   State any other complexity associated with numerical implementation of flow problems.

   (b) "*Numerical and experimental methods of investigation are complementary*", Do you agree with this statement? Write your opinion with discussion and appropriate illustration. **10**

2 a) Discuss following terms: **5**
   (i) Diagonal dominance of an algebraic equation,
   (ii) Grid sensitivity

   b) Solve the following system of equation by (i) Jacobi's method and (ii) Gauss-Seidel method. In each case, carryout computation to two decimal places and proceed up to 10 iterations. **15**

$$\begin{bmatrix} 17 & 65 & -13 & 50 \\ 12 & 16 & 37 & 18 \\ 56 & 23 & 11 & -19 \\ 3 & -5 & 47 & 10 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} = \begin{bmatrix} 84 \\ 25 \\ 36 \\ 18 \end{bmatrix}$$

3. a) Differentiate between modeling and simulation with illustration. Discuss a generalized approach of solving thermo-fluid problem. **5**

   b) Use following direct method to solve following system of equation using (a) Gauss Elimination and b) LU decomposition method **15**

$$2x_1 + 2x_2 + x_3 + 2x_4 = 7$$
$$x_1 - 2x_2 - x_4 = 2$$
$$3x_1 - x_2 - 2x_3 - x_4 = 3$$
$$x_1 - 2x_4 = 0$$

4 a) Differential between explicit and implicit method. **5**

   b) A very long ingot of copper of cross sectional size (30cm × 24cm) is insulated at two adjacent sides and other two sides are exposed to a convective ambience where **15**

ME (Mech / Thermal . Engg.), Sem. II, 2/5/15
Computational Fluid Dynamics.

temperature is 400°C with heat transfer coefficient of 80 W/m^2K. The objective of the problem is to determine temperature distribution across the section.

(i) Select a computational domain for numerical analysis with proper reasoning.

(ii) List down the available boundary condition with the governing equation in integral form.

(iii) Discretize the domain into 6×4 mesh size and develop nodal equation.

(iv) Show three iteration values in tabular form using line by line method.
Thermal conductivity of Cu, (k =350 W/mK)

5. a) Discuss any five of the following boundary condition and write down their mathematical representation. 10

i) No-slip and slip condition
ii) Insulating boundary condition
iii) Convective boundary condition
iv) Outflow condition
v) Symmetry condition
vi) Periodic boundary condition
vii) Interfacial condition

b) Consider one dimensional steady state heat conduction in an insulated steel rod (thermal conductivity, k =50W/m-K) of length 0.2 m carrying electric current which generates heat at a rate of 10^5 W/m^3. One end of the rod is maintained at 100°C and other end is insulated. 10

(a) Show computational domain descretized into 5 equal control volume.
(b) Starting with generalized integral form of energy equation, develop the governing equation for present case and write appropriate boundary conditions.
(c) Use Finite Volume Method and obtain discretized equations for all cells.

Solve discretized equations using Jacobi iterative procedure, and tabulate 6 iteration cell values.

6 a) Discuss numerical limitations of one dimensional transient convection-diffusion problem. Suggest methods to avoid it. 10

b) A cylindrical straight fin (l=5cm, d=1mm) of insulated tip is used for heat transfer enhancement of a body maintained at 200°C. The fin is suddenly exposed to an ambient temperature 4°C with a convective heat transfer coefficient 50 W/m^2K. To study fin's transient behavior using explicit scheme, 10

i) Develop a mathematical model of the problem using integral form of energy equation
ii) Calculate temperature at equally spaced 6 points along the fin at 4 different time step level for a good convergence.
iii) Plot temperature variation at all time steps.

(Take thermal diffusivity α for the material as 10^{-5} m^2/s).

7. a) (i) Discuss all fundamental conservation law which are sufficient to analyze a thermo-fluid problem and represent them in their control volume form. 10

(ii) Explain terms: a.) Relaxation factor, and b) Residue

b) Specify important feature of SIMPLE algorithm. 10

Using two dimensional NS equation derive pressure correction equation and write down the steps involved to implement SIMPLE algorithm.

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ME (mech / Therm. Engee), Sem - II. 5/5/15
Air Conditioning System Design

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END SEMESTER EXAMINATION MAY 2015

CLASS: **M.E.(Thermal Engineering)/Sem :II** (mech). TOTAL MARKS:**100**

SUBJECT: **AIR CONDITIONING SYSTEM DESIGN** DURATION: **4 HOURS**

1. Question number **One** is compulsory.
2. Attempt any **Four** questions out of remaining **Six** questions.
3. Figures to the right indicate full marks.
4. Assume suitable data and justify your assumption.
5. Use of refrigeration tables, steam table and phychrometric chart is permitted.

Master

1. (a) Explain principle of adiabatic dehumidification. In actual practice with use of materials like activated alumina do the adiabatic dehumidification process lies on constant WBT lines, if not why? [5]
(b) Discuss different processes possible with air washer. [5]
(c) Explain why evaporative cooling need not create comfort conditions. [5]
(d) Discuss the factors involved in the principle of air distribution. [5]

2. (a) Moist air enters a chamber at 5°C DBT and 60 % RH at a rate of 5400 m^3/hr. The barometric pressure is 1.01325 bar. While passing through the chamber, the air absorbs sensible heat at the rate of 40.7 kW and picks up 40 kg/h of saturated steam at 100°C. Determine the dry and wet bulb temperature of the leaving air. [10]
(b) Explain construction of psychrometric chart in detail [10]

3. A room for process work is maintained at 20° C DBT and 25 % RH. The outside air is at 40°C DB and 25°C WB temperatures. Twelve cmm of fresh air is mixed with a part of recirculated air and passed over the adsorption dehumidifier. It is then mixed with another part of recirculated air and is sensibly cooled in a cooler before being supplied to the room at 14°C.
The room sensible and latent heat gains are 6.0 and 0.8 kW respectively. Calculate the volume flow rate of the air entering the dehumidifier and the amount of heat removed in the cooler. The performance of the adsorbent material is as shown in table. The heat of adsorption may be taken as 390 kJ/kg of the moisture adsorbed. [20]

Entering moisture content g / kg d.a.	2.82	4.29	5.7	7.15	8.57	10	11.43	12.86	14.29
Leaving moisture content g / kg d.a.	0.43	0.57	1.0	1.57	2.15	2.86	3.57	4.27	5.23

ME (Mech / Therm. Engg.), Sem - II, 5/5/15
Air Conditioning System Design

4. A laboratory having an unusually large latent heat gain is required to be air conditioned. The design conditions and loads are as follows:

Summer design conditions	: 40°C DBT, 27°C WBT
Inside design conditions	: 25°C DBT, 50% RH
Room sensible heat	: 34.9 kW
Room latent heat	: 18.6 kW

The ventilation air requirement is 85 cmm. Determine the following:

(i) Ventilation load.
(ii) Room and effective sensible heat factors.
(iii) Apparatus dew point and amount of reheat for economical design.
(iv) Supply air quantity.
(v) Condition of air entering and leaving coil and supply air temperature
(vi) Grand total heat.

Assume suitable bypass factor. **[20]**

5. Write short notes on followings **[20]**

(i) Window and split air conditioner
(ii) Direct expansion system
(iii) Air water system
(iv) Winter air conditioning

6. (a) Explain in detail any two duct design methods **[10]**

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

7. With neat sketch explain in detail. (Any two) **[20]**

(i) Automobile air conditioning.
(ii) Railway air conditioning.
(iii) Marine air conditioning.

Lib
08/05/15

M.E. (Thermal Engg.) Sem II
Piping Engineering.

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END-SEMESTER

CLASS/SEM: **M.E.(Thermal Engg) Sem II** — Total Marks: **100**

SUBJECT: **Piping Engineering** — Duration: **4 Hours**

Date: **May 2015**

- Question no. **1** is **compulsory**. Attempt any **four** out of remaining six questions.
- Answers to all sub questions should be grouped together.
- Figures to the right indicate full marks.
- Refer Annexure 1 for additional design data. Assume suitable data if necessary.

MASTER FILE

1. a) Explain the interdisciplinary role of piping engineer in an EPC organization by describing typical interactions with various departments. **(4)**
   b) Describe important sections of ASME B31.3 code. Briefly explain difference between ASME B31.3 and B31.1 codes. **(4)**
   c) Write short note on non-destructive examinations employed in fabrication of piping systems. **(4)**
   d) List the contents of a valve data sheet. Which specification is commonly used as guideline to prepare valve data sheet? **(4)**
   e) Describe inputs required by and output produced by a typical piping design software. Mention few salient features of such software with examples. **(4)**

2. a) List typical piping system components and mention commonly used material specifications for these components. **(5)**
   b) A 500 NB pipe has internal design pressure of 2.8 MPa and design temperature of 520°C. The pipe material is seamless carbon steel pipe with allowable stress of 16 MPa. Corrosion allowance is 1.0 mm. Factor W = 1.0 for T< 510°C and W = 0.5 for T>815°C. Calculate required schedule of the pipe. **(5)**
   c) Classify different types of valve by their function. Describe construction and major components of *any two* of the following valves with sketch: ball valve, diaphragm valve, check valve. **(10)**

3. a) Explain significance of following rules/regulations in design of piping systems: IBR, Indian Explosives Act, Indian Factories Act and NFPA rules. **(8)**
   b) Find minimum schedule of 500 NB long radius elbow for internal pressure of 1.5 MPa and design temperature of 525°C. The pipe material is seamless carbon steel pipe with allowable stress of 15 MPa. Corrosion allowance is 1.0 mm. Factor W = 1.0 for T< 510°C and W = 0.5 for T>815°C. **(7)**
   c) Describe different types of piping supports. Indicate guidelines followed by piping engineer to locate the piping supports. **(5)**

M.E. (Thermal Engineering) Sem II

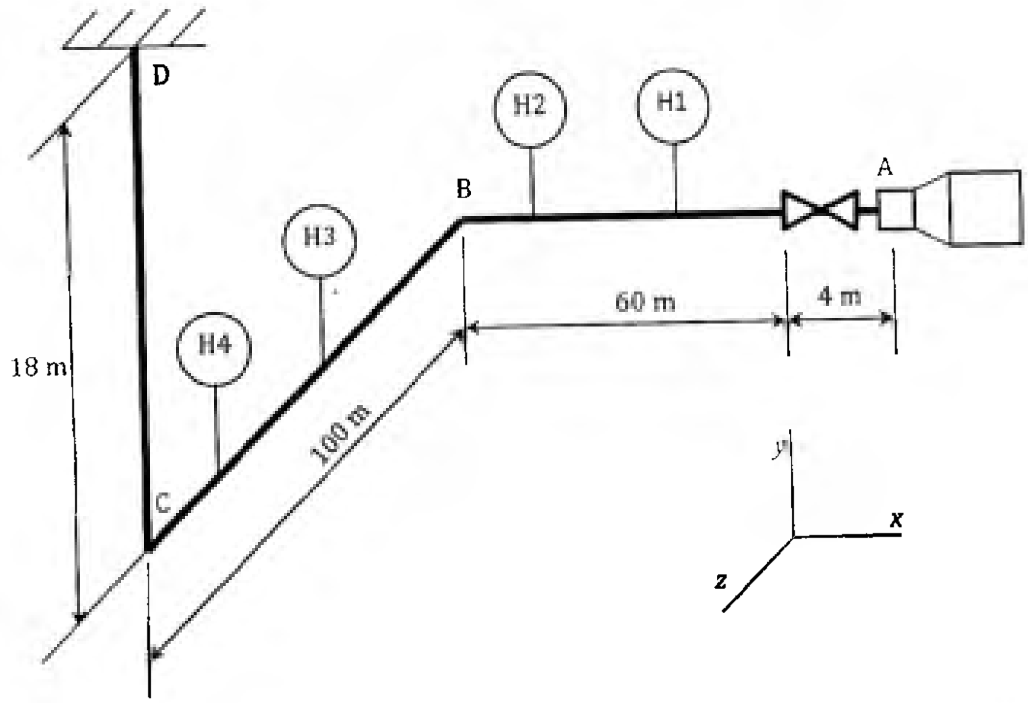
Piping Engineering.

Dt. 08/5/15

4. a) A 550 NB sch XS pipe is intersected perpendicularly by 500 NB sch 40 pipe. Required pressure thickness (corroded) of header and branch pipes are t_h = 10.5 mm and t_b = 9.35 mm respectively. Corrosion allowance is 1 mm. Calculate size of reinforcing pad. (5)

b) Figure shows pipeline ABCD connecting two process equipment. Design data is as follows. (8)

- Pipe size: 500 NB sch STD; Pipe material: SA106 Gr B; Elbows: LR type
- Allowable stress (cold/hot) = 137.9/131.7 MPa; Modulus of elasticity = 203,000 MPa, Corrosion allowance = nil
- Thermal expansion at operating temperature = 2.875 mm/m
- Suggested maximum span between supports = 45 m
- Displacement at point A in x,y,z directions = +10, -10, -10 mm
- Displacement at point D in x,y,z directions = 0, 0, 0 mm



(i) Select suitable locations for supports H1, H2, H3 and H4.

(ii) If reaction and corrected y-displacement at support H2 are 30,000 N and -30 mm (i.e., downwards) respectively, select variable spring hanger from spring catalogue (refer Annexure 1).

c) Explain with a sketch of typical P&ID, the standard piping arrangement around a centrifugal compressor. (7)

5. a) Explain different fabrication activities involved in manufacturing of piping system. (5)

b) A 150 NB sch 40 pipeline (168.3 mm OD, 7.1 mm wall thickness) has equivalent length of 300 m for the purpose of pressure drop calculations. The pipe inside surface has surface roughness of 0.05 mm. The fluid flowing through pipeline has density of 975 kg/m^3, viscosity of 1.5 cP and mass flow rate of 120,000 kg/hr. Calculate the pressure drop inside the pipeline. (8)

c) Following figure shows part of P&ID for a process plant. Sketch the diagram and describe function/type of instrument/valve symbols, nature of connection lines, interpretation of pipeline tag and other relevant information. (7)

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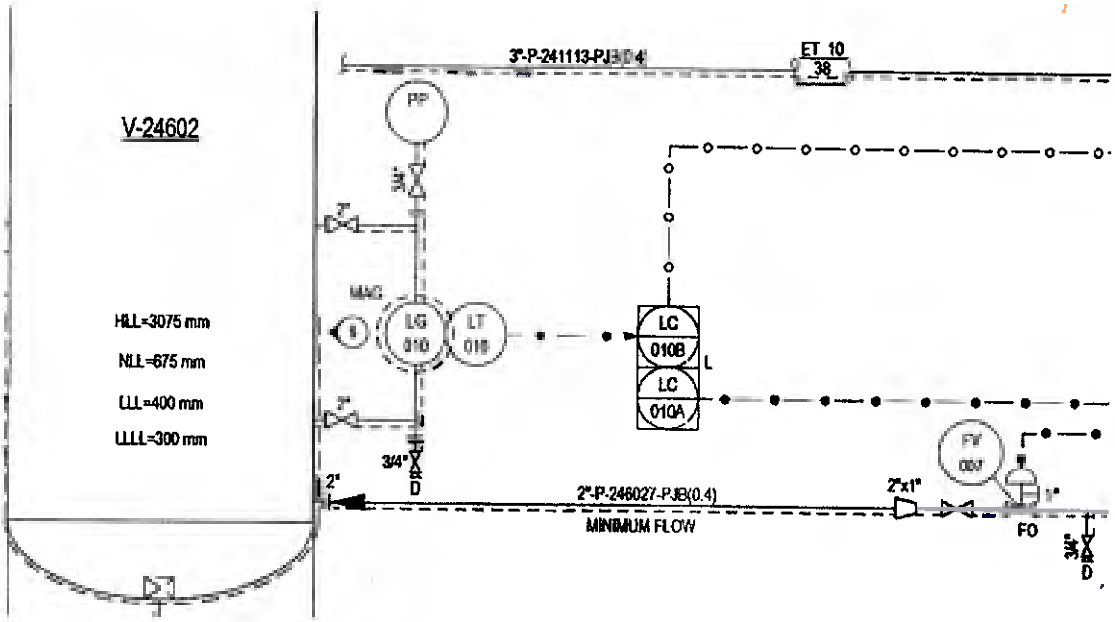
Piping Engineering.

Dt. 08/5/15



6. a) Write a short note on preparation of Plot Plan and Equipment Layout for a piping system. **(5)**

   b) For piping system described in question 4(b), check the need for performing flexibility analysis. Consider cyclic loading factor $f = 1.0$, factor $K_1 = 208300 S_A/E_a$. **(7)**

   c) Explain with a sketch of typical P&ID, the standard piping arrangement around (i) a pressure relief valve and (ii) a heat exchanger. **(8)**

7. a) Explain procedure for design of a straight pipe subjected to external pressure with necessary equations. **(5)**

   b) Describe various types of steam traps employed in piping systems. Compare their relative merits. **(7)**

   c) Explain with neat sketch, construction and working of constant spring hanger. Give step by step procedure to select a constant spring hanger from the manufacturer's catalogue. **(8)**

Annexure 1

Pipe Schedule

NPS inches	N.D.	O.D. mm	10	20	30	STD	40	60	XS	80	100	120	140	160
20	500	508	6.35	9.53	12.70	9.52	15.08	20.62	12.7	26.19	32.54	38.1	44.45	50.01
22	550	558.8	6.35	9.53	12.70	9.52	15.87	22.22	12.7	28.57	34.92	41.27	47.62	53.97
24	600	609.6	6.35	9.53	12.70	9.52	17.47	24.61	12.7	30.96	38.89	46.02	52.37	59.54

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Factor Y

	Temperature, °C (°F)					
Materials	≤ 482 (900 & Lower)	510 (950)	538 (1000)	566 (1050)	593 (1100)	≥ 621 (1150 & Up)
Ferritic steels	0.4	0.5	0.7	0.7	0.7	0.7
Austenitic steels	0.4	0.4	0.4	0.4	0.5	0.7

Variable Spring Hanger Catalogue

Series			Hanger size						
VS3	VS2	VS1	11	12	13	14	15	16	17
Travel in mm			Load Capacity in Kgs.						
4	2	1	546	672	890	1297	1565	1728	2466
0	0	0	558	688	913	1331	1610	1796	2553
8	4	2	580	720	958	1398	1700	1932	2726
16	8	4	603	752	1003	1466	1790	2068	2899
24	12	6	625	783	1048	1534	1880	2204	3073
32	16	8	648	815	1093	1602	1970	2340	3246
40	20	10	671	847	1138	1670	2060	2476	3419
48	24	12	693	878	1183	1737	2150	2612	3592
56	28	14	716	910	1228	1805	2240	2748	3765
64	32	16	738	942	1273	1873	2330	2884	3939
72	36	18	761	974	1318	1941	2420	3020	4112
80	40	20	784	1005	1363	2009	2510	3156	4285
88	44	22	806	1037	1408	2076	2600	3292	4458
96	48	24	829	1069	1453	2144	2690	3428	4631
104	52	26	851	1100	1498	2212	2780	3564	4805
112	56	28	874	1132	1543	2280	2870	3700	4978
120	60	30	897	1164	1588	2348	2960	3836	5151
128	64	32	919	1195	1633	2415	3050	3972	5324
136	68	34	942	1227	1678	2483	3140	4108	5497
140	70	35	953	1243	1700	2517	3185	4176	5584
4	2	1	964	1259	1723	2551	3230	4244	5671
12	6	3	987	1291	1768	2619	3320	4380	5844
20	10	5	1010	1322	1813	2687	3410	4516	6017

Pressure Drop Calculations

$f_D = 0.3164 R_e^{-0.25}$

Colebrook White equation: $\frac{1}{\sqrt{f_D}} = -2\log_{10}\left(\frac{e}{3.7D} + \frac{2.51}{R_e\sqrt{f_D}}\right)$

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