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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program:	**M.Tech. Pipeline Engineering**	**Semester – 1**	
Subject (Course):	**Petroleum Transport System &Operations-1**	**Max. Marks**	**: 100**
Course Code :	**CHPL7004**	**Duration**	**: 3 Hrs.**
No. of page/s: 6			

Note: ***Assume Suitable and necessary data if required and Justify***

SECTION-A

4 *5 = 20 Marks

Answer ***all*** the questions

1. Difference between the terms '*line fill volume*' and '*line pack volume*'.
2. Explain the terms '*Adiabatic efficie*ncy' and '*Hydraulic Balance*' in Compressors.
3. Illustrate the advantages of pipeline transportation over other transportation modes.
4. Explain the variation in water performance curves while transporting crude oil.

SECTION B

Answer ***all*** the questions

5. Mention the reason for two phase formation in pipelines. Explain with figures the various type of flow patterns in the two phases. **10 MARKS**
6. Calculate the compressor horsepower required for an adiabatic compression of 106 MMSCFD gas with inlet temperature of 68°F and 725 psia pressures. The discharge pressure is 1305 psia. Assume the compressibility factors at suction and discharge conditions to be $Z_1 = 1.0$ and $Z_2 = 0.85$, respectively, and the adiabatic exponent = 1.4, with the adiabatic efficiency = 0.8. If the mechanical efficiency of the compressor driver is 0.95, what BHP is required? Also, calculate the outlet temperature of the gas.

15 MARKS

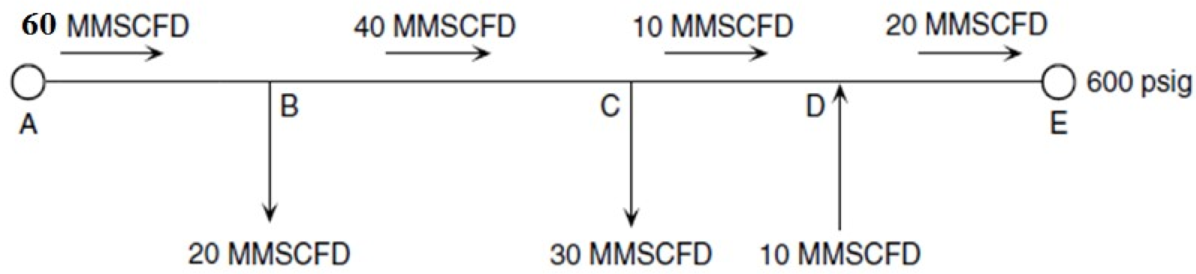
7. Calculate the pressure drop per mile in an NPS 16 pipeline, 0.250 inch. wall thickness flowing crude oil (S.G = 0.895 and Viscosity = 15 cSt) at 100,000 bbl/day. Assume pipe absolute roughness = 0.002 in. Compare the results using the Colebrook-White, Miller and MIT equations. **15 MARKS**

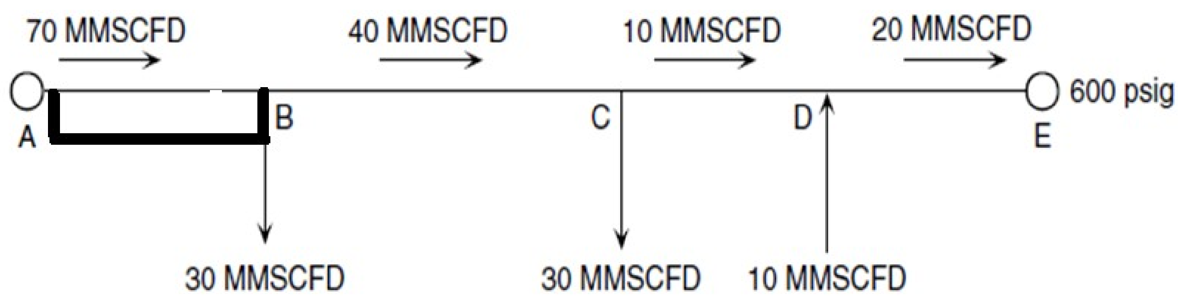
SECTION C

Solve any TWO Question **2*20 = 40MARKS**

8) A natural gas pipeline, 140 miles long from Dover to Leeds, is constructed of NPS 16, 0.250 in. wall thickness pipe, with an MOP of 1200 psig. The gas specific gravity and viscosity are 0.6 and 8×10^{-6} lb/ft-s, respectively. The pipe roughness can be assumed to be 700μin. and the base pressure and base temperature are 14.7 psia and 60°F, respectively. The gas flow rate is 175 MMSCFD at 80°F, and the delivery pressure required at Leeds is 800 psig. **a)** Calculate the pressure required at inlet to deliver the gas at Leeds? **b)** Can the gas be delivered at the calculated inlet pressure from Dover? If not, mention the reasons. **c)** Assuming if only one intermediate compressor is installed at mid-point of the pipeline at Kent, will it be able to deliver the gas at Leeds at the required delivery pressure. Mention reasons. **d)** If not calculate the exact location of compressor. Also for this location, calculate the suction pressure and compression ratio at Kent. Assume Z= 0.85

9. In a gas distribution pipeline, 60 MMSCFD enters the pipeline at A, as shown in Figure. If the delivery at B is increased from 20 MMSCFD to 30 MMSCFD by increasing the inlet flow at A, keeping all downstream flow rates the same, calculate the looping necessary if entire length AB is looped to ensure pressures are not changed throughout the pipeline. Pipe AB is NPS 14, 0.250 in. wall thickness; BC is NPS 12, 0.250 in. wall thickness; CD is NPS 10, 0.250 in. wall thickness; and DE is NPS 12, 0.250 in. wall thickness. The delivery pressure at E is fixed at 600 psig. The pipe lengths are as follow: AB=12 miles; BC=18 miles; CD=20 miles; DE =8 miles. The gas gravity is 0.60, and the flow temperature is 60°F. The compressibility factor and transmission factor can be assumed 0.85 and 20, respectively, throughout the pipeline. The base pressure and base temperature are 14.7 psia and 60°F, respectively. Also, calculate the loop length if a particular length of AB is looped with a diameter of 10 NPS and 0.25-inch wall thickness.





10. A crude oil pipeline 150 miles long from Beaumont pump station to a tank farm at Glendale is used to transport Alaskan North Slope crude oil (ANS crude). The pipe is 20 in. in outside diameter and constructed of X-52(52000 psi) steel. It is desired to operate the system at ANSI 600 pressure level (1440 psi). The pipeline profile is such that there are two peaks located between Beaumont and Glendale. The first peak occurs at milepost 65.0 at an elevation of 1500 ft. The second peak is located at milepost 110.0 at an elevation of 2500 ft. Beaumont has an elevation of 350 ft and Glendale is situated at an elevation of 650 ft. During the initial phase of operation, 6000 bbl/hr of ANS crude will be pumped at a temperature of 60°F and delivered to Glendale tankage at a pressure of 30 psi. The specific gravity and viscosity of ANS crude at 60°F may be assumed to be 0.895 and 43 cSt respectively. **(a)** Determine the minimum wall thickness required to operate the pipeline system at a pressure of 1400 psi. **(b)** At a flow rate of 6000 bbl/hr, how many pump stations would be required? **(c)** During the second phase it is planned to expand the capacity of pipeline to 9000 bbl/hr. How many additional pump stations would be required? **(d)** Assuming 80% pump efficiency; calculate the total pumping HP required during the initial phase and under the expansion scenario. Use a minimum suction pressure of 50 psi at each pump station.

APPENDIX

(All Notations have the Usual Standard Meaning)

1. CNGA Equation:

$$z = \frac{1}{\left[1 + \frac{\left(P_{av} \times 344,400 \times 10^{1.785G}\right)}{T_f^{\,3.825}}\right]}$$

2. Colebrook – White Equation(a) and Modified Colebrook White Eqn.(b)

(a) $$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{e}{3.7D} + \frac{2.51}{\mathrm{Re}\sqrt{f}}\right)$$ (b) $$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{e}{3.7D} + \frac{2.825}{\mathrm{Re}\sqrt{f}}\right)$$

3. Coversion Equations for SSU to Centistokes

i) $$Centistokes = 0.226(SSU) - \frac{195}{SSU} \qquad SSU \leq 100$$

ii) $$Centistokes == 0.220(SSU) - \frac{135}{SSU} \qquad SSU \succ 100$$

4. Miller Equation

$$Q = 4.06(M)\left(\frac{D^5 \times P_m}{S_g}\right)^{0.5} \quad , \ M = \log_{10}\left(\frac{D^3 \times S_g \times P_m}{c_p^2}\right) + 4.35$$

Q=Flow rate, bbl/day; D=Pipe internal diameter, in. ; Cp=Liquid viscosity, centipoise

Pm=Frictional pressure drop, psi/mile; Sg=Liquid specific gravity

5. **Shell MIT Equations**

$$R = 92.25\left(\frac{Q}{\nu D}\right);\ R_m = \frac{R}{7742}$$

$$f = \frac{0.00207}{R_m}\ \text{(Laminar flow)}; \qquad f = 0.0018 + 0.006621\left(\frac{1}{R_m}\right)^{0.335}\ \text{(Turbulent flow)}$$

$$P_m = 0.241\left(\frac{f \times S_g \times Q^2}{D^5}\right)$$

Where, R=Reynolds number, dimensionless; Rm=Modified Reynolds number, dimensionless

Q=Flow rate, bbl/day; D=Pipe internal diameter, in.; ν=Kinematic viscosity, cSt; Pm=Frictional pressure drop, psi/mile; f=Friction factor, dimensionless; S_g=Liquid specific gravity; Q=Flow rate, bbl/day; D=Pipe internal diameter, in.

6. **AGA Equations**

For the fully turbulent zone, $F = 4\log_{10}\left(\frac{3.7D}{e}\right)$

For the partially turbulent zone, $F = 4D_f \log_{10}\left(\frac{\text{Re}}{1.4125F_t}\right)$ $F_t = 4\log_{10}\left(\frac{\text{Re}}{F_t}\right) - 0.6$

7. **Equivalent Diameter**

$$De = D_1\left[\frac{1+K}{K}\right]^{2/5}, \quad K = \sqrt{\left(\frac{D_1}{D_2}\right)^5\left(\frac{L_2}{L_1}\right)}$$

8. **Reynolds Number for Gases:**

$$a)\ SI: \text{Re} = 0.5134\left(\frac{P_b}{T_b}\right)\left(\frac{GQ}{\mu D}\right) \quad b)\ USCS: \text{Re} = 0.0004778\left(\frac{P_b}{T_b}\right)\left(\frac{GQ}{\mu D}\right)$$

9. Reynolds No. for Crude Oil Pipelines

a) **R=92.24 Q/(ν D)** Where: Q=Flow rate, bbl/day; D=Internal diameter, in. ; ν=Kinematic viscosity, cSt

b) **R=353,678 Q/(νD)**

Where: Q=Flow rate, m^3/hr.; D=Internal diameter, mm; ν= Kinematic viscosity, cSt

10. Pressure Drop per unit length for oil pipelines (USCS)

$$P_m = 0.0605\left(fQ^2\right)\left(\frac{S_g}{D^5}\right)$$

Pm= pressure drop due to friction (psi/mile); Q= Liquid flow rate (bbl./day) D=Pipe internal diameter, in.

11. Horsepower required to compress gas in compressor

$$HP = 0.0857QT_1\left(\frac{\gamma}{\gamma-1}\right)\left(\frac{Z_1+Z_2}{2}\right)\left(\frac{1}{\eta_a}\right)\left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma}{\gamma-1}}-1\right]$$

12. Adiabatic Efficienecy of Compressor

$$\eta_a = \left(\frac{T_1}{T_2-T_1}\right)\left[\left(\frac{z_1}{z_2}\right)\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}-1\right]$$

13. BHP required to pump the liquid

$$BHP = \frac{QP}{2449E}$$

Q=flow rate (bbl./hr.); **P**=Differentia pressure (psi)