UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

SECOND SEMESTER EXAMINATIONS, MAY 2018

COURSE NO: PE 380

COURSE NAME: PETROLEUM PRODUCTION ENGINEERING

CLASS: PE 2015 TIME: THREE (3) HOURS

Name**:** ____ Index Number: ________________

ANSWER ANY THREE (3) QUESTIONS

Q1. A. A productivity test was conducted on a well. The test results show that the well is capable of producing at a stabilised flow rate of 109 STB/day and a bottom-hole flowing pressure of 800 psi. After shutting the well for 24 hours, the bottom-hole pressure reached a static value of 1200 psia. Calculate the:

i. Productivity Index (PI).
ii. Absolute Open Flow (AOF).
iii. Oil flow rate at a bottom-hole flowing pressure of 500 psia.
iv. Wellbore flowing pressure required to produce 280 STB/day. **[8 MARKS]**

B. A well is producing from a saturated reservoir with an average reservoir pressure of 5500 psia. If the bubble point pressure is given as 3500 psia.

i. Calculate the Productivity Index PI.
ii. Find the production flow rate at the bubble point pressure.
iii. Construct the IPR curve (use pressure interval of 500 psia) by using the generalised Vogel's approach.

Additional data can be found in the Table below:

Parameter	**Value**
Porosity	0.19
Effective horizontal permeability	8.2 md
Pay zone thickness	53 ft
Fluid formation volume factor	1.1
Fluid viscosity	1.7 cp
Total compressibility	0.0000129 psi^{-1}
Drainage radius	2980 ft
Wellbore radius	0.328 ft
Skin factor	0

[17 MARKS]

Q2.A. Suppose that 1,200 bbl/day of 38 °API from the Jubilee Field, having a viscosity of 1.2 cp is being produced through 3⅞-in., 8:6-lbm/ft tubing in a well that is 12 degrees from vertical. If the tubing wall relative roughness is 0.001, and the length of the tubing is given as 1,500 ft. Calculate the following:

i. Pressure drop due to friction over the tubing length
ii. Pressure drop due to changes in elevation over the tubing length
iii. Pressure drop due to kinetic energy over the tubing length
iv. Total pressure drop over the tubing length

[17 MARKS]

B. Briefly explain the following terms as applied to gas-oil two-phase flow:

i. Slug flow
ii. Churn flow
iii. Bubble flow
iv. Annular flow

[8 MARKS]

Q3. A Natural gas produced from the TEN Fields in Ghana having a specific gravity of 0.75 flows from a 2-in. pipe through a 1.5-in. nozzle-type choke. The upstream pressure and temperature are given as 110 psia and 65 °F respectively. The downstream pressure is 85 psia (measured 2 ft from the nozzle). The gas-specific heat ratio is 1.25. The gas viscosity according to Carr-Kobayashi-Burrows correlation is given as 0.0107 cp.

i. What is the expected daily flow rate?
ii. Is icing a potential operational problem?
iii. What is the expected pressure at the nozzle outlet?

[10 MARKS]

B. Given the following data:

Parameter	**Value**
Downstream pressure	350 psia
Choke size	32 1⁄64 in.
Flowline ID	2 in.
Gas production rate	4,000 Mscf/d
Gas-specific gravity	0.70 1 for air
Gas-specific heat ratio	1.25
Upstream temperature	100 °F
Choke discharge coefficient	0.95

Estimate the upstream gas pressure at the choke.

[15 MARKS]

Q4. A. Explain the following API codes as applied to sucker rod pumping unit geometry dimensions:

i. C - 320D - 213 - 86
ii. M - 640D - 200 - 74
iii. B - 160D - 200 - 144

[6 MARKS]

B. Explain the principle of the pumping cycle for the Sucker Rod's plunger motion using appropriate diagrams. **[7 MARKS]**

C. An oil field has 16 oil wells to be gas lifted. The gas lift gas at the central compressor station is first pumped to two injection manifolds with 4-in. ID, 1-mile lines and then is distributed to the wellheads with 4-in. ID, 0.2-mile lines. Given the following data, calculate the required output pressure of compression station:

Gas-specific gravity	0.65
Valve depth (D_v)	5,000 ft
Maximum tubing pressure at valve depth (p_t)	500 psia
Required lift gas injection rate per well	2 MMscf/day
Pressure safety factor (S_f)	1.1
Base temperature (T_b)	60 ºF
Base pressure (p_b)	14.7 psia

[8 MARKS]

D. Compare the field applications of Gas lift and Sucker Rod Pumping systems in the Petroleum Industry.

[4 MARKS]

Note: The following maybe helpful**:**

For Inflow Performance:

$$\Delta q = q_v\left[1 - 0.2\left(\frac{p_{wf}}{p_b}\right) - 0.8\left(\frac{p_{wf}}{p_b}\right)^2\right]$$

$$q = q_b + q_v\left[1 - 0.2\left(\frac{p_{wf}}{p_b}\right) - 0.8\left(\frac{p_{wf}}{p_b}\right)^2\right]$$

$$q_v = \frac{J^* p_b}{1.8}$$

$$J = \frac{q}{(p_e - p_{wf})}$$

$$q_b = J^*(\bar{p} - p_b)$$

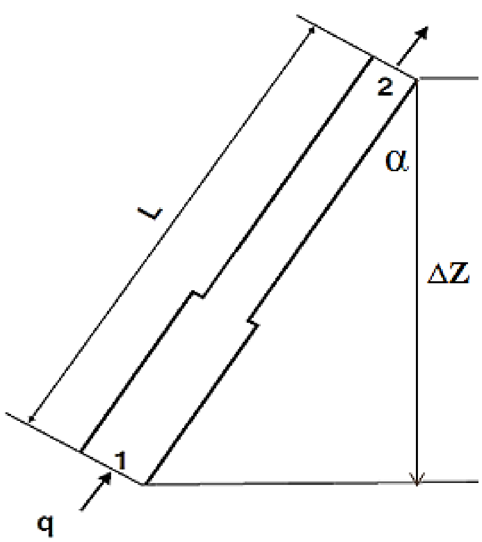
$$q = J^*(\bar{p} - p_b) + \frac{J^* p_b}{1.8} \times \left[1 - 0.2\left(\frac{p_{wf}}{p_b}\right) - 0.8\left(\frac{p_{wf}}{p_b}\right)^2\right]$$

$$J^* = \frac{kh}{141.2B\mu\left(\ln\frac{r_e}{r_w} - \frac{3}{4} + S\right)}$$

$$q = q_{\max}\left[1 - 0.2\left(\frac{p_{wf}}{\bar{p}}\right) - 0.8\left(\frac{p_{wf}}{\bar{p}}\right)^2\right]$$

$$J^* = \frac{kh}{141.2B\mu\left(\ln\frac{r_e}{r_w} + S\right)}$$

***For Multiphase Flow in Oil Wells*:**
Internal Diameter: ID = OD – 0.616



$$\gamma_o = \frac{141.5}{{}^\circ API + 131.5}$$

$$\rho = 62.4\gamma_o$$

$$\Delta P = P_1 - P_2 = \frac{g}{g_c}\rho\Delta z + \frac{\rho}{2g_c}\Delta u^2 + \frac{2f_F\rho u^2 L}{g_c D}$$

$$N_{Re} = \frac{1.48 q\rho}{d\mu}$$

$$\frac{1}{\sqrt{f_F}} = -4 \times \log\left\{\frac{\varepsilon}{3.7065} - \frac{5.0452}{N_{Re}}\log\left[\frac{\varepsilon^{1.1098}}{2.8257} + \left(\frac{7.149}{N_{Re}}\right)^{0.8981}\right]\right\}$$

$$u = \frac{4q}{\pi D^2}$$

For Choke Performance:

$$T_{dn} = T_{up} \frac{z_{up}}{z_{outlet}} \left(\frac{p_{outlet}}{p_{up}} \right)^{\frac{k-1}{k}}$$

$$N_{\mathrm{Re}} = \frac{20 q_{sc} \gamma_g}{\mu d_2}$$

$$\left(\frac{p_{outlet}}{p_{up}} \right)_c = \left(\frac{2}{k+1} \right)^{\frac{k}{k-1}}$$

$$Q_{sc} = 879 C_D A p_{up} \sqrt{\left(\frac{k}{\gamma_g T_{up}} \right) \left(\frac{2}{k+1} \right)^{\frac{k+1}{k-1}}}$$

$$q_{sc} = 1{,}248 C_D A_2 p_{up} \times \sqrt{\frac{k}{(k-1)\gamma_g T_{up}} \left[\left(\frac{p_{dn}}{p_{up}} \right)^{\frac{2}{k}} - \left(\frac{p_{dn}}{p_{up}} \right)^{\frac{k+1}{k}} \right]}$$

$$v = \sqrt{v_{up}^2 + 2 g_c C_p T_{up} \left[1 - \frac{z_{up}}{z_{outlet}} \left(\frac{2}{k+1} \right) \right]}$$

***For Artificial Lift*:**

$$\mathrm{PRL_{max}} = S_f (62.4) D (\frac{A_p - A_r)}{144} + \frac{\gamma_s D A_r}{144} + \frac{\gamma_s D A_r}{144} \left(\frac{S N^2 M}{70{,}471.2} \right),$$

$$p_L = \sqrt{p_{up}^2 + \left(\frac{q_{gM} p_b}{0.433 T_b} \right)^2 \frac{\gamma_g \bar{T} \bar{z} L_g}{D^{16/3}}}$$

$$p_{c,s} = \frac{p_{c,v}}{1 + \frac{D_v}{40{,}000}}$$

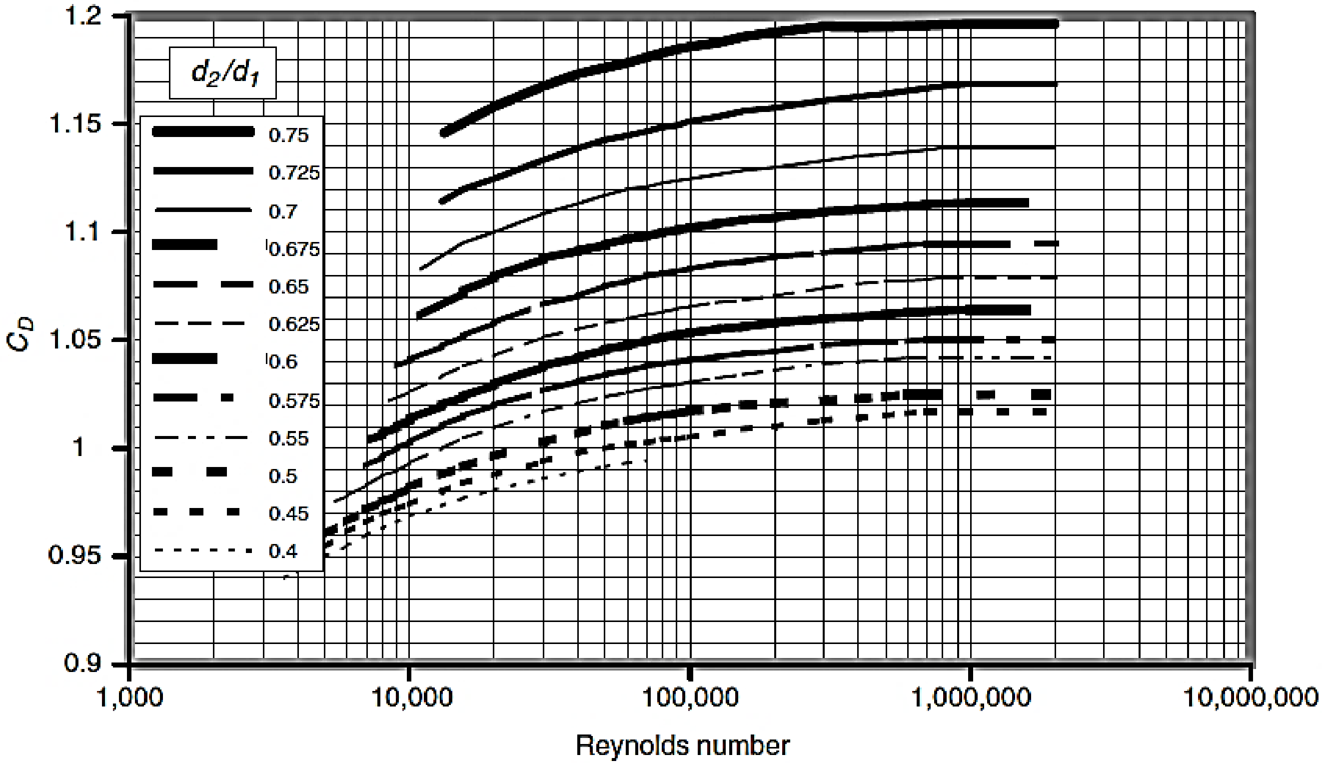


Figure 1 Choke flow coefficient for nozzle-type chokes

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