$\frac{ft^3}{day} \times 0.002 = 1000$

$\frac{ft^3}{day} = \frac{1000}{0.002} = 500,000$ [flowrate of gas]

* Since Z was not given, we use d Z-factor chart

$\frac{T}{T_{pc}} = \frac{580}{395} = 1.47$, $\frac{P}{P_{pc}} = \frac{1000}{667} - 1.5$

From d chart.

$Z = 0.85$

There fore:

$$U_{sg} = \frac{4}{\pi \times (\frac{2}{12})^2 ft^2} \times \left(\frac{500,000 \times 0.850}{86400}\right)\left(\frac{580}{520}\right)\left(\frac{14.7}{1000}\right)$$

$$U_{sg} = \frac{4}{0.087} \frac{4}{0.08726} \times \left(\frac{425000}{86400}\right)\left(\frac{580}{520}\right)\left(\frac{14.7}{1000}\right)$$

$$U_{sg} = \frac{14,494,200.000}{3,920,417,280} = 3.697 ft/sec$$

$U_m = U_{sL} + U_{sg} - 1.48 + 3.69 = 5.17 ft/sec$

$

Step 3 - To get the baker flow regime.

To calc density of oil & gas, given that

$\gamma_o (S.G) = 32°API$

$\gamma_g (S.G) = 0.71$

for oil —— *

$API = \frac{141.5}{S.g} - 131.5$

$32 = \frac{141.5}{S.g} - 131.5$

$163.5 \times S.g = 141.5$

$$S.g = \frac{141.5}{163.5} = 0.865$$

Therefore $\rho_l = 0.865 \times 62.4 = 53.96\,lbm/ft^3$

For Gas ---(*)

Use the formula given $\gamma_g = 0.71$

$$\rho_g = \frac{2.7 \times \gamma_g \times P}{Z \times T} = \frac{2.7 \times 0.71 \times 1000}{0.85 \times 580}$$

$$\rho_g = 3.88\,lbm/ft^3$$

To get $G_l$ and $G_g$

$G_l = U_{sl}\rho_l$ --- (*)

$G_g = U_{sg}\rho_g$ --- (*)

$$G_l = \left(1.68\,\frac{ft}{s}\right)\left(53.96\,\frac{lbm}{ft^3}\right)\left(3600\,\frac{sec}{hr}\right)$$

$$G_l = 287498.88\,lbm/hr \cdot ft^2$$

$$G_g = \left(3.64\,\frac{ft}{s}\right)\left(3.88\,\frac{lbm}{ft^3}\right)\left(3600\,\frac{sec}{hr}\right)$$

$$G_g = 51{,}541.92\,lbm/hr \cdot ft^2$$

To get $\lambda$ & $\phi$

$$\lambda = \left[\left(\frac{\rho_g}{0.075}\right)\left(\frac{\rho_l}{62.4}\right)\right]^{\frac{1}{2}} \quad ---(*)$$

$$\phi = \frac{73}{\sigma}\left[\mu_l\left(\frac{62.4}{\rho_l}\right)^2\right]^{\frac{1}{3}} \quad ---(*)$$

$$\lambda = \left[\left(\frac{3.88}{0.075}\right)\left(\frac{53.96}{62.4}\right)\right]^{\frac{1}{2}}$$

$$\lambda = \sqrt{(44.7360)} = 6.688$$

$$\phi = \frac{73}{20}\left[67.2\left(\frac{62.4}{53.96}\right)^2\right]^{\frac{1}{3}}$$

$$\phi = \frac{73}{20}(2.67457)^{\frac{1}{3}} = 5.1$$

* The coordinates for the baker map are

$$\frac{G_g}{\lambda} = \frac{51541.92}{6.688} = 7706.63$$

$$\frac{G_L \lambda \theta}{G_g} = \frac{287498.88 \times 6.688 \times 5.1}{51541.92} = 190.28$$

* Reading from the baker map the flow regime is predicted to be slug flow

* Reading from the mandhane map using $U_{SL} = 1.48\,ft/s$, $U_{sg} = 3.67\,ft/sec$ is predicted to be slug flow

* Reading from the beggs & brill map using the formular

$$N_{FR} = \frac{U_m^2}{gD}, \quad \lambda_L = \frac{U_{SL}}{U_m}$$

$$N_{FR} = \frac{(5.176)^2}{32.17 \times \left(\frac{2}{12}\right)}$$

where g is constant 32.17

$$N_{FR} = \frac{26.79076}{5.3616} = 4.99$$

$$\lambda_L = \frac{U_{SL}}{U_m} = \frac{1.48}{5.176} = 0.286$$

Beggs & Brills map is predicted to be intermittent

Question Two (2)

data

$q_o = 4000\,bbl/day$ — Temp $= 150°F + 460 = 610°R$

$q_g = ?$ — Pressure $= 200\,psia$

$D = 3\,inches$ — $GOR = 500\,scf/bbl$

$\sigma = 20\,dynes/cm$

Step 1: Calc d Area

Using $A = \frac{\pi d^2}{4} = \frac{\pi \times \left(\frac{3}{12}\right)^2}{4} = 0.049\,ft^2$

Step 2: Calc $U_{SL}$, $U_{sg}$, $U_m$

$$U_{SL} = \frac{q_L}{A} = \frac{\frac{4000 \times 5.614\,ft^3}{86400\,sec}}{0.049} = 5.30\,ft/sec$$

$U_{sg} = \frac{q_g}{A} = \frac{4}{\pi d^2}[qz]\left[\frac{T}{T_{sc}}\right]\left[\frac{P_{sc}}{P}\right]$

to calc d gas flowrate

GOR = 500 scf/bbl

$$\frac{\frac{ft^3}{day}}{\frac{bbl}{day}} = 500$$

$$\frac{ft^3}{day} \times \frac{1}{\frac{bbl}{day}} = 500$$

$$\frac{ft^3}{day} \times \frac{1}{4000} = 500$$

$$\frac{ft^3}{day} \times 0.00025 = 500$$

$$\frac{ft^3}{day} = \frac{500}{0.00025} = 2000000$$

~~to~~

to get z-factor

$$\frac{T}{T_{pc}} = \frac{610}{395} = 1.54 \quad \frac{P}{P_{sc}} = \frac{200}{667} = 0.30$$

From the chart $z = 0.96$

$$U_{sg} = \frac{4}{\pi d^2}[q_g z]\left[\frac{T}{T_{sc}}\right]\left[\frac{P_{sc}}{P}\right]$$

$$U_{sg} = \frac{4}{\pi \times (\frac{3}{12})^2} \times \left[\frac{2\times10^6 \times 0.96}{86400}\right]\left[\frac{610}{520}\right]\left[\frac{14.7}{200}\right]$$

$$U_{sg} = \frac{68,806,560,000}{1,706,318,634 \cdot 25603} = 39.038\ ft/sec$$

$U_m = U_{sg} + U_{sl} = 39.03 + 5.30 = 44.33\ ft/sec$

To get Beggs & brill reading, use d formula

$$N_{Fr} = \frac{U^2_m}{gD}, \quad \lambda_l = \frac{U_{sl}}{U_m}$$

$$N_{Fr} = \frac{(44.33)^2}{32.17 \times (\frac{3}{12})} = \frac{1915.689}{8.0425} = 244.35\ ft/sec$$

$$\lambda_l = \frac{U_{sl}}{U_m} = \frac{5.30}{44.33} = 0.12$$

∴ The Reading is

Step 3 - Calc d holdup for horizontal flow. Using this formula

Recall that:

$L_1 = 316 \lambda_l^{0.302}$

$L_2 = 0.0009252 \lambda_l^{-2.4684}$

$L_3 = 0.10 \lambda_l^{-1.4516}$

$L_4 = 0.5 \lambda_l^{-6.738}$

$L_1 = 316(0.2)^{0.302} = 166.57$

$L_2 = 0.0009252 \times (0.12)^{-2.4684} = 0.17345$

$L_3 = 0.10 \times (0.12)^{-1.4516} = 2.171$

$L_4 = 0.5 \times (0.2)^{-6.738} = 6800,657.68$

The flow regime ~~transition~~ transition is a distributed flow because

$L_4 < 0.4$ and $N_{FR} \geq L_4$

So therefore, from the holdup constants table

$a = 1.065 \quad b = 0.5824 \quad c = 0.0609$

$$Y_{LR} = \frac{a \lambda_l^{b}}{N_{FR}^{c}} = \frac{1.065 \times (0.12)^{0.5824}}{(244.34)^{0.0609}}$$

$$Y_{LR} = \frac{0.30978812}{1.39775} = 0.22163$$

Step 4 - calc d no-slip friction factor based on the mixture $N_{Re}$

$\rho_m = \rho_l \lambda_l + \rho_g \lambda_g$

$$\lambda_l = 0.12, \quad \lambda_g = \frac{u_{sg}}{u_m} = \frac{39.033}{44.33} = 0.8805$$

$\rho_l = 53.98 \, lbm/ft^3$

$$\rho_g = \frac{2.7 \times \gamma_g \times P}{z \times T} = \frac{2.7 \times 0.71 \times 200}{0.96 \times 610}$$

$\rho_g = 0.654 \, lbm/ft^3$

$\rho_m = 53.96 \times 0.12 + 0.654 \times 0.8805$

$\rho_m = 6.475 + 0.5758 = 7.0508 \, lbm/ft^3$

Question one (theory)

x Horizontal multiphase flow regimes

multiphase flow in horizontal pipes differs from that of vertical pipes. Due to d P.E constant in horizontal flow, the flow regime has no significant effect and pressure drop in horizontal flow. However certain correlations consider flow regime.

Flow regime can be classified into

- Segregated flow
- Intermittent flow
- Distributed flow

*Segregated is further divided into

- Stratified smooth
- Stratified wavy

* Intermittent f is divided into

slug

Distributed is divided into

· Bubble, mist, dispersed bubble flow.

Flow regimes are predicted

- by Baker (1958) modified to Scott (1963)

mandhane et al (1979)

- Beggs and brills correlation

(4.) Restricted flow refers to flow of fluid under a choke used to control flow due to many factors such as prevention of the causes of sand production. Fluid flowing through a restriction may be accelerated to reach some veloci in the thrust of choke. This is the critical condition. As downstream pressure of choke do affect d Q.

For single phase liquid flow through choke.

It is rare for this case, the flowing pressure is below bubble point

But in case it happens

flowrate is related to d pressure drop accross the choke by

$$q = CH\sqrt{\frac{2g_c D}{\rho}}$$

C = co-efficient of d choke

A = 8.5, $q = 22000\, C(D_2)^2 \sqrt{\frac{\Delta P}{\rho}}$

D in choke is diameter in inches

Omachi Victor Ojoajogwu
15/Eng07/037
Pte 516
Assignment

Question One

Given data

$q_o = 500 bbl/day$ Area = ?

$d = 2 inches$

$Temp = 120°F + 460 = 580°R$

Pressure = 1000 scf/bbl

Step 1: Calc Area

∴ using $A = \frac{\pi d^2}{4} = \frac{3.142 \times (\frac{2}{12})^2}{4} = 0.02182 ft^2$

Step 2 → Calc $U_{sl}$, $U_{sg}$, $U_m$

where ~~bcc~~ $U_{sl} = \frac{q_L}{A}$

$U_{sl} = \frac{\frac{500 \times 5.614 ft^3}{86400 sec}}{0.02182} = 1.48 ft/s$

$U_{sg} = \frac{q_g}{A} = \frac{4}{\pi d^2} [q_o \times z] [\frac{T}{T_{sc}}] \times [\frac{P_{sc}}{P}]$

To calc q of gas when GOR and flowrate of oil is given

$GOR = 1000 scf/bbl = \frac{ft^3}{bbl} = 1000$

$\frac{\frac{ft^3}{day}}{\frac{bbl}{day}} = 1000$

$\frac{ft^3}{day} \times \frac{day}{bbl} = 1000$

$\frac{ft^3}{day} \times \frac{1}{\frac{bbl}{day}} = 1000$

$\frac{ft^3}{day} \times \frac{1}{500} = 1000$