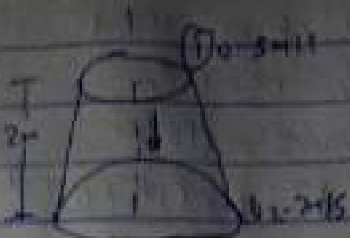
Afolabi - Anton
Petroleum - Engineering
16/ENG04/001
Petroleum ENG 284

1 $\frac{P_1}{\omega} = 2.5m$



$H_L = \frac{0.35(V_1 - V_2)^2}{2g}$

$\frac{P_1}{\omega} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\omega} + \frac{V_2^2}{2g} + Z_2 + H_L$

$\frac{P_2}{\omega} = \frac{P_1}{\omega} + \frac{V_1^2 - V_2^2}{2g} + (Z_1 - Z_2) - \frac{0.35(V_1 - V_2)^2}{2g}$

$\frac{P_2}{\omega} = 2.5 + \frac{5^2 - 2^2}{2(9.81)} + 2 - \frac{0.35(5-2)^2}{2(9.81)}$

$\frac{P_2}{\omega} = 2.5 + 1.07 + 2 - 0.161$

$\frac{P_2}{\omega} = 5.409m$ of liquid.

2

inlet : $d_1 = 20cm = 20 \times 10^{-2} m$

$A = \frac{\pi d^2}{4} = \frac{\pi (20 \times 10^{-2})^2}{4}$

$A_1 = 0.0314 m^2$

$P_1 = 17.658 N/cm^2$

$= 17.658 \times 10^4 N/m^2$

$Cd = 0.98$

$D_2 = 10cm = 10 \times 10^{-2} m$

$A = \frac{\pi d^2}{4} = \frac{\pi (10 \times 10^{-2})^2}{4}$

$A_2 = 7.85 \times 10^{-3} m^2$

i.e. Δh

$\frac{P_1}{\omega} - \frac{P_2}{\omega} = h$

$P_1 = 17.658 \times 10^4 N/m^2$

$\omega = 9.81 \times 10^3 N/m^2$

Due to the vacuum pressure

$= 30cm$ of $Hg = 0.3m$ Hg

$= 0.3 \times 13.6 = 4.08$

$\frac{P_2}{\omega} = -4.08$

Then $\frac{P_1}{\omega} = \frac{17.658 \times 10^4}{9.81 \times 10^3} = 18$

$\therefore \frac{P_1}{\omega} - \frac{P_2}{\omega} = 18 - (-4.08) = 22.08$

$Q = Cd A_1 A_2 \frac{\sqrt{2gh}}{\sqrt{(A_1^2 - A_2^2)}}$

$= 0.98 \times 0.0314 \times 7.85 \times 10^{-3} \times \frac{\sqrt{2 \times 9.81 \times 22.08}}{\sqrt{(0.0314^2 - (7.85 \times 10^{-3})^2)}}$

$= 2.4156 \times 10^{-4} \times 684.59$

$= 0.1653 m^3/s$

3. Orificemeter: Given that

$d_o = 15cm = 15 \times 10^{-2} m$

$d_p = 30cm = 30 \times 10^{-2} m$

$A_o = \frac{\pi d^2}{4} = \frac{\pi \times (15 \times 10^{-2})^2}{4} = 0.01767 m^2$

$A_p = \frac{\pi d^2}{4} = \frac{\pi \times (30 \times 10^{-2})^2}{4} = 0.07069 m^2$

SPG of oil = 0.9 (S_o)

Coefficient of discharge = 0.64

Reading of differential = 50cmHg

Differential head $h = y\left[\frac{S_{hL}}{S_o} - 1\right]$

$S_{hL} = 13.6$

$y = 50 \times 10^{-2}$

$h = 50 \times 10^{-2}\left[\frac{13.6}{0.9} - 1\right]$

$Q = \frac{C_d A_o A_p \sqrt{2gh}}{\sqrt{A_p^2 - A_o^2}}$

$= \frac{0.64 \times 0.01767 \times 0.07069 \times \sqrt{2 \times 9.81 \times 7.055}}{\sqrt{(0.07069^2) - (0.01767^2)}}$

$= 0.1374 m^3/s$

4. $y = 170mmHg = 0.17mHg$, $S_{gHg} = 13.6$, $S_{gsw} = 1.026$

$\Delta h = y\left[\frac{S_{gHg}}{S_{gsw}} - 1\right]$

$\Delta h = 0.17\left[\frac{13.6}{1.026} - 1\right]$

$\Delta h = 2.08m$

$v = \sqrt{2g\Delta h}$

$v = \sqrt{2 \times 9.81 \times 2.08}$

$v = 6.388 m/s$

5 $Q = 0.05 dm^3/min = 8.33 \times 10^{-5} m^3/sec$

Speed of Rotation: 1700 Rev/min = 28.3 Rev/sec

Nominal displacement = $10 cm^3/rev = 10^{-5} m^3/rev$

Torque Input = 15 NM

Pressure Charge: 15 bar = $15 \times 10^5 N/m^2$

- Ideal flowrate = Nominal displace × Speed Rotation

$10^{-5} \times 28.3 = 2.83 \times 10^{-4} m^3/sec$

a, Volumetric Efficiency = $\frac{\text{Actual flowrate}}{\text{Ideal flowrate}} \times 100$

$= \frac{8.33 \times 10^{-5} \times 100}{2.83 \times 10^{-4}} = 29.43\%$

b, Fluid Power, $P_f = Q \times \Delta P$

$= 8.33 \times 10^{-5} \times 15 \times 10^5$

= 124.95 watts

c, Shaft Power = $T \times \omega$

$\omega = 2 \times \pi \times$ speed of rotation

$\omega = 2 \times \pi \times 28.3$

$\omega = 177.81$ rad/sec

∴ Shaft Power = 15×177.81

= 2667.2 watts

d, Overall Efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100$

$= \frac{124.95}{2667.2} \times 100 = 4.68\%$

[illegible]

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1. Given data

Flow rate (Q) = 10 dm^3/min, ideal flow rate = normal displacement

Pressure change (ΔP) = 12 bar $\times$ speed = 10 cm^3/rev

Speed (N) = 1500 rpm $\times$ 1500 rpm

Normal displacement = 10 cm^3/rev = 15000 cm^3/min

Torque input (T) = 12.5 N·m = 15 dm^3/min

Volumetric efficiency = $\frac{\text{Actual flow}}{\text{Ideal flow}} = \frac{10}{15} = 0.667$

$Q = \frac{10 \times 10^{-03}}{60} m^3/sec = 16.7 \times 10^{-05} m^3/sec$

$\Delta P = 12 \times 10^5 N/m^2$

Fluid Power = $\Delta P \times Q = 16.7 \times 10^{-05} m^3/s$

$\times 12 \times 10^5 N/m^{-2} = 200$ watts

Shaft Power = $\frac{2\pi N T}{60} = \frac{2\pi \times 1500 \times 12.0}{60} = 1963.5$ watts

Overall efficiency = F.P/S.P = $\frac{200}{1963.5}$ = 0.1020, 10.2%

2. Pump delivers = 35 dm^3/min

$\frac{35 \times 10^{-3}}{60} = 5.83 \times 10^{-4}$

P = 100 bar = $100 \times 10^5 Nm^{-2}$

Overall efficiency = 57%

Fluid Power = $Q \cdot \Delta P$

$= 5.83 \times 10^{-4} \times 100 \times 10^5$

= 5830 watts

Recall

Overall efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100\%$

Shaft Power = $\frac{\text{Fluid Power} \times 100}{\text{Overall efficiency}} = \frac{5830 \times 100}{57}$ = 8701.10

3. Nominal displacement of $50 cm^3/rev$
$= 50 \times 10^{-6} m^3/rev$

Pressure $= 100 bar = 100 \times 10^5 N/m^2$

Shaft Power $= 15 kW = 15000 watts$

Actual flowrate $= 35 dm^3/min = \frac{35 \times 10^{-3} m^3}{60}$

$= 5.83 \times 10^{-4} m^3/s$

Speed $= 850 rev/min = \frac{850}{60} = 14.166 rev/s$

Ideal flowrate = Nominal displacement × speed

$= 50 \times 10^{-6} m^3 \times 14.17$

$= 7.085 \times 10^{-4} m^3/s$

i Volumetric efficiency $= \frac{5.83 \times 10^{-4}}{7.085 \times 10^{-4}} \times 100\%$

$= 82.29\%$

ii Fluid Power $= Q \cdot dP$

$= 5.83 \times 10^{-4} \times 100 \times 10^5$

$= 5830 watts$

Overall efficiency $= \frac{5830}{15000} \times 100$

$= 38.867\%$

4. $z = 2400 cm = 24 m$

Volumetric flowrate, $Q = 13 litres/sec$

$= 0.013 m^3/sec$

Velocity $= 6 m/sec$

The general formula

$$P = \rho g Q \left(\frac{p}{\rho g} + \frac{v^2}{2g} + z \right)$$

$$P = Qp + \frac{\rho Q v^2}{2} + \rho g Q z$$

$z = 0 \quad \therefore P = \frac{\rho Q v^2}{2}$

and $Q = 0.013$, $\rho = 1000$, $v = 66\text{m/s}$

$$P = \frac{1000 \times 0.013 \times (66)^2}{2} = 28.314 \text{ kwatts}$$

ii Power supplied from reservoir

At atmospheric pressure = $P = 0$ and $v = 0$.

$\therefore P = \rho g Q z$

$= 1000 \times 9.81 \times 0.013 \times 240$

$= 30607.2$ watts.

$\simeq 30.607$ kwatts.

Head loss in pipeline = 2.2932 kwatts

$$H = \frac{\text{Power lost in transmission}}{\rho g Q}$$

$$= \frac{2293.2}{1000 \times 9.81 \times 0.013}$$

$$= \frac{2293.2}{127.53} = 17.98\text{m}$$

$$\text{Efficiency} = \frac{\text{Power of jet}}{\text{Power of reservoir}} \times 100\%$$

$$= \frac{28314}{30607.7} \times 100 = 92.51\%$$

5. Sg of oil = 0.89.

$z = 300000\text{m} = 300\text{m}$

$Q = 220\text{L/sec} = 0.22\text{m}^3/\text{sec}$

$v = 7\text{m/sec}$

Introducing $z = 0$, Pressure 0

$$P = \frac{\rho Q v^2}{2}$$

but, Sg = 0.89

$$Sg = \frac{x}{1000}$$

$x = 0.89 \times 1000$

$x = 890$

$P = x = 890$. $P = \frac{890 \times 0.22 \times (7)^2}{2} = 4797\text{w}$

ii) Power loss in transmission
= Power received - Power of ...
= (596259.4 - 4.9971) kilowatt
= 571442.5 watt
= 571.44425 kilowatt

Head used to overcome losses
$= \frac{571442.5}{890 \times 9.81 \times 0.22} = 297.5 m$

iv) Efficiency $= \frac{4997.1}{571442.5} \times 100\%$
$= 0.83\%$

6) $P = \rho g Q z$
$z = 20m - h$
$\rho = 1000$
$g = 9.81$
$Q = vA$
$d = 10cm = 10 \times 10^{-2} m$

$v = 0$ $v^2 = u^2 - 2gh$
$u = \sqrt{v^2 + 2gh}$, $u = \sqrt{0^2 + 2 \times 9.81 \times 20}$
$u = \sqrt{392.4}$, $u = 19.809 \approx 19.81 m/s$
∴ The velocity = 19.81 ∴ $Q = vA = 19.81 \times 7.85 \times 10^{-3}$
$= 0.15558 m^3/s$

Then
$P = \rho g Q z$
$= 1000 \times 9.81 \times 0.1556 \times 20$
$P = 30510.7677$ watt
≈ 30.5 kilowatt

7. $d_1 = 0.3m$

$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.3^2}{4} = 0.0707 m^2$

$d_2 = 0.2m$

$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.2^2}{4} = 0.0314 m^2$

$Cd = 0.98$

Specific weight of gas = 19.62 N/m³

$S = \frac{mg}{V} = \rho g = \frac{19.62}{9.81} = \frac{\rho \times 9.81}{9.81}$, so $\rho g = 19.62$

$\therefore \rho = 2 kg/m^3$

Calculating $Q_1 = A_1 V_1$ $\quad Q_2 = A_2 V_2$, $Q = Q_d$

$\therefore V_1 = \frac{Q_1}{A_1}$ $\quad V_2 = \frac{Q_2}{A_2}$

$V_1 = \frac{Q}{0.0707}$ $\quad V_2 = \frac{Q}{0.0314}$

For the manometer

$P_1 + \rho g S Z_1 = P_2 + \rho g S(Z_2 - RP) + \rho_w g RP$

$P_1 - P_2 = \rho g S(Z_2 - R_2) + \rho_w g RP - \rho S Z_2$

$P_1 - P_2 = 19.62(Z_2 - Z_1) + 587.423$ — i

For the venturimeter

$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2$

$P_1 - P_2 = 19.62(Z_2 - Z_1) + 0.805 V_2^2$ — ii

& $Z_2 - Z_1 = 0.06m$

equation (i) and (ii)

$19.62(Z_2 - Z_1) + 587.423 = 19.62(Z_2 - Z_1) + 0.805 V_2^2$

$0.805 V_2^2 = 587.423$

$V_2^2 = \frac{587.423}{0.803}$, $V_2 = \sqrt{731.535}$

$V_2 = 27.0469 m/s$

$Q_{ideal} = A_2 v_2$

$= 27.047 \times 0.0314$

$Q_{ideal} = 0.8492 = 0.85 m^3/s$

$Q_{real} = C_d \times Q_{ideal}$

$= 0.96 \times 0.85$

$= 0.816 m^3/s$

b. Throat diameter = 0.076m (d_2)

Initial diameter = 0.152m (d_1)

Relative density = 0.8

Throat below = 0.914m

$C_d = 0.91$

Bernoulli's equation

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

Recall that

$Q_1 = V_1 A_1$, $Q_2 = V_2 A_2$

$$A_2 = \frac{\pi d^2}{4} = \frac{\pi \times 0.076^2}{4} = 4.64 \times 10^{-3} m^2$$

$$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times 0.152^2}{4} = 0.0181 m^2$$

ii. Then $P_1 - P_2 = 15170$

$$\left(\frac{P_1}{\rho g} + z_1\right) - \left(\frac{P_2}{\rho g} + z_2\right) = \frac{v_2^2}{2g} - \frac{v_1^2}{2g}$$

$$\frac{P_1 - P_2}{\rho g} + (z_1 - z_2) = \frac{v_2^2}{2g} - \frac{v_1^2}{2g}$$

Recall $z_1 - z_2 = 0.914$

$$\frac{P_1 - P_2}{\rho g} = \frac{v_2^2}{2g} - \frac{v_1^2}{2g} - 0.914$$

Recall $Q = VA$, $V = Q/A$

$\rho = 800$, $g = 9.81$

$$\frac{15170}{800 \times 9.81} = \left(\left(\frac{Q}{A_2}\right)^2 - \left(\frac{Q}{A_1}\right)^2\right) - 0.914$$

$1.932 = \frac{Q^2(11651 6.36 - 3052.41)}{2g} - 0.914$

$(1.932 + 0.914) 2g = Q^2(118516.36 - 3052.41)$

$\frac{56.3678}{45403.95} = Q^2$

$Q = 0.0352 m^3/s$

91. $d_1 = 300mm = 0.3m$

$d_2 = 150mm = 0.15m$

$\therefore A_1 = 0.07069 m^2$

$A_2 = 0.0177 m^2$

$Q = 40L/sec = 0.04 m^3/sec$

$Z = 10m, Z_2 = 6m,$

$P_1 = 400kN/m^2, P_2 = ?,$

$$\frac{P_1}{\rho g} + Z_1 + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + Z_2 + \frac{v_2^2}{2g}$$

But, $Q = A_1 V_1$

$\therefore V_1 = \frac{Q}{A_1} = \frac{0.04}{0.07069}$

$V_1 = 0.5656 m/s$

Then $V_2 = \frac{Q}{A_2} = \frac{0.04}{0.0177} = 2.2598$

$$\frac{P_1}{\rho g}(Z_1 - Z_2) + \left(\frac{v_1^2}{2g} - \frac{v_2^2}{2g}\right) = \frac{P_2}{\rho g}$$

$$\frac{400kN}{9.81kN} + (10 - 6) + \left(\frac{0.57^2 - 2.26^2}{2 \times 9.81}\right) = \frac{P_2}{9.81kN}$$

$40.77 + 4 + (-0.2436) = \frac{P_2}{9.81kN}$

$P_2 = 431.74kN$

16. Reading of manometer = 170mm = 0.17m
Specific gravity of mercury = 13.6
" " of seawater = 1.026

$y = 0.17m$

For $h = y\left(\frac{S_{H}}{S_{L}} - 1\right)$

$= 0.17\left(\frac{13.6}{1.026} - 1\right)$

$= 0.17 \times 12.255$

$= 2.0834m$

Recall $v = \sqrt{2gh}$

$v = \sqrt{2 \times 9.81 \times 2.0834}$

$v = \sqrt{40.87}$

$v = 6.393 m/s$