

DEPARTMENT: EJIM CHISOM PRECIOUS  
MECHATRONICS

MATRIC NO: 18/ENG05/015

NAME: EJIM CHISOM PRECIOUS

ENG 214  
ASSIGNMENT

$$Q_1 \text{ Actual flow rate} = 10 \text{ dm}^3/\text{min}$$

$$= \frac{10}{1000 \times 60} = 1.67 \times 10^{-4} \text{ m}^3/\text{sec}$$

$$\text{Speed, } N = 1500 \text{ rev/min}$$

$$= \frac{1500}{60} = 25 \text{ rps}$$

$$\Delta \text{ Pressure, } \delta P = 12 \text{ bar} = 12 \times 10^5 \text{ N/m}^2$$

$$\text{Nominal displacement} = 10 \text{ cm}^3/\text{rev}$$

$$= \frac{10}{(10^{-2})^3} = \frac{10}{1000000}$$

$$= 1 \times 10^{-5} \text{ m}^3/\text{rev}$$

$$\text{Torque input, } T = 12.5 \text{ Nm}$$

$$\text{Ideal flow rate} = \frac{\text{Nominal displacement} \times \text{speed}}{\text{Actual flow rate}}$$

$$= 1 \times 10^{-5} \times 25 = 2.5 \times 10^{-4} \text{ m}^3/\text{sec}$$

$$\text{i) Volumetric efficiency} = \frac{\text{Actual flow rate}}{\text{Ideal flow rate}} \times 100\%$$

$$= \frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times 100$$

$$= 66.8\%$$

$$\text{ii) Fluid Power, } P_F = Q \times \delta P$$

$$= 1.67 \times 10^{-4} \times 12 \times 10^5$$

$$= 200.4 \text{ Watts}$$

$$\text{iii) Shaft Power} = T \times w$$

where  $w$  = angular speed

$$w = 2\pi N = 2 \times \frac{22}{7} \times 25$$

$$= 157.14 \text{ rad/sec}$$

$$\text{Shaft Power} = 12.5 \times 157.14$$

$$= 1964.25 \text{ Watts}$$

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

$$= \frac{200.4}{1964.25} \times 100\% = 10.2024\%$$

$$\text{overall efficiency} \approx 10.2\%$$

2

$$\text{Actual flow rate} = 35 \text{ dm}^3/\text{min}$$

$$= \frac{35}{1000 \times 60} = 5.83 \times 10^{-4} \text{ m}^3/\text{sec}$$

$$\Delta P (\Delta \text{ Pressure}) = 100 \text{ bars} = 100 \times 10^5 \text{ N/m}^2$$

$$\text{Overall efficiency} = 87\%$$

$$\frac{\text{Fluid Power}}{\text{Shaft Power}} (P_F) = Q \times \delta P$$

$$5.83 \times 10^{-4} \times 100 \times 10^5 = 5830 \text{ Watts}$$

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

$$\text{Shaft Power} = \frac{\text{Fluid Power} \times 100\%}{\text{overall efficiency}} = \frac{5830}{87\%} = \frac{583000}{87}$$

$$\text{Shaft Power} = 6701.149 \text{ Watts}$$

$$\approx 6701.15 \text{ watts}$$

3

$$\text{Nominal displacement} = 50 \text{ cm}^3/\text{rev}$$

$$= 50 \times (10^{-2})^3 = 5 \times 10^{-5} \text{ m}^3/\text{rev}$$

$$\Delta \text{ Pressure} (\delta P) = 100 \text{ bar} = 100 \times 10^5 \text{ N/m}^2$$

$$\text{Shaft Power} = 15 \text{ kW} = 15000 \text{ W}$$

$$\text{Actual flow rate} = 35 \text{ dm}^3/\text{min}$$

$$= \frac{35}{1000 \times 60} = 5.83 \times 10^{-4} \text{ m}^3/\text{sec}$$

$$\text{Speed, } N = 850 \text{ r.p.m}$$

$$= \frac{850}{60} = 14.17 \text{ r.p.s}$$

$$\text{Ideal flow rate} = \frac{\text{Nominal displacement} \times \text{speed}}{5 \times 10^{-5} \times 14.17} = 7.085 \times 10^{-4} \text{ m}^3/\text{sec}$$

$$\text{Volumetric efficiency} =$$

$$\frac{\text{Actual flow rate} \times 100\%}{\text{Ideal flow rate}}$$

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## ENG 214 (FLUID MECHANICS) ASSIGNMENT

DEPT: MECHATRONICS ENGINEERING

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Volumetric efficiency =

$$\frac{5.83 \times 10^{-4}}{7.085 \times 10^{-4}} \times 100\% = 82.287\%$$

volumetric efficiency  $\approx 82.29\%$ 

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$$z = 24000 \text{ cm} = 240 \text{ m}$$

volumetric flow rate,  $Q = 13 \text{ l/s}$ 

$$Q = \frac{13}{1000} = 13 \times 10^{-3} \text{ m}^3/\text{s}$$

Velocity of jet = 66 m/s

- i)  $P=0$  and  $z=0$  since the jet issuing from the nozzle will be at atmospheric pressure and datum head

Density,  $\rho$  of water =  $1000 \text{ kg/m}^3$ 

$$P = PQ + \frac{PQV^2}{2} + \rho g Q z - \textcircled{1}$$

Thus, power of jet is gotten by,

Substituting  $P=0$  and  $z=0$ in equ  $\textcircled{1}$ 

$$P = Q \cdot 0 + \frac{\rho Q V^2}{2} + \rho g Q \cdot 0$$

$$P = \frac{\rho Q V^2}{2} = \frac{1000 \times 13 \times 10^{-3} \times 66^2}{2}$$

$$P = 28.314 \text{ Watts or}$$

$$P = 28.314 \text{ kW}$$

Power of the jet =  $28.314 \text{ kW}$ 

ii) Power supplied from the reservoir

 $P=0$ , as the reservoir operates at atmospheric pressure,  $V=0$ Substituting  $P=0$  and  $V=0$ in equ  $\textcircled{1}$ 

$$P = Q \cdot 0 + \frac{\rho Q \cdot 0^2}{2} + \rho g Q z$$

$$P = \rho g Q z$$

$$= 1000 \times 9.81 \times 13 \times 10^{-3} \times 240$$

$$P = 30607.2 \text{ W}$$

Power supplied from the reservoir

$$= 30607.2 \text{ Watts or } 30.6072 \text{ kW}$$

III Head used to overcome losses

Head loss in pipeline,  $h = \frac{(\text{Power lost in transmission})}{\rho g Q}$ 

Power loss in transmission =

Power of reservoir - power of jet

$$= 30607.2 - 28314 = 2293.2 \text{ W}$$

$$\text{Thus, } h = \frac{2293.2}{1000 \times 9.81 \times 13 \times 10^{-3}}$$

$$h = 17.98165 \text{ m}$$

$$h \approx 17.982 \text{ m}$$

IV Efficiency of the pipeline and nozzle

in transmitting operation

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

$$= \frac{28314}{30607.2} \times 100\% = 92.508\%$$

$$\text{efficiency} = 92.5\%$$

$$5 \quad z = 30000 \text{ cm} = 300 \text{ m}$$

volumetric flow rate,  $Q = 220 \text{ l/s}$ 

$$Q = \frac{220}{1000} = 0.22 \text{ m}^3/\text{s}$$

$$\text{velocity of jet} = 7 \text{ m/s}$$

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(5)

Power of jet

$P=0$  and  $z=0$  since the jet issuing from the nozzle will be at atmospheric pressure and datum head.

$$\text{Specific gravity of oil} = \frac{\text{density of oil}}{\text{density of water}} = \frac{0.89}{1000}$$

$$\text{Density of oil} = 890 \text{ kg/m}^3$$

$$P = PQ + \frac{PQV^2}{2} + PgQz \quad \text{--- (1)}$$

Substituting  $P=0$  and  $z=0$  in equ (1)

$$P = 0 \cdot Q + \frac{P \cdot QV^2}{2} + Pg \cdot Q \cdot z$$

$$P = \frac{PQV^2}{2} = 980 \times 0.22 \times 7^2$$

$$\text{Power of jet, } P = 5282.2 \text{ W or } 5.282 \text{ kW}$$

Power supplied from the reservoir

As the reservoir operates at atmospheric pressure,  $P=0$ ,  $v=0$

Substituting  $P=0$  and  $v=0$  in equ (1)

$$P = 0 \cdot Q + \frac{P \cdot Q \cdot 0^2}{2} + PgQz$$

$$P = PgQz = 980 \times 9.81 \times 0.22 \times 300$$

Power supplied from the reservoir,  $P$

$$= 634510.8 \text{ W or } 634.51 \text{ kW}$$

Head used to overcome losses

$$\text{head loss in pipeline, } h = \frac{\text{Power loss in transmission}}{PgQ}$$

$$\text{Power loss in transmission} = (\text{Power of reservoir}) - (\text{Power of jet})$$

$$= (634510.8 - 5282.2) \text{ W}$$

$$\text{Power loss in transmission} = 629228.6 \text{ W}$$

$$h = \frac{629228.6}{890 \times 9.81 \times 0.22} = 327.582 \text{ m}$$

$$h \approx 327.6 \text{ m}$$

IV Efficiency of the pipeline and nozzle in transmitting operations

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

$$= \frac{5282.2}{634510.8} \times 100\% = 0.83\%$$

$$0.8325\%$$

$$\text{Efficiency} = 0.83\%$$

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Height = 20m

The internal diameter,  $d = 10 \text{ cm} = 0.1 \text{ m}$ 

$$A = \frac{\pi d^2}{4} = \frac{\pi \times 0.1^2}{4} = \frac{1}{400}\pi = \frac{1}{400} \times \frac{22}{7} = 7.063 \text{ m}^2$$

$$A = 7.063 \times 10^{-3} \approx 7.854 \times 10^{-3} \text{ m}^2$$

Power to send water to 20m = ?

The speed of the water at the upper end of the stream is zero.  $V_f = 0$

The initial speed of water is defined by

$$V_i^2 = V_f^2 + 2gh$$

$$V_i = \sqrt{V_f^2 + 2gh}$$

$$V_i = \sqrt{0^2 + 2 \times 9.81 \times 20} = 19.8090882 \text{ m/s}$$

$$V_i \approx 19.81 \text{ m/s}$$

Flow rate is equal to the speed through the area

$$Q = VA = 19.81 \times 7.854 \times 10^{-3} = 0.15558774 \text{ m}^3/\text{s}$$

$$Q \approx 0.1556 \text{ m}^3/\text{s}$$

The power (hydraulic) required to send water to 20m is,

$$P = PgQh$$

$$= 1000 \times 9.81 \times 0.1556 \times 20$$

$$P = 30528.72 \text{ W or } 30.52872 \text{ kW}$$

ENG  
214

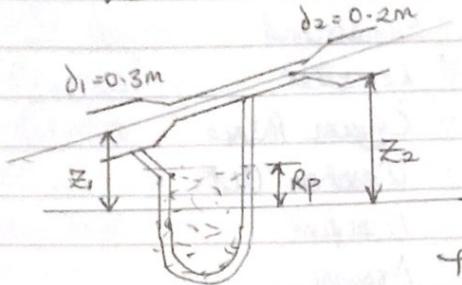
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$\rho_g$  = density of gas,  $\rho_w$  = density of water

$$\text{Specific weight} = \frac{\rho_g}{\rho_w} = 19.62 \text{ N/m}^3$$

$$Cd = 0.96, d_1 = 0.3m, d_2 = 0.2m$$

$$A_1 = \frac{\pi(d_1)^2}{4} = \frac{22}{7} \times \frac{0.3^2}{4} = 0.0707 \text{ m}^2$$

$$A_2 = \frac{\pi(d_2)^2}{4} = \frac{22}{7} \times \frac{0.2^2}{4} = 0.0314 \text{ m}^2$$

From continuity equation,  $Q_i = V_1 A_1 = V_2 A_2$

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

For the manometer,

$$P_1 + \rho_g z_1 = P_2 + \rho_g(z_2 - R_p) + \rho_w R_p$$

$$P_1 - P_2 = 19.62(z_2 - z_1) + \rho_g(z_2 - R_p) - \rho_g z_1 + \rho_w R_p$$

$$P_1 - P_2 = 19.62(z_2 - R_p) - 19.62z_1 + 9810R_p$$

$$P_1 - P_2 = 19.62(z_2 - z_1) + \cancel{R_p}(-19.62 + 9810) = 19.62(z_2 - z_1) + 0.06(9790.33)$$

$$P_1 - P_2 = 19.62(z_2 - z_1) + 587.423 \quad \text{--- (1)}$$

For the venturimeter

$$\frac{P_1}{\rho_g g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho_g g} + \frac{V_2^2}{2g} + z_2$$

$$P_1 - P_2 = \rho_g g \left[ \left( \frac{V_2^2 - V_1^2}{2g} \right) + z_2 - z_1 \right]$$

$$P_1 - P_2 = \cancel{\rho_g} \cdot 19.62(z_2 - z_1) + \frac{19.62}{0.803} 0.803 V_2^2$$

$$P_1 - P_2 = 19.62(z_2 - z_1) + 0.803 V_2^2 \quad \text{--- (2)}$$

Relating eqn (1) and (2)

$$19.62(z_2 - z_1) + 587.423 = 19.62(z_2 - z_1) + 0.803 V_2^2$$

$$\therefore V_2^2 \times 0.803 = 587.423$$

$$V_2 = \sqrt{\frac{587.423}{0.803}} = 27.047 \text{ m/s} = V_{2 \text{ ideal}}$$

Thus,  $Q_{\text{ideal}} = V_{2 \text{ ideal}} \times A_2 = 27.047 \times 0.0314 = 0.8492758 \text{ m}^3/\text{s}$

$$Q = Cd \times Q_{\text{ideal}} = 0.96 \times 0.8492758$$

$$Q = 0.815305 \text{ m}^3/\text{s}$$

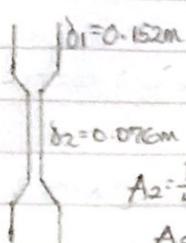
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$$A_1 = \frac{\pi}{4} (D_1)^2 = \frac{22}{7} \times \frac{(0.162)^2}{4}$$

$$D_2 = 0.076m \quad A_1 = 0.01815m^2$$

$$A_2 = \frac{\pi}{4} (D_2)^2 = \frac{22}{7} \times \frac{0.076^2}{4} = \underline{\underline{0.01768}}$$

$$A_2 = 4.538 \times 10^{-3} m^2$$

$$R.D = \frac{\text{Density of substance}}{\text{Density of water}}, 0.8 = \frac{x}{1000}$$

$$\text{Thus, } \rho \text{ of liquid} = 800 \text{ kg/m}^3, C_D = 0.97$$

Applying Bernoulli's equation,

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

$$a) P_1 = P_2, \text{ thus } z_1 - z_2 = 0.914m$$

$$\frac{V_1^2}{2g} + z_1 = \frac{V_2^2}{2g} + z_2$$

By continuity equation,  $Q = V_1 A_1 = V_2 A_2$ 

$$\frac{A_1}{A_2} = \frac{0.01815}{0.004538} = 3.999556, V_2 = V_1 \cdot \frac{A_1}{A_2}$$

$$\frac{V_1^2}{2g} + 0.914 = \frac{15.99645 V_1^2}{2g}$$

$$2 \times 9.81 \times 0.914 = 15.99645 V_1^2 - V_2^2$$

$$V_1^2 = 1.195795, V_1 = \sqrt{1.195795}$$

$$V_1 = 1.0935 \text{ m/s}$$

$$Q = C_D A_1 V_1 = 0.96 \times 0.01815 \times 1.0935 =$$

$$Q = 0.01905 \text{ m}^3/\text{s} \text{ ANS}$$

$$(B) P_1 - P_2 = 15170 \text{ N/m}^2, \frac{P_1 - P_2}{\rho g} = \frac{V_2^2 - V_1^2}{2g} - 0.914$$

$$15170 = Q^2 (220.43^2 - 55.11^2) - 0.914$$

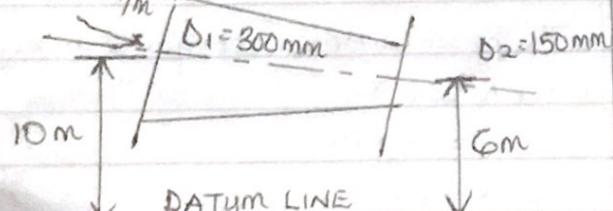
$$\frac{15170}{9.81 \times 1000} 2g$$

$$\left( \frac{15170}{9.81 \times 1000} + 0.914 \right) 2g = Q^2 \times 45552.2728$$

$$Q^2 = \frac{45552.2728}{45552.2728} = \frac{15.99645 V_1^2}{2g}$$

$$Q = 0.035 \text{ m}^3/\text{s} \text{ ANS} \quad V_2 = 3.999556 V_1$$

$$9) P_1 = 400 \text{ kN/m}^2$$



SECTION 1

$$D_1 = 300 \text{ mm} = 0.3 \text{ m}$$

$$A_1 = \frac{\pi}{4} (D_1)^2 = \frac{22}{7} \times \frac{0.3^2}{4} = 0.0707 \text{ m}^2$$

$$z_1 = 10 \text{ m}$$

$$P_1 = 400 \text{ kN/m}^2$$

SECTION 2

$$D_2 = 150 \text{ mm} = 0.15 \text{ m}$$

$$A_2 = \frac{\pi}{4} (D_2)^2 = \frac{22}{7} \times \frac{0.15^2}{4} = 0.01768 \text{ m}^2$$

$$z_2 = 6 \text{ m}, P_2 = ?$$

$$\text{Rate of flow, } Q = 40 \text{ l/s} = \frac{40}{1000} = 0.04 \text{ m}^3/\text{s}$$

From continuity equation,

$$Q = A_1 V_1 = A_2 V_2$$

$$V_1 = \frac{Q}{A_1} = \frac{0.04}{0.0707} = 0.56577 \text{ m/s}$$

$$V_2 = \frac{Q}{A_2} = \frac{0.04}{0.01768} = 2.2624 \text{ m/s}$$

Applying bernoulli's equation at section 1 and 2,

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

$$P_2 = \rho g \left( \frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 - \frac{V_2^2}{2g} - z_2 \right)$$

$$P_2 = 1000 \times 9.81 \left( \frac{400000}{9.81 \times 1000} + \frac{(0.56577)^2}{2 \times 9.81} + 10 - \frac{2.2624^2}{2 \times 9.81} - 6 \right)$$

$$= 9810 \left( 50.79103444 - 6.260879397 \right)$$

$$P_2 = 436840.821 \text{ N/m}^2 \text{ or } 436.840821 \text{ kN/m}^2$$

10) Specific gravity of mercury = 13.6

Specific gravity of sea water = 1.026

Difference of mercury level = 170mm = 0.17m

= x

$h = (\text{specific gravity of mercury} - 1) x$   
 $\text{specific gravity of sea water}$

$$h = \left( \frac{13.6}{1.026} - 1 \right) 0.17 = 2.0834 \text{ m}$$

$$V = \sqrt{2gh}$$

$$= \sqrt{2 \times 9.81 \times 2.0834} = 6.3934 \text{ m/s}$$

$$V = 6.3934 \text{ m/s} \text{ or } \frac{6.3934 \times 3600}{1000}$$

$$23.01624 \text{ km/hr}$$