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| INYANG BASSEY EYO |
| 18/ENG05/022 |
| MECHATRONICS ENGR |
| ENG 214 |

① $V_1 = 5ms^{-1}$
$V_2 = 2ms^{-1}$
Length = 2.0m
Pressure head = 2.5m

$h_f$ = loss of head = $\frac{(0.35(V^1 - V^2)^2}{2g}$

$$h_f = \frac{0.35(V^1 - V^2)^2}{2g}$$

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

$$\frac{P_2}{w} = \frac{P_1}{w} + \frac{1}{2g}(V_1^2 - V_2^2) + (z_1 - z_2) - h_f$$

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

$= 2.5 + 1.070 + 2 - 0.16055$
$= 5.40945m$
$P_2 = 5.4094 \times 9810 \times 10^{-5} = 0.5306$ bar

inlet = 20cm
Throat = 10cm
Pressure inlet = 17.658 N/cm²
30cm of mercury (0.3m of mercury)
Cd = 0.98

Area of inlet $= \frac{\pi}{4} \times 0.2^2 = 0.0314m^2$

Area of throat $= \frac{\pi}{4} \times 0.1^2 = 7.85 \times 10^{-3} m^2$

Pressure at inlet $= \frac{P_1}{w} = \frac{17.658}{9.81} = 1.8m$

$\frac{P_2}{w} = -0.3 \times 13.6m = -4.08m$ (struck through)

$h = 1.8 - (-4.08) = 5.88m$ (struck through)

$$h = 0.3m\left[\frac{13.6}{1} - 1\right] = 3.78m$$

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

$$Q = \frac{0.98 \times 7.85 \times 10^{-3} \times 0.0314}{\sqrt{(0.0314)^2 - (7.85 \times 10^{-3})^2}} \times \sqrt{2 \times 9.81 \times 3.78}$$

$Q = 0.98 \times 8.107 \times 10^{-3} \times 8.611$
$Q = 0.0684 m^3/s$

3) $A_2 = 0.3^2 \times \frac{\pi}{4} = 0.0706m$

$A_1 = 0.15^2 \times \frac{\pi}{4} = 0.0176m$

50cm of mercury (0.5m of mercury)

specific gravity = 0.9
Cd = 0.64

$$= 0.5\left[\frac{13.6}{0.9} - 1\right]$$

$= 7.05m$ of oil

$$Q = Cd \cdot \frac{A_1 \times A_2 \times \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

$$Q = 0.64 \times \frac{0.0176 \times 0.0706 \times \sqrt{2 \times 9.81 \times h}}{\sqrt{(0.0706)^2 - (0.0176)^2}}$$

$Q = 0.64 \times 0.2137$

$Q = 0.136768 m^3/s$

4) Axis = 15m

Mecury level is 170mm = 0.17m

Specific gravity = 13.6

Specific gravity $H_2O$ = 1.026

$$h = y\left(\frac{Shl}{St} - 1\right)$$

$$h = 0.17\left(\frac{13.6}{1.026} - 1\right) = 2.08$$

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

$V = 6.388 m/s$

5) $0.05 m^3/min$

$\Delta p = 15 bar$

Speed of rotation = 1700 rev/min

displacement = $100 cm^3/rev$

Torque input = 15Nm

(i) Volumetric efficiency

Flowrate = Normal Displacement $\times$ 1700

Flowrate = $0.05 \times 1700$

$= 85 m^3/min$

(i) volumetric efficiency

$$= \frac{\text{Actual Flow}}{\text{Ideal Flow}} = \frac{10}{85} = 0.117$$

(iii) $$Q = \frac{0.05 \times 10^{-3}}{60} = 8.33 \times 10^{-7} m^3/sec$$

$\Delta p = 15 \times 10^5 N/m^2$

Fluid power = $\Delta p \times Q$

$= 15 \times 10^5 \times 8.33 \times 10^{-7}$

$= 1.2495$ kWatts

(iv) Shaft power $$= \frac{2\pi NT}{60} = \frac{2\pi \times 1700 \times 15}{60}$$

$= 2670.35$ kW

(v) Overall efficiency $$= \frac{\text{Fluid Power}}{\text{Shaft Power}}$$

~~= 200~~ $$\frac{1.2495}{2670.35} = 0.046\%$$

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| INYANG BASSEY ETO |
| 18/ENG05/022 |
| ENG 214 |
| MECHATRONICS ENG. |

1) Flow rate = $10dm^3/min$

Pressure chang = 12bar

N = 150rpm

Normal displacement = $10cm^3/rev$

Torque input = 12.5N-m

Flow rate = $10cm^3/rev \times 1500rpm$

$= 15000cm^3/min$

i) Volumetric efficiency = $\frac{10}{15} = 0.667$

ii) $Q = \frac{10\times10^{-3}}{60} m^3/sec = 16.7\times10^{-5} m^3/sec$

$\Delta p = 12\times10^5 Nm^{-2}$

Fluid power = $\Delta p \times Q$

$= 16.7\times10^{-5} \times 12\times10^5 = 200.4$ watts

Shaft power = $\frac{2\pi NT}{60} = \frac{2\pi\times1500\times12.6}{60}$

$= 1963.5W$

Overall efficiency = $\frac{200}{1963.5} = 10.2\%$

2) Volume flow rate from the pump

$= 35dm^3/min$

$= \frac{35\times10^{-3}}{60} m^3sec^{-1} = 5.833\times10^{-4} m^3/sec$

Pressure change = $\Delta P$ = 100bar = $100\times10^5$

$= 100\times10^5 N/m^2$

Overall efficiency of pump is given as $= \frac{SgQH}{P}$

$\therefore$

$P = \frac{5.833\times10^{-4}\times100\times10^3}{0.87}$

$\therefore$ Shaft power = 6704.98 watts

3) Normal displacement = $50cm^3/rev$

speed of rotation = 850rev/min

Theoritcal discharge = Nominal displacement $\times$ speed of rotation

$= 50\times850 = 42500cm^3/min$

$= 42.5dm^3/min$

Volumetric efficiency = $\frac{35dm^3/min}{42.5dm^3/min} \times 100$

$= 82.353\%$

3b) Overall efficiency of the pump is given as $\% = \frac{SgQH}{\text{Power of shaft}}$

$Sgh = \Delta p = 100bar = 100\times10^5 Nm^{-2}$

$Q = 35dm^3/min$

$= \frac{35\times10^{-3}}{60} = 5.8333\times10^{-4} m^3/se$

Power of shaft $= 15\times1000 = 15000W$

$\% = \frac{100 \times 10^{-3} \times 5.8333 \times 10^{4}}{15000} \times 100$

$\% = 38.88\%$

4) power of jet $= \frac{1}{2} \rho v^2 Q$

$= \frac{1}{2} \times 1000/9.81 \times 66^2 \times 0.13$

$= 28862$ kgm/sec

$= 28862 \times 9.81 = 283.14$ kW

ii) At the reservoir, pressure is atmospheric and velocity of free surface is zero, $\phi = 0, v = 0$

Power supplied from reservoir

$= \rho Q g z = 1000 \times 0.13 \times 240$

$= 31200$ kgm/sec

$= 31200 \times 9.81 = 306072$ kW

iii) If $H_1$ = Total head at the reservoir

$H_2$ = Total head at the jet

$h$ = head loss in tranmission

$a = 31200$ kgm/s

$b = 28862$ kgm/sec

∴ power loss in tranmission $(a-b)$

$= 2338$ kgm/sec

Head loss in pipe $= h = \frac{(\text{power lost})}{\gamma Q}$

$= h = \frac{2338}{1000 \times 0.13}$

$h = 17.98$ m

$40000 = 416.67Q + 0.0625Q^2$

$\Longrightarrow Q = 94.65$ ft/day

5) $\rho = 890$ kg/m$^3$

$H = 300$ m

$Q = 220$ L/s $= 0.22$ m$^3$/s

$V = 7$ ms$^{-1}$

(i) $P = \frac{1}{2} \rho Q V^2 = \frac{1}{2} \times 890 \times 0.22 \times 7^2$

$P = 4.797$ kW

(ii) power supply

$\bar{P} = \omega Q H$

$\bar{P} = 890 \times 9.81 \times 0.22 \times 300$

$\bar{P} = 576.239$ kW

iii) power supplied from reservoir = $\gamma Q H$

$= 890 \times 0.22 \times 300 = 58740$ kgm/sec

Power issuing jet $= \frac{1}{2} \rho v^2 Q$

$= \frac{1}{2} \times 890/9.81 \times 7^2 \times 0.22$

$= 489$ kgm/s

Power lost in transmission =

$\gamma Q h = 58740 - 489 = 58251$ kgm/s

or $h = \frac{58251}{890 \times 0.22} = 297.50$ m

iv) $\eta = \frac{489}{58740} = 0.8324\%$

6) Power $= \frac{\text{Workdone}}{\text{time}}$

Workdone $= \frac{mgh}{\text{time}}$

V = Velocity of stream

$\rho$ = Density of water (1000 kg/m³)

$m = \rho \times V$

$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 20}$

$= 19.7989 ms^{-1}$

$P = \frac{\rho \pi r^2 V g h}{t}$

power $= 1000 \times \left(\frac{10 \times 10^{-2}}{2}\right) \times 19.7989 \times 9.81 \times 20$

Power = 30478.03W

7) Cd = 0.96 $d_1 = 0.3m$ $d_2 = 0.2m$

$\rho_g g = 19.62 Nm^{-2}$

Q = ?

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

For the manometer

$P + \rho_g g z = P_2 + \rho_z g(z_2 - R_t) + \rho_w g R_f$

$P_1 - P_2 \Rightarrow 19.62(z_2 - z_1) + 587.423$ (i)

For the manometer

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

$P_1 - P_2 = 19.62(z_2 - z_1) + 0.803V_2^2$ .. (ii)

combining equation (i) & (ii)

$0.803 V_2^2 = 587.423$

$V_2$ ideal $= 27.047 ms^{-1}$

Q ideal $= 27.047 \times \pi \times \left(\frac{0.2}{2}\right)^2$

$= 0.85 m^3 s^{-1}$

$Q = Cd\, Q$ideal $= 0.96 \times 0.85$

$= 0.816 m^3/s$

8) $d_1 = 0.152m \Rightarrow 0.01814 m^2$

$d_2 = 0.076m \Rightarrow 0.004254 m$

$\rho = 0.8 \times 100 = 800 kgm^3$

cd = 0.97

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

a) $P_1 = P_2$

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

By continuity

$Q = V_1 A_1 = V_2 A_2$

$V_2 = V_1 \frac{A_1}{A_2} = V_1 (A_1)$

$\frac{V_1^2}{2g} + 0.314 = \pm \frac{6(V_1^2)}{2g}$

$V_1 = \sqrt{\frac{0.314 \times 2 \times 9.81}{15}} = 1.0934 ms^{-1}$

$Q = Cd A_1 V_1 = 0.97 \times (0.01814) \times (1.0924)$

$Q = 0.0192 m^3/s$

$P_1 - P_2 = 15170$

$\rightarrow \frac{P_1 - P_2}{\rho g} = \frac{V_2^2 - V_1^2}{2g} - 0.914$

$\frac{15170}{800 \times 9.81} = \frac{Q^2(220.43^2 - 55.11)^2}{2 \times 9.81} - 0.914$

$Q = 0.035 m^3/s$

SECTION 1

9) $D_1 = 300mm = 0.3m$

$A_1 = \frac{\pi}{4} \times 0.3^2 = 0.070695 m^2$

$P_1 = 400 KN/m^2 = 400000 Nm^{-2}$

SECTION 2

$D_2 = 0.15m$

$A_2 = \frac{\pi}{4} \times (0.15)^2 = 0.0177 m^2$

$Z_2 = 6m$

$P_2 = ?$

Rate of Flow or Discharge $Q = 40 lit/sec$

$= \frac{40}{1000} = 0.040 m^3/sec$

Now $Q = A_1 V_1 = A_2 V_2$

$V_1 = \frac{Q}{A_1} = \frac{0.040}{0.070695} = 0.566 ms^{-1}$

$V_2 = \frac{Q}{A_2} = \frac{0.040}{0.0177} = 2.2599 ms^{-1}$

Applying Bernoulli's equation

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

$\frac{400000}{1000 \times 9.81} + \frac{0.566}{2 \times 9.81} + 10 = \frac{P_2}{1000 \times 9.81} +$

$\frac{2.2541}{2 \times 9.81} + 6$

$50.7988 = \frac{P_2}{9810} + 6.115$

making $P_2$ subject of Formula

$P_2 = 50.7988 \times 9810 - 6.115$

$\therefore P_2 = 438348.078 N/m^2$

10) $y = 170mm = 0.17m$

$Sg = 13.6$

$So = 1.76$

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

$= 2.0834m$

$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.0834}$

$= 6.393 m/s$

$= \frac{6.93 \times 60 \times 60}{1000} Km/hr = 23.01 Km/hr$