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18/ENG06/033
MECHANICAL ENG.
ENG 214

(1) Given data:

Flow rate (Q) = 10 dm^3/min

pressure change (ΔP) = 12 bar

Speed (N) = 1500 rpm

Normal Displacement = 10 cm^3/rev

Torque input (T) = 12.5 N-m

Solution.

Flow rate = Normal Displac × Speed = 10 cm^3/rev × 1500 rpm

= 15000 cm^3/min = 15 dm^3/min

(i) Volumetric efficiency = $\frac{\text{Actual Flow}}{\text{Ideal flow}} = \frac{10}{15} = 0.6667$

(ii)

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

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

Fluid power = $\Delta P \times Q = 16.7 \times 10^{-05} m^3/sec \times 12 \times 10^5 N/m^2 = 200$ Watts

Shaft Power = $\frac{2\pi NT}{60} = \frac{2\pi \times 1500 \times 12.6}{60}$

= 1963.5 Watts

Overall Efficiency = F.P/S.P = $\frac{200}{1963.5}$

= 0.102 or 10.2%//

~~(7)~~ Question 7

$\rho g g = 19.62\ N/m^2$

$cd = 0.96$

$d_1 = 0.3m$

$d_2 = 0.2m.$

Calculate Q

$V_1 = Q/0.0707$ $\qquad$ $V_2 = Q/0.0314$

for the manometer.

~~$P_1 + \rho$~~

$P + \rho_g g z = P_2 + P_2 g (z_2 - Rf) + P_w g Rf$ ~~(1)~~

$P_1 - P_2 \Rightarrow 19.62 (z_2 - z_1) + 587.423$ — (1)

For the manometer.

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

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

Combining 1 \$ 2 we get

$0.803 V_2^2 = 587.423$

$V_2 \text{Ideal} = 27.047 m/s$

$Q \text{ideal} = 27.047 \times \pi \times \left(\frac{0.2}{2}\right)^2 = 0.85 m^3/s$

$Q = Cd\ Q\text{ideal} = 0.96 \times 0.85 = 0.816 m^3/s$ //

Continuation of Number 9

$$40.77 + 0.0288 + 10 = \frac{P_2}{1000 \times 9.81} + 6.115$$

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

$$\frac{P_2}{9810} = 50.7988 - 6.115 = 44.6838$$

$$P_2 = 44.6838 \times 9810$$

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

Question 9.
Solution
Given
At Section 1

$D_1 = 300mm = 0.3 m$

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

$P_1 = 400 kN/m^2 = 400000 N/m^2$

$Z_1 = 10 m$

At section 2

$D_2 = 0.15 m$

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

$Z_2 = 6 m$

$P_2 = ?$

Rate of flow or Discharge $Q = 40 lit/sec = \frac{40}{1000}$

$= 0.040 m^3/sec$

Now $Q = A_1 V_1 = A_2 V_2$

$\therefore V_1 = \frac{Q}{A_1} = \frac{0.040}{0.070695} = 0.566 m/s$

$V_2 = \frac{Q}{A_2} = \frac{0.040}{0.0177} = 2.2599 m/s$

Applying Bernoullis equation at section 1 and 2, we get

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

$$\frac{400000}{1000 \times 9.81} + \frac{0.566}{2 \times 9.81} + 10 = \frac{P_2}{1000 \times 9.81} + \frac{2.2599}{2 \times 9.81} + 6$$

Question 8.

$d_1 = 0.152\,m \implies A_1 = \frac{\pi}{4}(0.152)^2 = 0.01814 m^2$

$d_2 = 0.076m \implies A_2 = \frac{\pi}{4}(0.076)^2 = 0.004\,54m$

$\rho = 0.8 \times 1000 = 800 kg/m^3$

$Cd = 0.97$

→ Applying Bernoulli's

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

a) $P_1 = P_2$

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

By Continuity

$Q = V_1 A_1 = V_2 A_2$

$V_2 = V_1 \frac{A_1}{A_2} = V_1 (4)$

$$\frac{V_1^2}{2g} + 0.314 = \frac{16(V_1^2)}{2g}$$

$$V_1 = \sqrt{\frac{0.314 \times 2 \times 9.81}{15}} = 1.0934 \text{ m/s}$$

$Q = Cd\, A_1 V_1 = 0.97 \times (0.01814) \times (1.0934)$

$Q = 0.0192 m^3/s$

(b) $P - P_2 = 15170$

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

$$\frac{15170}{800 \times 9.81} = \frac{Q^2(220.43^2 - 55.11^2)}{2 \times 9.8} - 0.914$$

$Q = 0.035 m^3/s$ //

Question 6

Power = $\frac{\text{Work done}}{\text{time}}$

Work done = $\frac{mgh}{\text{time}}$

V = Velocity of Stream.

ρ = Density of water (1000kg/m³)

$\dot{m} = \rho \times V$

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

$= 19.7989 \, m/s$

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

Power $= 1000 \times \left(\frac{10 \times 10^{-2}}{2}\right) \times 19.7989 \times 9.8 \times 20$

$= 1000 \times \pi \times 2.5 \times 10^{-3} \times 19.7959 \times 9.8 \times 20$

$\Rightarrow 30478.03 W$

Power = 30478.03 W //

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Question 5

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

$H = 300\ m$

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

$V = 7\ m/s$

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

$P = 4797.1\ Watt = 4.797\ kW.$

(2) Power supplied from reservoir $\bar{P} = WQH$

$= 890 \times 9.81 \times 0.22 \times 300$

$\bar{P} = 576239.4\ W$

$\bar{P} = 576.239\ kW$

(3) Power supplied from reservoir $= \gamma QH$

$= 890 \times 0.22 \times 300 = 58740\ kg\ m/sec$

Power issuing jet $= \frac{1}{2} \rho V^2 Q = \frac{1}{2} \times \frac{890}{9.81} \times 7^2 \times 0.22$

$= 489\ kg\ m/s.$

Power lost in transmission $= \gamma Q h = 58740 - 489$

$= 58251\ kgm/s$

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

(4) $\eta = \frac{\text{power of jet}}{\text{power supplied}} = \frac{489}{58740} = 0.0083 = 0.8324\%$ //

Question 4

Solution

(i) Power of jet $= \frac{1}{2} \rho V^2 Q$

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

$= 28862$ kgm/sec

$= 28862 \times 9.81$

$= 283140$ W $= 283.14$ kW

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

Power supplied from reservoir $= \rho Q g Z$
$= \gamma Q Z$

$= 1000 \times 0.13 \times 240$

$= 31200$ kgm/sec

$= 31200 \times 9.81 = 306072$ W

$= 306.072$ kW.

(iii) If H_1 = Total head at the reservoir

H_2 = Total head at the jet

h = Head loss in transmission

a. power supplied from reservoir $= \gamma Q H_1 = 31200$ kgm/s

b. power of issuing jet $= \gamma Q H_2 = 28862$ kgm/sec

a − b = c, Power lost in transmission $= \gamma Q h = 2338$ kgm/sec

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

$= h = 2338 / 1000 \times 0.13$

$h = 17.98$ m

$40000 = 416.67Q + 0.0625Q^2$

$\Rightarrow Q = 94.65$ ft/day

Question 3 Continues

Overall efficiency of the pump is given as

$$\% = \frac{\rho g Q H}{P_{shaft}}$$

$\rho g H = \Delta P = 100\,bar = 100 \times 10^5\ N/m^2$

$Q = Q_{actual} = 35\ dm^3/min$

$= \frac{35 \times 10^{-3}}{60} = 5.8333 \times 10^{-4}\ m^3/sec$

$(P)_{shaft} = 15\ Kwatts = 15 \times 10^3\ watts$

$$\% = \frac{100 \times 10^5 \times 5.8333 \times 10^{-4} \times 100}{15 \times 10^3}$$

$\% = 38.88\%$ //

Question 2

Q_{actual} = Volume flow rate from the pump

$= 35\ dm^3/min$

$= \frac{35 \times 10^{-3}}{60}\ m^3/sec = 5.8333 \times 10^{-4}\ m^3/sec$

pressure change $= \Delta P = 100\ bar = 100 \times 10^5\ Pa$

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

Overall efficiency of pump is given as

$$\% = \frac{S g Q H}{P}$$

P = shaft power

$S g H = \Delta P$

$$\Rightarrow \boxed{P = \frac{Q \Delta P}{\%}} \Rightarrow P = \frac{5.8333 \times 10^{-4} \times 100 \times 10^5}{0.87}$$

P = shaft power = 6704.98 watts

P = 6.705 kwatts.

Question 3

Given: Norminal displacement of pump

$= 50\ cm^3/rev$

Speed of rotation $= 850\ rev/min$

$(\dot{Q})_{theory}$ = theoritical discharge

= Norminal displacement x Speed of rotation

$= 50 \times 850$

$= 42500\ cm^3/min = 42.5\ dm^3/min$

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

$= 82.353\%$

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Question 10
Solution.
Given;
Diff. of mercury level $x = 170 mm = 0.17 m$
Sp. gr. of mercury $S_g = 13.6$
Sp. gr. of sea-water, $S_o = 1.026$

$$h = x\left[\frac{S_g}{S_o} - 1\right] = 0.17\left[\frac{13.6}{1.026} - 1\right] = 2.0834 m$$

$$V = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 2.0834} = 6.393 m/s$$

$$= \frac{6.393 \times 60 \times 60}{1000} km/hr = 23.01 km/hr //$$