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DEPARTMENT: COMPUTER ENGINEERING
COURSE CODE & TITLE: FLUID MECHANICS ENG 214

1. A pump delivers at the rate of $10 dm^3/min$ with a pressure change of 12bar. The speed rotation is 1500 revolution/min while the nominal displacement is given as $10 cm^3/rev$. If the torque input is 12.5 N/m compute.
- volumetric Efficiency
- fluid power
- shaft Power
- Overall Efficiency.

Solution.

Ideal flow rate = nominal displacement × speed
$= 10 \times 1500 = 15 dm^3/min$

(i) volumetric Efficiency — $\frac{\text{Actual flow}}{\text{Ideal flow}} = 10/_{15} = 0.67 = 67\%$

(ii) fluid Power = $\Delta P Q$
$= \Delta P = 1.2 \times 10^5 = 1200000$
$Q = \frac{10 \times 10^{-3}}{60} = 1.67 \times 10^{-4}$
$= \Delta P Q = 200.4$ watts.

(iii) Shaft Power
$= \frac{2 \pi N T}{60} = 2 \times \pi \times 1500 \times 12.5$
$= 1964.3 N/m$

(iv) Overall Efficiency $= \frac{\text{Fluid Power}}{\text{Shaft Power}}$ 3

$= \frac{200.4}{1964.3}$

$= 0.102$

$= 10.2\%$

2. A pump delivers $35 dm^3/min$ with a pressure change of 100bar. If the overall efficiency is 87%. Calculate the shaft Power.

Solution

$\frac{F.P}{S.P} = \frac{\text{fluid Power}}{\text{Shaft Power}} = 87\% = 87/100$

fluid Power $= \Delta PQ$

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

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

$87\% = \frac{5.83 \times 10^{-4}}{x}$

$x * 87\% = 5.83 \times 10^{-4}$

$x = \frac{5.83 \times 10^{-4}}{0.87}$ 4

$x = 6.701 \times 10^{-4}$

$= 67011 Nm$ //

3. A pump has a nominal displacement of 50cm³/rev and a pressure rise of 100bar. If the shaft Power is 15 kilowatts. Calculate the overall Efficiency and volumetric Efficiency. Taking Actual flow rate = 35dm³/min and speed rotation = 850rpm.

Solution.

Ideal flow rate = normal displacement x speed

$= 50 \times 850 = 42500$

$= 42.5 dm^3/min$

volumetric Efficiency $= \frac{\text{Actual flow}}{\text{Ideal flow}} = 35/42.5 = 0.825$

$= 82.5\%$

fluid Power $= \Delta P Q$

$\Delta P = 100 \times 10^5$

$Q = \frac{50 \times 10^{-3}}{60} = 8.3 \times 10^{-4}$

$\Delta P Q = 8300$

Shaft = 15 kwatts = 15000

overall Efficiency $= \frac{\text{Flud Power}}{\text{Shaft Power}} = \frac{8300}{15000}$

$= 0.553$ or 53%

4. Water is drawn from a reservoir in which the water level is 24000cm above the datum at the rate of 13liters/sec. the outlet of the Pipe is at datum level and is fitted a nozzle to produce a high speed jet in order to drive a turbine of pelton wheel type. If the velocity of the Jet is 66m/s. Calculate

i Power of Jet

ii Power supplied from reservoir

iii) Head used to overcome losses
iv) Efficiency of the Pipeline and nozzle in transmitting operation.

Solution

$Z = 24000cm$

$= 240m$

vol flow rate = 13 l/s , $Q = 13/1000 = 13 \times 10^{-3} m^3/sec.$

Jet velocity = 66 m/sec

when $P = Z = 0$

$P = \frac{\rho Q \cdot V^2}{2} = \frac{1000 \times 13 \times 10^{-3}}{2} \times 66^2 = 28314$ watts

$P = V, V = 0$

$P = \rho g Q Z = 1000 \times 9.81 \times 13 \times 10^{-13} \times 240$

$= 30607.2$ watts

$P = 30.6072$ kwatts

ii) Power lost in transmission.

Power of reservoir - Power of Jet

$= 30607.2 - 28314$

$= 2293.2$ watts

(iii) Head used to overcome losses

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

$H = \frac{2293.2}{1000 \times 9.81 \times 13 \times 10^{-3}} = 17.982m.$

(iv) Efficiency of the Pipeline

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

$= \frac{28314}{30607.2} \times 100 = 92.5 \simeq 93\%$

5. Oil of Specific gravity 0.89 is drawn from a reservoir in which the oil is 30,000cm above the datum at the rate 220lit/sec. If the velocity of jet is 7m/sec. calculate

i. Power of Jet

ii. Power supplied from reservoir.

iii. Head used to overcome losses.

iv. Efficiency of the Pipeline and nozzle in transmitting operation.

Solution:

$T = 890$, $h = 300m$, $v = 7m/s$ $Q = 220 6m/s = 0.22 m^3/s$

(i) Power of Jet $P = \frac{1}{2} \times r a v^3 = \frac{1}{2} \times 890 \times 0.22 \times 7^2$

$P = 4797.1$ watts.

(ii) Power Supplied from reservoir

$PWQH$

$= 890 \times 9.81 \times 0.22 \times 300 + 5\cancel{8740}$

$= 576239.4\ W$

Power from reservoir

$= rQH = 890 \times 0.22 \times 300 = 58740 kgm/s$

Supply $= \frac{1}{2} Pv^2 Q = \frac{\frac{1}{2} \times 890}{9.81} \times 7^2 \times 0.22$

$= 489 kgm/s$

Power lost in transmission $= rQh = 58740 - 489$

$= 58251 kgm/s$

(iii) Head used to overcome losses

$H = \frac{58251}{890 \times 0.22} = 297.5m$ //

(iv) Efficiency of the Pipeline and nozzle in transmitting Operation.

Solution

$$\text{Efficiency} = \frac{\text{Power of Jet}}{\text{Supply}} = \frac{489}{58740} = 0.0083 \times 100 = 0.83\%$$

6. A fountain sends a stream of water 20m up into the air. If the base of the stream is 10cm in diameter, what power is required to send the water to this height?

Solution.

$H = 20m$

$d = 10cm = 0.1m$

$A = \frac{\pi d^2}{4} = 0.7854$

$W = ?$

$v_f^2 = v_1^2 - 2gh$

$v_1 = \sqrt{v_f^2 + 2gh}$

$v_1 = \sqrt{(0)^2 + (2(9.8)(20)}$

$= 19.80 m/s.$

$Q = v_A = (19.80 m/s)(7.854 \times 10^{-3} m^2)$

$= 0.155 m^3/s$

$W = \rho g Q h$

$= (1000 \times (9.8) \times (0.155) \times (20)$

$= 303800 kg m^2/s^3$

$= 30 \times 10^3 W$

7. A venturimeter with an entrance diameter of 0.3m and a throat diameter of 0.2m is used to measure the volume of gas flowing through a

Pipe. The discharge coefficient of the meter is 0.96. Assuming the specific weight of the gas to be constant at 19.62N/m3, calculate the volume flowing when the pressure difference between the entrance and the throat is measured as 0.06m on a water U-tube manometer.

Solution.

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

$Cd = 0.96$

$d_1 - 0.3m$

$d_2 - 0.2m$

$U_1 - 10.07 \quad U_2 - 10.0314$

for the manometer

$- P_1 + \rho_g g z = P_2 + \rho_g g (z_2 - R) + (\rho_u g R_p)$

$- P_1 - P_2 = 19.62 (z_2 - z_1) + 587.423.$

for the venturimeter

$- \frac{P_1}{\rho_g g} + \frac{U_1^2}{2g} + z_1 = \frac{P_2}{\rho_g g} + \frac{U_2^2}{2g} + z_2 \quad \leftarrow eq (2)$

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

combining eqn (1) and (2)

$0.803 u_2^2 = 587.423$

$u_2 \text{ ideal} = 27.047 m/s$

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

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

18. A venturimeter of throat diameter 0.076m is fitted in a 0.152m diameter vertical pipe in which liquid of relative density 0.8 flows downwards. Pressure gauges are fitted to the inlet and to throat sections. The throat being 0.914m below the inlet. Taking the coefficient of the meter as 0.97 find the discharge

a) when the pressure gauges read the same

b) when the inlet guage reads 15170 N/m² higher than the throat guage.

Solution.

$d_1 - 0.152m$ $A_1 - 0.01814m$

$d_2 - 0.076m$ $A_2 = 0.0045m$

$\rho - 300kg/m^3$

$Cd = 0.97$

Apply Bernoulli's method

$$P_1/\rho g + v^2/2g + z_1 = P_2/\rho g + v_2^2/2g + z_2$$

a) $P_1 = P_2$

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

$$Q = v_1 A_1 = v_2 A_2$$

$$v_1 = \sqrt{\frac{0.914 \times 2 \times 9.81}{15}} = 1.0934 m/s$$

$$Q = Cd A_1 v_1$$

$$Q = 0.96 \times 0.01814 \times 1.0934 = 0.019 m^3/s$$

$$P_1 - P_2 = 15170$$

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

$$\frac{15170}{\rho g} = \frac{Q_2(220.43^2 - 55.11^2)}{2g} = -0.914$$

$$Q = 0.03 m^3/s$$

9. The water is flowing through a tapering pipe having diameter 300mm and 150mm at section 1 & 2 respectively. The discharge through the pipe is 40lit/sec. The section 1 is 10m above datum and section 2 is 6m above datum. Find the intensity of pressure at section 2, if that at section 1 is 400kN/m².

Solution.

$P_1 = P_2$

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

$Q = v_1 A_1 = V_2 A_2$

$v_2 = \frac{V_1 A_1}{A_2} = v_1 A$

$v = \sqrt{\frac{0.914 \times 2 \times 9.81}{15}} = 1.0934 m/s$

$Q = C_d A_1 V_1$

$Q = 0.16 \times 0.1814 \times 1.0934 = 0.019 m^3/s$

$A_1 V_1 = A_2 V_2$

$= 40 litre/sec = 40 \times 10^{-3} m/sec$

$v_1 = \frac{40 \times 10^{-3}}{0.707}$

$= 0.566 m/s$

$v_2 = \frac{40 \times 10^{-3}}{0.017}$

$= 2.264 m/s$

Applying Bernoulli's method

$\frac{400 \times 10^3}{9800} + \frac{(0.556)^2}{2 \times 9.8} + 10 = \frac{P_2}{W} + \frac{(1.274)^2}{2 \times 9.8} + 6$

$P_2 = 436.8 kN/m^2$

(10) A submarine moves horizontally in sea and has its axis 15m below the surface of water. A pitot tube properly placed just in front of the submarine and along its axis is connected to the 2 limbs of U-tube containing mercury. The difference in mercury level is found to be 170mm. Find the speed of the submarine knowing that the specific gravity of mercury is 13.6 and that of sea water is 1.026 with respect to that of fresh water.

Solution

Reading of manometer = 170mm
Spg of mercury - 13.6
Spg of water - 1.026

$$h = y\left[\frac{Spg\,M}{Spg\,W} - 1\right]$$

$$h = 0.17\left[\frac{13.6}{1.026} - 1\right] \quad h = 2.083$$

velocity of submarine

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

$$= \sqrt{2 \times 9.81 \times 2.083}$$

$$= 6.39 m/s$$