FLUID MECHANICS-II
(6Th Term B.Sc. Civil Engineering)
(Session-2014)
Teacher Incharge: Prof. Dr. Habib-ur-Rehman

Assignment No. 4
(Centrifugal Pump)

Part (A):

Go through Solved Examples 14.1, 14.2, 14.5 of Text Book, "Solving Problems in Fluid Mechanics" Vol-2, By J. F. Douglas.

Part (B):

Go through Solved Example 14.1 of Text Book "Fluid Mechanics with Practical Applications by Daugherty (8th or S.I edition).

Part (C):

Solve the following numerical problems.

Q. No.1. The diameter of an impeller of a pump is 1.20 m and its peripheral speed is 9 m/s. Water enters radially and is discharges from the impeller with a velocity whose radial component is 1.50 m/s. The vanes are curved backwards at exit and make an angle of 30° with the periphery. If the pump discharges 3.40 m^3/min, what will be the turning moment on the shaft. (217.6 N-m)

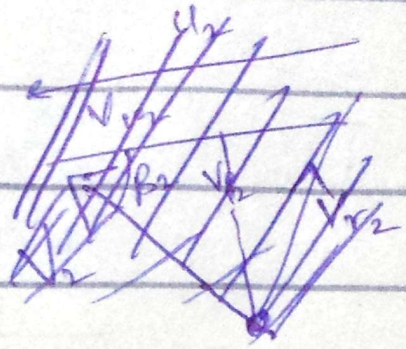
Q. No.2. A pump delivers 1.27 m^3 of water per minute at 1200 rev/min. The impeller diameter is 350 mm and breadth at outlet 12.7 mm. The pressure difference between inlet and outlet flanges is 272 kN/m^2. Taking manometric efficiency as 63 %, calculate the impeller exit blade angle. (32.39^O)

Q. No.3. If the static suction and delivery lifts of a pump are 5 m and 6 m respectively. Dia. of suction pipe is 10 cm and of delivery 8 cm. If the pumping capacity of a pump is 0.08 cumecs of water. Calculate (a) manometric suction head, (b) manometric delivery head (c) total manometric head, (d) power developed by the pump. Use f = 0.031 both for suction and delivery pipes. (19.3 m, 43.636 m. 62.94 m, 49.395 KW)

Q. No.4. Calculate the maximum suction lift for a centrifugal pump if it discharges 50 lit/s. Dia of suction pipe is 15 cm. Barometric pressure is 100 kNlm^2 abs. and vapor pressure for water is 2.34 kNlm^2 abs. Frictional losses in the pipe are 2 V^2/2g. (8.731 m)

CP

Q=1



Data:

$D = 1.2\ m$

$u = 9\ m/s$

$V_{f2} = 1.5\ m/s$

$\theta_2 = 30^\circ$

$Q = 3.4\ m^3/min = 56.667 \times 10^{-3}\ m^3/s$

$T = ?$

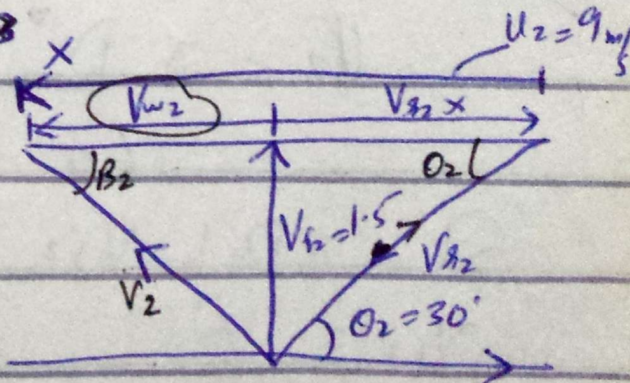
Sol:

Applying IME in radial direction

$(\Sigma F)_x = \rho Q (V_{w2} - V_{w1})$

$-F = \rho Q (-V_{w2} - 0)$

$F = \rho Q V_{w2}$



$\tan 30^\circ = \frac{1.5}{V_{r2x}}$

$V_{r2x} = 2.6\ m/s$

$V_{w2} = U_2 - V_{f2} x$

$V_{w2} = 9 - 2.6 = 6.4\,m/s$

$F = \rho Q V_{w2}$

$= 1000 \times 56.67 \times 10^{-3} \times 6.4$

$F = 362.68\,N$

$T = F \times r$

$= 362.68 \times 0.6 = 217.6\,Nm$

Q=2

$V = 1.27\,m^3$

$t = 1\,min$ $\quad Q = 21.17 \times 10^{-3}\,m^3/s$

$N = 1200\,rev/min$

$D = 350\,mm$

$b_2 = 12.7\,mm$

$P_1 - P_2 = 272\,KN/m^2$

$\eta_m = 63\%$

$\theta_2 = ?$

Sol:

$U_2 = \frac{\pi D N}{60} = \frac{\pi \times 0.35 \times 1200}{60} = 22\,m/s$

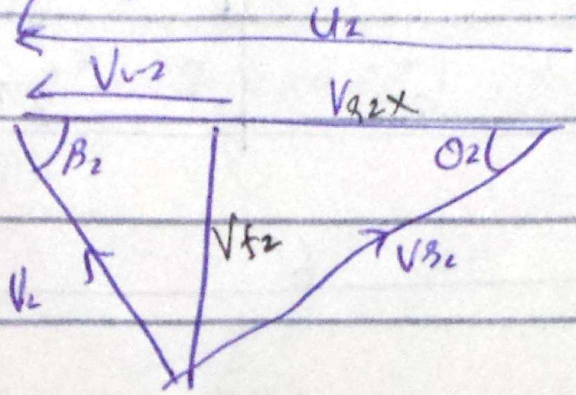
$Q = \pi D_2 b_2 V_{f2}$

$V_{f2} = \frac{Q}{\pi D_2 b_2} = \frac{21.17 \times 10^{-3}}{\pi \times 0.35 \times 0.0127} = 1.52$

$$H = \frac{P_2}{\gamma} = \frac{272 \times 10^3}{9810} = 27.73 \text{ m}$$

$$\eta = \frac{gH}{V_{w2} U_2}$$

$$V_{w2} = \frac{gH}{\eta U_2} = \frac{9.81 \times 27.73}{0.63 \times 22} = 19.63 \text{ m/s}$$



$$U_2 = V_{w2} + V_{\beta 2 x}$$

$$V_{\beta_2 x} = U_2 - V_{w2}$$

$$= 22 - 19.63 = 2.37 \text{ m/s}$$

$$\theta = \tan^{-1}\left(\frac{V_{f2}}{U_2 - V_{w2}}\right)$$

$$= \tan^{-1}\left(\frac{1.53}{2.37}\right) = 32.81^\circ$$

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Q-3

Data:

$H_s = 5m$

$H_d = 6m$

$D_s = 10cm = 0.1m$

$D_d = 8cm = 0.08m$

Q = Pumping capacity $= 0.08\ m^3/s$

a) $H_{ms} = ?$

b) $H_{md} = ?$ c) $H_m = ?$

d) Power developed $= ?$

$f = 0.031$ (Both for suction and delivery)

Sol:

a) $H_{ms} = H_s + H_{fs} + \frac{V_s^2}{2g}$

$= 5 + \frac{0.031 \times 5 \times 10.19^2}{2 \times 9.81 \times 0.1} + \frac{10.19^2}{2 \times 9.81}$

$= 13.46$ m of H_2O

$Q = AV_s$

$V_s = 10.19\ m/s$

$H_f = \frac{fLV^2}{2gD}$

b) $H_{md} = H_d + H_{fd} + \frac{V_d^2}{2g} - \frac{V_s^2}{2g}$

$= 6 + \frac{0.031 \times 6 \times 15.92^2}{2 \times 9.81 \times 0.08}$

$+ \frac{15.92^2}{2 \times 9.81} - \frac{10.19^2}{2 \times 9.81}$

$V_D = \frac{0.08}{\frac{\pi 0.08^2}{4}}$

$V_D = 15.92$

c) $H_m = H_s + H_d + H_{fS} + H_{fD} + \frac{V_D^2}{2g}$

$= 5 + 6 + \frac{0.031 \times 5 \times 10.19^2}{2 \times 9.81 \times 0.1}$

$+ \frac{0.031 \times 6 \times 15.92^2}{2 \times 9.81 \times 0.08} + \frac{15.92^2}{2 \times 9.81}$

$H_m = 62$ m

d) Power

$P = \gamma Q H_m$

$= 9810 \times 0.08 \times 62$

$= 48.6$ KW

Problem = 4 $(H_s)_{max} = ?$

$Q = 50\ l/s = 0.05\ m^3/s$

$D_s = 15\ cm = 0.15\ m$

$P_{atm} = 100\ KN/m^2$ abs.

$P_{vap} = 2.34\ KN/m^2$ abs.

$H_L = 2\left(\frac{V_s^2}{2g}\right)$

Sol:

Area of pipe $= \frac{\pi D_s^2}{4} = 17.67 \times 10^{-3}\ m^2$

$V_s = \frac{Q}{A_s} = 2.83\ m/s$

$\frac{V_s^2}{2g} = H_{vs} = 0.41$ m of H_2O

$H_{fs} = 2\left(\frac{V_s^2}{2g}\right) = 0.82$ m of H_2O

$H_{atm} = \frac{P_{atm}}{\gamma} = \frac{100 \times 10^3}{9810} = 10.19$ m of H_2O

$H_{vap} = \frac{P_{vap}}{\gamma} = \frac{2.34 \times 10^3}{9810} = 0.238$ m of H_2O

$(H_{max}) = 10.19 - (0.238 + 0.41 + 0.82)$

$= 8.72$ m of H_2O

$(H_{max}) = 28.35$ ft of H_2O

Dayhardy

14-1

Data:

C.P

$D_1 = 50\,cm$

$Q_1 = 3.2\,m^3/s$

$H_1 = 25\,m$

$N_1 = 1450\,rpm$

a) $\eta = 88\%$. BHP = ?

b) Homologous pump of

$D_2 = 80\,cm$ $Q_2 = ?$ Shaft Power = ?

$N_2 = 1200\,rpm$ $H_2 = ?$

Both pumps same efficiency.

c) N_s for both pumps = ?

Sol:

As

$$\eta = \frac{P_o}{P_{in}} \times 100$$

a)

$$B.P = \frac{\gamma Q H}{\eta}$$

$$= \frac{9810 \times 3.2 \times 25}{0.82} = 957.07 \text{ KW.}$$

b)

$$\frac{Q_2}{Q_1} = \left(\frac{D_2}{D_1}\right)^3 \left(\frac{N_2}{N_1}\right)$$

$$\frac{Q_2}{3.2} = \left(\frac{0.8}{0.5}\right)^3 \left(\frac{1200}{1450}\right)$$

$$Q_2 = 10.85 \text{ m}^3/\text{s}$$

As

$$\frac{H_2}{H_1} = \left(\frac{D_2}{D_1}\right)^2 \left(\frac{N_2}{N_1}\right)^2$$

$$\frac{H_2}{25} = \left(\frac{0.8}{0.5}\right)^2 \left(\frac{1200}{1450}\right)^2$$

$$H_2 = 43.83 \text{ m}$$

As

$$\frac{P_2}{P_1} = \left(\frac{D_2}{D_1}\right)^5 \left(\frac{N_2}{N_1}\right)^3$$

$$\frac{P_2}{957.07} = \left(\frac{0.8}{0.5}\right)^5 \left(\frac{1200}{1400}\right)^3$$

$$P_2 = 5688 \text{ KW}$$

c) $$N_{s_1} = \frac{N_1\sqrt{Q_1}}{H_1^{3/4}}$$

$$= \frac{1450\sqrt{3.2}}{25^{3/4}} = 232$$

$$N_{s_2} = \frac{N_2\sqrt{Q_2}}{H_2^{3/4}}$$

$$= \frac{1200\sqrt{10.85}}{43.83^{3/4}} = 232$$