Deadline :- 15/3/17

FLUID MECHANICS-II
(6th Semester Civil Engineering)
(Session-2014)
Teacher Incharge: Prof. Dr. Habib-ur-Rehman

CIV-14

Assignment No. 2
(Pelton Wheel)

Q.N 0. 1. A Pelton wheel is supplied with water under a head of 30 m at a rate of 41 m^3/min. The bucket deflect the jet through an angle of 160° and the mean bucket speed is 12 m/s. Calculate the power and hydraulic efficiency of the machine. (196.10 KW, 97%).

Q. No.2. The distance between reservoir and turbine is 1.6 Km. The water is brought in four penstocks each having a dia. of 130 cm connected to a nozzle of 20 cm dia. at the end. Find (a) Power of each jet, (b) Total power available at the reservoir. Head available at nozzle is 500 m, use C_f = 0.008. (14376 KW, 61152 KW).

Q. No.3. A double overhung Pelton wheel Unit is directly coupled to 10000 kW Generator. Find the power developed by each runner, if generator efficiency is 94 %. (5320 KW).

Q. No.4. A Pelton wheel has to develop 18000 b.h.p under a net head of 800 m while running at a speed of 600 rpm. If the coefficient of the jet is 0.97, Speed ratio 0.46 and the ratio of the jet diameter is 1/15 of wheel diameter, calculate the: (a) Number of jets, (b) Diameter of each jet, (c) Diameter of pitch circle, (d) Quantity of water supplied to the wheel. Assume overall efficiency as 85 %. [(a) 12 cm, (b) 1.78 m, (c) 2.013 m^3/s].

Q. No.5. A Pelton wheel is running under a head of 150 m at the speed of 300 rpm. The overall efficiency of the turbine is 85 % and the ratio of the jet to wheel diameter is 1/10. Find (a) Dia. of the wheel, (b) Dia. of the jet, (c) Width of the bucket, (d) Depth of the bucket, (e) Number of buckets. (1.55 m, 15.5 cm, 78 cm, 18.72 cm, 20).

Q. No.6. Design a Pelton wheel for the following data. H = 150 m, power to be developed = 800 h.p, speed of wheel = 360 rpm, (1.3 m, 10.60 cm, 53 cm, 12.7 cm).

Q. No.7. In a Pelton wheel the dia of bucket circle is 0.9 m, the deflecting angle of the buckets is 160°. The jet is 75 mm in dia. Neglecting friction, find the power developed by the wheel and the hydraulic efficiency when the speed is 300 rev/min and the pressure behind the nozzle is 690 KPa. (104 kW, 91.2 %).

Q. No.8. The bucket circle of a Pelton wheel is 1.8 m in dia and the deflecting angle of the buckets is 160°. The jet is 100 mm and the head over the nozzle is 135 m. Find the hydraulic efficiency when the speed is 250 rev/min. (96.80 %).

Q. No.9. A single jet Pelton wheel with a head over the nozzle of 210 m has its buckets on a circle of 0.9 m diameter. The deflecting angle of the buckets is 162°. Find (a) The specific speed (b) The hydraulic efficiency of the turbine when the speed is 800 rev/min. C_v for nozzle is 0.975. (664 rpm, 93.9 %).

Q. No.10. A double jet Pelton wheel is supplied with water through a pipe line 1650 m long from a reservoir in which the level of the water is 375 m above that of the wheel. The turbine runs at 500 rev/min and develops 5000 kW. If the pipe line losses are 10% of the gross head, and C_f = 0.005, calculate the diameter of the pipe, the cross sectional area of the jets and the mean diameter of the wheel. Assume Cv = 0.98, bucket speed = 0.46 x jet speed, and efficiency of turbine = 86 %. (0.741 m, 0.011 m^2, 1.4 m).

Q. No.11. A Pelton wheel has a mean bucket speed of 12 m/s and is supplied with water at the rate of 0.68 m^3/s under a head of 30 m. If the bucket deflects the jet through an angle of 160°, find the power and efficiency of the wheel. (194 kW, 97 %).

Q. No.12. The following data were obtained from a test on a Pelton wheel. Area of jet = 77.5 cm^2, head at nozzle = 30.50 m, discharge = 0.18 m^3/s, out put = 41.80 kW, Power absorbed in windage and friction = 2.20 kW. Determine the energy lost in nozzle & also the energy absorbed due to losses in the wheel at discharge (5.32 kW, 4.50 kW).

Q. No.13. A double jet Pelton wheel required to develop 5400 kW has a specific speed of 25 and water is supplied through a pipe line 790 m long from a reservoir, the level of which is 350 m above the nozzle. Allowing 10 % frictional losses in pipe line, calculate (a) the speed in rev/min (b) dia of jets (c) mean dia of bucket circle (d) diameter of supply pipe. Assume Cv for the jets is 0.98, bucket speed is 0.46 x jet speed, overall efficiency of the wheel 85 % and C_f for pipe 0.006. (483 rpm, 125 min, 1.44 mm, 0.61 m).

Q. No.14. A Pelton wheel working under a head of 380 m develops 16,250 h.p. at the rate of 750 rpm. Find the diameter of the wheel and the number of jets. Use over all efficiency as 86 %. (1 m, 4).

$D_b = 2.5d - 4d$

$W_b = $ "

$d_b = 1.2d$

9.62

Specific speed of turbine

$N_s = \frac{N\sqrt{P_o}}{H^{5/4}}$

SEISMIC GROUP UET LHR

Q=1

Data:

head = H = 30m

Q = 41 m³/min = 0.683 m³/s

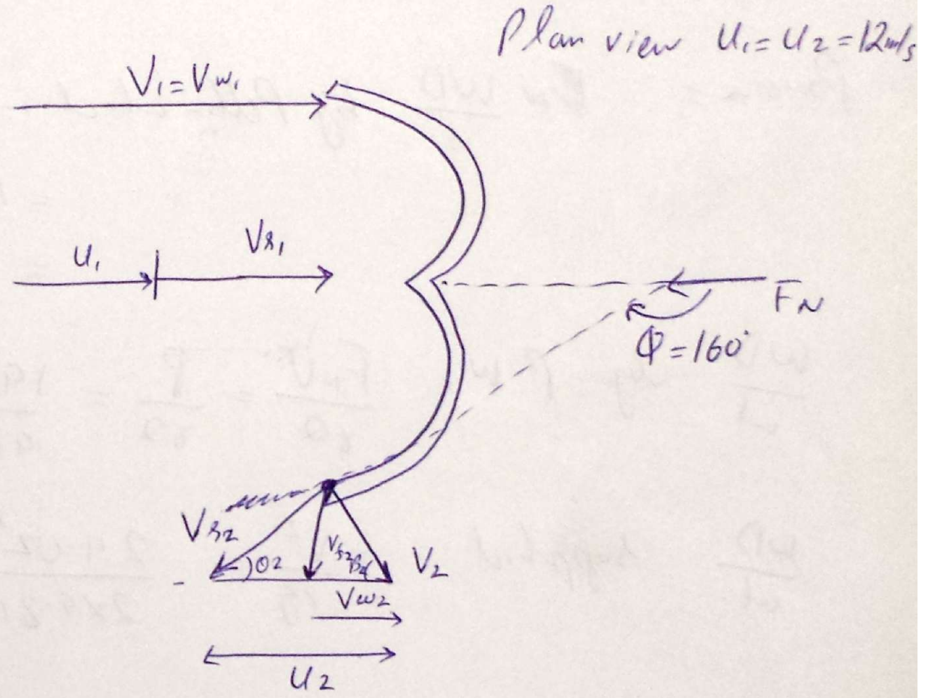
deflection angle = $\Phi = 160°$

bucket speed = $U = 12$ m/s

Power = ?

efficiency = ?

Sol:



$\Rightarrow V_1 = V_{r_1} + u_1$

$V_{r_1} = V_1 - u_1$

Also

$\Rightarrow V_1 = C_v\sqrt{2gH}$

$= 0.99\sqrt{2 \times 9.81 \times 30}$ assuming $C_v = 0.99$

$V_1 = 24.02$ m/s

Hence

$V_{r_1} = V_1 - u_1$

$= 24.02 - 12$

$V_{r_1} = 12.02$ m/s

For real bucket V_{r_2} should be less than V_{r_1} due to frictional loss.

But here, assuming no frictional loss

Hence $V_{r_1} = V_{r_2}$

Applying IME in x-direction:

$\Sigma F_x = \rho Q (V_{r_2x} - V_{r_1x})$

$-F_N = \frac{\rho Q}{2} (-V_{r_2} \cos \theta_2 - V_{r_1}) \times 2$

$F_N = \rho Q (V_{r_2} \cos \theta_2 + V_{r_1})$

$= 1000 \times 0.683 (12.02 \cos 20^\circ + 12.02)$

$F_N = 15931.2 \text{ N}$

Power $= \frac{WD}{s}$ by Pelton wheel $= F_N u$

$= 15931.2 \times 12$

$= 191.2 \text{ KW}$ Ans

$\frac{WD}{wt.}$ by P.W $= \frac{F_N U}{\gamma Q} = \frac{P}{\gamma Q} = \frac{191.2 \times 10^3}{9810 \times 0.683} = 28.5 \text{m}$

$\frac{WD}{wt.}$ supplied $= \frac{V^2}{2g} = \frac{24.02^2}{2 \times 9.81} = 29.41 \text{ m}$

$\eta_h = \frac{\frac{WD}{wt.} \text{ by PW}}{\frac{WD}{wt.} \text{ supplied}} = \frac{28.5}{29.41} \times 100$

$\eta_h = 97\%$ Ans

Q=3
Data: Double Overhung Pelton wheel Unit (2 runners)

$P_o = 10{,}000 KW$

$P_{in} = ?$

$\eta = 94\%$

Sol:

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

$\frac{94}{100} = \frac{10{,}000}{P_{in}}$

$P_{in} = 10638.298 KW$ (By both turbines)

$P_{in} = 5320 KW$ (By one turbine)

Q=4

Data:

$P_o = 18000\ bhp$

$= 18000 \times 746 = 13.428 \times 10^6\ watts$

1 BHP = 746 watts

$H = 800m$

$N = 600\ rpm$

$C_v = 0.97$

Speed ratio $= \frac{u}{V} = 0.46$

Jet dia $= \frac{1}{15}$ wheel dia

$d = \frac{D}{15}$

Overall Efficiency = 85%

Calculate

a) No. of jets $= N_j$

b) dia of jet $= d$

c) dia of circle $= D$

d) $Q = ?$

Sol:

c) $D = \frac{60u}{\pi N}$ $\Rightarrow u = 0.46V$ $\Rightarrow V = C_v\sqrt{2gH}$

$= 0.97\sqrt{2 \times 9.81 \times 800}$

$V = 121.53\ m/s$

$u = 0.46 \times 121.53$

$u = 55.9\ m/s$

$= \frac{60 \times 55.9}{\pi (600)}$

$\boxed{D = 1.78m}$

b) $d = \frac{D}{15}$ (As given)

$d = \frac{1.78}{15}$

$d = 0.1187m$

$d \simeq 0.12m$

d) $\eta = \frac{P_o}{\gamma Q H}$

$\frac{85}{100} = \frac{13.428 \times 10^6}{9810 \times Q \times 800}$

$\boxed{Q = 2.013\ m^3/s}$

a) $N_j = \frac{Q}{Q_j}$

$Q_j = AV$

$= \frac{\pi d^2}{4} V$

$= \frac{\pi (0.1187)^2}{4} \times 121.53$

$= 1.3449$

$N_j = \frac{2.013}{1.3449}$

$N_j = 1.497$

$\boxed{N_j = 2}$ (say)

Q=5

Data:

$H = 150m$

$N = 300 rpm$

$\eta = 85\%$

$\frac{d}{D} = \frac{1}{10}$

Find

a) D

b) d

c) W_b

d) D_b

e) N_b

Sol

Assuming $C_v = 0.975$

$V = C_v\sqrt{2gH}$

$= 0.975\sqrt{2 \times 9.81 \times 150}$

$V = 52.89 m/s$

Assuming $\frac{u}{V} = 0.46$

$u = 0.46V$

$= 0.46 \times 52.89$

$u = 24.33 m/s$

a) $D = \frac{60u}{\pi N}$

$= \frac{60 \times 24.33}{\pi(300)}$

$\boxed{D = 1.55m}$

b) $\frac{d}{D} = \frac{1}{10}$

$d = \frac{D}{10} = \frac{1.55}{10}$

$\boxed{d = 0.155m}$

c) $W_b = 2.5d - 4d$

Choose any

d) $D_b = 2.5d - 4d$

choose any

e) $N_b = 15 + \frac{D}{2d}$

$= 15 + \frac{1.55}{2 \times 0.155}$

$\boxed{N_b = 20}$

=6

Data:

$H = 150m$

$P_o = 800hp = 800 \times 746 = 596800$ watts

speed of wheel $= N = 360$ rpm

Sol:

Assuming $C_v = 0.99$

$V = C_v \sqrt{2gH}$

$= 0.99\sqrt{2 \times 9.81 \times 150}$

$V = 53.71$ m/s

Assume $\frac{u}{V} = 0.46$

$u = 0.46V$

$= 0.46 \times 53.71$

$u = 24.71 m/s$

⇒ Dia of runner:

$D = \frac{60u}{\pi N}$

$D = 1.31m$

⇒ Dia of jet:

$\eta = \frac{P_o}{\gamma Q H}$ Assuming $\eta = 85\%$

$\frac{85}{100} = \frac{596800}{9810 \times Q \times 150}$

$Q = 0.4771 m^3/s$

$d = \sqrt{\frac{4Q}{\pi V}}$

$d = 0.1063m$

⇒ No. of jets

$d_{range} = \frac{D}{18}$ to $\frac{D}{9}$

$= \frac{1.31}{18}$ to $\frac{1.31}{9}$

$= 0.0727$ to 0.1455

Our $d = 0.1063$ is within the upper range

Hence only 1 jet is required.

⇒ No. of bucket:

$$N_b = \frac{D}{2d} + 15$$

$$= \frac{1.31}{2 \times 0.1063} + 15$$

$$\boxed{N_b = 21}$$

Q-1

Data:

$D = 0.9\,m$

$\phi = 160°$

$d = 75\,mm$

Friction = neglected

Find $P_o = ?$

$\eta = ?$

$N = 300\,rev/min$

Pressure = 690 KPa

Sol:

$\Rightarrow V_1 = C_v\sqrt{2gH}$

$= 0.99\sqrt{2 \times 9.81 \times 70.34}$

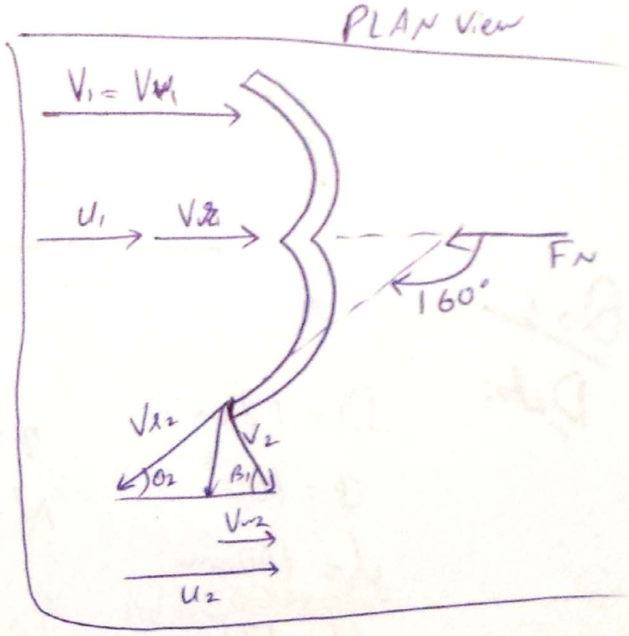
$V = 36.78\,m/s$

Assuming

$\frac{U}{V} = 0.46$

$U = 0.46\,V$

$U = 16.92$



$\Rightarrow V_{r_1} = V_1 - u_1$

$= 36.78 - 16.92$

$V_{r_1} = 19.86\,m/s = V_{r_2}$

Assuming that bucket is ideal

$V_{r_1} = V_{r_2}$

Head available at base of nozzle $= \frac{P}{\gamma}$

$= \frac{690 \times 10^3}{9810}$

$H = 70.34\,m$

Apply IME in x-direction

$(\Sigma F)_x = \rho Q\,(V_{r_2x} - V_{r_1x})$

$-F_N = \frac{\rho Q}{2}\,(-V_{r_2}\cos\theta_2 - V_{r_1})\,2$

$F_N = 1000 \times 0.1625\,(19.86\cos 20° + 19.86)$

$F_N = 6260\,N$

$Q = AV$

$= \frac{\pi (0.075)^2}{4} \times 36.78$

$Q = 0.1625\,m^3/s$

Power $= F_N U$

$= 6260 \times 16.92$

$P_o = 106\,KW$

$\frac{WD}{wt.}$ by machine $= \frac{P_0}{\gamma Q} = \frac{106\times10^3}{9810\times0.1625} = 66.49\,m$

$\frac{WD}{wt.}$ supplied $= \frac{V^2}{2g} = \frac{(36.78)^2}{2\times9.81} = 68.95\,m$

$$\eta = \frac{66.49}{68.95}\times100$$

$$\boxed{\eta = 96.4\%}$$

Q=3

Data:

$D = 1.8\,m$ $\quad \eta = ?$

$\phi = 160°$ $\quad N = 250\,rpm$

$d = 100\,mm$

$H = 135\,m$

Sol:

Same figure as previous

$\Rightarrow U = \frac{\pi DN}{60}$

$U = 23.56\,m/s$

$\Rightarrow V = C_v\sqrt{2gH}$

$= 0.99\sqrt{2\times9.81\times135}$

$V = 50.95\,m/s$

$V_{r1} = V - u$

$= 50.95 - 23.56$

$V_{r1} = 27.39\,m/s$

$Q = AV$

$= \frac{\pi(100)^2}{4}\times50.95$

$Q = 0.4\,m^3/s$

Applying IME in x direction and assuming frictionless flow

$F_N = \rho Q(V_{r2}\times\cos\theta_2 + V_{r1})$

$F_N = 1000\times0.4(27.39\cos20° + 27.39)$

$F_N = 21252\,N$

Power = $\frac{WD}{s}$ by machine = $F_x u$
= $21252 \times 23.56 = 500680$ watts

$\frac{WD}{wt.}$ by machine = $\frac{P}{\gamma Q} = \frac{500680}{9810 \times 0.4} = 127.6\,m$

$\frac{WD}{wt.}$ supplied = $\frac{V^2}{2g} = \frac{50.95^2}{2 \times 9.81} = 132.31\,m$

$\eta = \frac{127.6}{132.31} \times 100$

$\boxed{\eta = 96.44\%}$

Q=9

Single jet P.W

Data:

$N_j = 1$

$H = 210\,m$

$D = 0.9\,m$

$\phi = 162°$

Find a) $N_s = ?$

b) $\eta_h = ?$ $N = 800\,rev/min$

$C_v = 0.975$

Sol:

$\Rightarrow V = C_v \sqrt{2gH}$
$= 0.975\sqrt{2 \times 9.81 \times 210}$

$\boxed{V = 62.58\,m/s}$

$\Rightarrow u = \frac{D \pi N}{60}$

$u = \frac{0.9 \pi\, 800}{60}$

$\boxed{u = 37.7\,m/s}$

$\Rightarrow V_{x_1} = V_1 - u$
$= 62.58 - 37.7$

$\boxed{V_{x_1} = 24.88\,m/s}$

$\Rightarrow d_{range} = \frac{D}{18}$ to $\frac{D}{9}$

$= \frac{0.9}{18}$ to $\frac{0.9}{9}$

$d_{range} = 0.05$ to $0.1\,m$
$= 50\,mm$ to $100\,mm$

Also

$Q_{ij} = \frac{Q}{N_j} \Rightarrow Q_{ij} = Q \quad \because N_j = 1$

Let $\boxed{d = 75\,mm}$

$\Rightarrow Q = AV$
$= \frac{\pi}{4}(75 \times 10^{-3})^2 \times 62.58$

$\boxed{Q = 0.2765\,m^3/s}$

Applying IME in x direction (Assuming no frictional loss)

$F_N = \rho Q (V_{r_1} + V_{r_2} \cos\theta_2)$ $\theta_2 = 180° - 162$ $= 18°$

$= 1000 \times 0.2765 (24.88 + 24.88 \cos 18)$

$F_N = 13422 \, N$

$Power = F_N U$
$= 13422 \times 37.7$
$= 506009.4$ Watts

$\frac{WD}{wt.}$ by P.W $= \frac{P_o}{\gamma Q} = \frac{506009.4}{9810 \times 0.2765} = 186.55 m$

$\frac{WD}{wt.}$ supplied $= \frac{V^2}{2g} = \frac{62.58^2}{2g} = 200$ m of water

$\eta = \frac{186.55}{200} \times 100$

$\boxed{\eta = 93.3\%}$

a) $N_s = \frac{N\sqrt{P_o}}{H^{5/4}}$

$\boxed{N_s = 711.86 \text{ rpm}}$

Q=10

Data:

$N_j = 2$

$L_p = 1650m$

$H = 375m$

$N = 500 rev/min$

$P_o = 5000 kW$

Pipe line losses = 10% of gross head

$C_f = 0.005$

$\eta = 86\%$

$D_p = ?$

$a = ?$

$D = ?$

$C_v = 0.98$

Bucket speed = 0.46 x jet speed

$\therefore U = 0.46 V$

Sol:

$\Rightarrow h_f = \text{losses} = \frac{10}{100}(375) = 37.5m$

$\Rightarrow$ Net head $= H = 375 - 37.5 = 337.5m$

(1) $\Rightarrow V = C_v\sqrt{2gH}$

$= 0.98\sqrt{2 \times 9.81 \times 337.5}$

$V = 79.75 m/s$

(2) $\Rightarrow u = 0.46V$

$= 0.46 \times 79.75$

$u = 36.69 m/s$

(3) $\Rightarrow D = \frac{60u}{\pi N}$

$= \frac{60(36.69)}{\pi(500)}$

$D = 1.40 m$ Ans

(4) $\Rightarrow \eta_o = \frac{P_o}{\gamma Q H}$

$\frac{86}{100} = \frac{5000000}{9810 \times Q \times 337.5}$

$Q = 1.756 m^3/s$ Total

(6) $\Rightarrow d = \sqrt{\frac{4Q}{\pi V}}$

$= \sqrt{\frac{4 \times 0.878}{\pi(79.75)}}$

$d = 0.118m$

(7) $\Rightarrow a = \frac{\pi d^2}{4}$

$a = \frac{\pi(0.118)^2}{4}$

$a = 0.011 m^2$ Ans

(5) $\Rightarrow Q_{ij} = \frac{Q}{N_j}$

$= \frac{1.756}{2}$

$Q_{ij} = 0.878 m^3/s$

To calculate Dia of Pipe

$Q = A_p \times V_p$

$1.756 = \frac{\pi}{4} D_p^2 \times V_p$

$2.236 = D_p^2 \times V_p$ —— (1)

Using Darcy Weisbach equation

$h_f = f \times \frac{L_p}{D_p} \times \frac{V_p^2}{2g}$

$37.5 = 0.02 \times \frac{1650}{D_p} \times \frac{V_p^2}{2 \times 9.81}$

$h_f = 37.5m$

$f = 4C_f$
$= 4 \times 0.005 = 0.02$

$22.295 = \frac{V_p^2}{D_p}$

$D_p = \frac{V_p^2}{22.295}$ —— (2)

Putting in (1)

$2.236 = \left(\frac{V_p^2}{22.295}\right)^2 \times V_p$

$V_p = 4.066 \, m/s$

Putting in (2)

$D_p = \frac{V_p^2}{22.295}$

$= \frac{(4.066)^2}{22.295}$

$D_p = 0.742 \, m$

Q=11

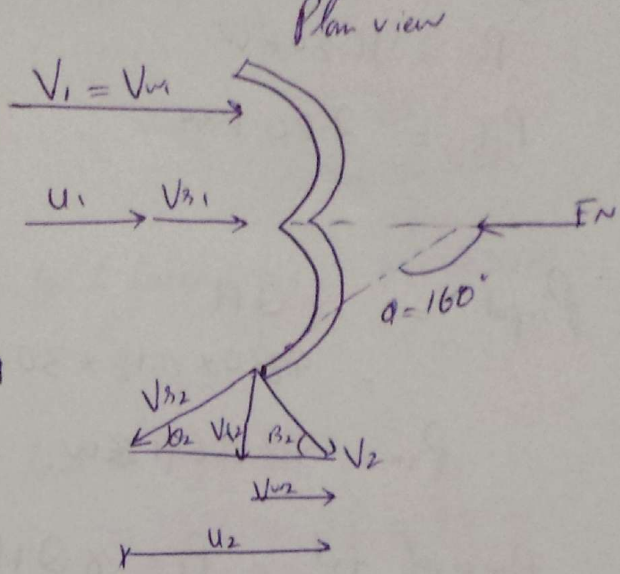
Data:

$u = 12\,m/s$ Find

$Q = 0.68\,m^3/s$ $P = ?$

$H = 30\,m$ $\eta = ?$

$\phi = 160^\circ$



Sol:

$\Rightarrow V_1 = V_{r1} + u_1$

$\Rightarrow V_1 = C_v\sqrt{2gH}$ Assuming $C_v = 0.99$

$= 0.99\sqrt{2 \times 9.81 \times 30}$

$V_1 = 24.02\,m/s$

$\Rightarrow V_{r1} = V_1 - u_1$

$= 24.02 - 12$

$V_{r1} = 12.02\,m/s$

If friction loss then

$V_{r2} = \frac{loss\%}{100} \times V_{r1}$

Assuming no friction loss Hence $V_{r1} = V_{r2}$

Applying IME in x direction

$(\Sigma F_x) = \rho Q (V_{r2x} - V_{r1x})$

$-F_N = \frac{\rho Q}{2}(-V_{r2}\cos\theta_2 - V_{r1}) \times 2$

$F_N = 1000 \times 0.68\,(12.02\cos 20^\circ + 12.02)$

$F_N = 15931.2\,N$

Power $= \frac{WD}{s}$ by P.W $= F_N u = 191.2\,KW$

$\frac{WD}{wt.}$ by P.W $= \frac{P}{\gamma Q} = \frac{191.2 \times 10^3}{9810 \times 0.68} = 28.5\,m$

$\frac{WD}{wt.}$ supplied $= \frac{V^2}{2g} = \frac{24.02^2}{2 \times 9.81} = 29.41\,m$

$\eta = \frac{28.5}{29.41} \times 100 = 97\%$

(48)

Q=12

Data:

$a = 77.5 cm^2$ ΔP_{nozzle} = Energy lost in nozzle = ?

$H = 30.5m$ ΔP_{wheel} = Energy absorbed due to losses = ?

$Q = 0.18 m^3/s$

$P_o = 41.80 KW$

$P_f = 2.20 KW$

Sol:

$\Rightarrow P_{input} = \gamma Q H$

$= 9810 \times 0.18 \times 30.5$

$P_{in} = 53856.9 W$

$\Rightarrow Q = AV$

$V = \frac{Q}{A} = \frac{0.18}{77.5 \times 10^{-4}}$

$V = 23.23 m/s$

$\Rightarrow$ Power of jet $= P_j = \gamma Q H = \gamma Q \frac{V^2}{2g}$

$= 9810 \times 0.18 \times \frac{23.23^2}{2 \times 9.81}$

$P_j = 48566.96 W$

$\Rightarrow \Delta P_{nozzle} = P_{in} - P_j$

$= 53856.9 - 4856696$

$\Delta P_{nozzle} = 5289.94$ Watts Ans

~~$\Delta P_{wheel} = P_{in} - P_o$~~

~~$= 53856.9 - 41.8 \times 10^3$~~

$P_{input} = P_{output} + \Delta P_{nozzle} + \Delta P_{wheel} + \Delta P_{(windage + friction)}$

$53856.9 = 41800 + 5289.94 + \Delta P_{wheel} + 2200$

$\Delta P_{wheel} = 4566.96$ Watts Ans

Q=13

Data:

$N_j = 2$

$P_o = 5400\,kW$

$N_s = 25$

$L_P = 790\,m$

$H_g = 350\,m$

frictional losses = 10%.

a) $N = ?$

b) $d = ?$

c) $D = ?$

d) $D_P = ?$

$C_v = 0.98$

$u = 0.46\,V$

$\eta = 85\%$

$C_f = 0.006$

Sol:

Frictional losses = $h_f = 350 \times 10\%$

$h_f = 35\,m$

Net head = $h_g - h_f$

$= 350 - 35 = 315\,m$

a) $N = \dfrac{N_s H^{5/4}}{\sqrt{P_o}}$

$= \dfrac{25 \times 315^{5/4}}{\sqrt{5400}}$

$\boxed{N = 451\,rpm}$ Ans

c) $V = C_v \sqrt{2gH}$

$= 0.98\sqrt{2 \times 9.81 \times 315}$

$V = 77.04\,m/s$

$u = 0.46\,V$

$= 0.46 \times 77.04$

$u = 35.44\,m/s$

$\Rightarrow u = \dfrac{\pi D N}{60}$

$35.44 = \dfrac{\pi D (451.5)}{60}$

$\boxed{D = 1.5\,m}$ Ans

b) $\Rightarrow \eta = \frac{P_o}{\gamma Q H}$

$Q = \frac{P_o}{\gamma \eta H} = \frac{5400 \times 10^3}{9810 \times \frac{85}{100} \times 315}$

$Q = 2.056 \, m^3/s$

$\Rightarrow \quad Q_{,j} = \frac{Q}{N_j}$

$Q_{,j} = \frac{2.056}{2} = 1.028 \, m^3/s$

$Q_{,j} = \frac{\pi d^2}{4} V$

$d = \sqrt{\frac{Q_{,j} \times 4}{\pi V}} = \sqrt{\frac{1.028 \times 4}{\pi (77.04)}}$

$d = 0.13 \, m$

d) Using Darcy Weisbach equation

$h_f = f \times \frac{L_P}{D_P} \times \frac{V_P^2}{2g}$

$f = 4 C_f$
$= 4 \times 0.006$
$f = 0.024$

$35 = 0.024 \times \frac{790}{D_P} \times \frac{V_P^2}{2 \times 9.81}$

$36.22 = \frac{V_P^2}{D_P}$

$D_P = \frac{V_P^2}{36.22}$ — ①

Also

$Q = A_P V_P$

$2.056 = \frac{\pi}{4} D_P^2 V_P$

$2.62 = D_P^2 V_P$ — ②

Putting ① in eq ②

$2.62 = \left(\frac{V_P^2}{36.22}\right)^2 V_P$

$V_P = 5.096 \, m/s$ Putting in ①

$D_P = \frac{5.096^2}{36.22}$

$D_P = 0.717 \, m$

14

Data:

$H = 380m$

$P_o = 16250\ hp \Rightarrow 16250 \times 746 = 12122500$ watts

$N = 750$ rpm

a) $D = ?$

b) $N_j = ?$

$\eta = 86\%$

Sol:

a) $\Rightarrow D = \frac{60u}{\pi N}$ $\Rightarrow u = 0.46V$ $\Rightarrow V = C_v\sqrt{2gH}$

$= 0.99\sqrt{2 \times 9.81 \times 380}$

$u = 0.46 \times 85.48$ $V = 85.48\ m/s$

$D = \frac{60 \times 39.32}{\pi \times 750}$ $u = 39.32\ m/s$

$$\boxed{D = 1.00m}$$

b)

$\Rightarrow d_{range} = \frac{D}{18}$ to $\frac{D}{9}$ $\Rightarrow d = \sqrt{\frac{4Q}{\pi V}}$ $\eta = \frac{P_o}{\gamma Q H}$

$d_{range} = 0.055$ to 0.111 $d = \sqrt{\frac{4 \times 3.83}{\pi \times 85.48}}$ $\frac{86}{100} = \frac{12122500}{9810 \times Q \times 380}$

$Q = 3.83\ m^3/s$

$d = 0.239m$ for $N_j = 1$

it is not within range hence revising

$\Rightarrow$ Let $N_j = 2$

Hence $Q_{ij} = \frac{3.83}{2} = 1.915\ m^3/s$

Now $d = 0.169m$

Try again

$\Rightarrow$ Let $N_j = 3$

Hence $Q_{ij} = \frac{3.83}{3} = 1.28\ m^3/s$

Now $d = 0.138\ m$ Try again

⇒ Let $N_j = 4$

$$Q_{ij} = \frac{3.83}{4} = 0.9575\,m^3/s$$

Now $d = 0.119$

Try again

⇒ Let $\boxed{N_j = 5}$

$$Q_{ij} = \frac{3.83}{5} = 0.766\,m^3/s$$

Now $\boxed{d = 0.1068}$

Hence this lies within range