Solution

Fluid Machinery Mid Semester examination - 2018.

Ans (1) (a) Classification of turbine

(i) according to the type of energy at inlet.

(a) impulse Turbine (b) Reaction Turbine.

(2). according to the direction of flow through runner.

(a) Tangential flow Turbine (b). Radial flow turbine

(c) Axial flow turbine (d). Mixed flow Turbine

(3). According to the head at the inlet of turbine.

(a). High head turbine (b) Medium head turbine

(c) low head turbine

(4). According to the specific speed of the turbine

(a) low specific speed turbine (b) Medium ~~head~~ specific speed turbine

(c) High specific speed turbine

(b). Indicator diagram for a Reciprocating pump is defined as the graph b/w pressure head in the cylinder and the distance travelled by the piston from inner dead centre for one complete revolution of the crank.

As maximum distance travelled by the piston is equal to the stroke length and hence the indicator diagram is a graph between pressure head and

Stroke length of the piston.

H_{atm} = atmospheric pressure head
= 10.3 m of water

L = length of stroke

h_s = suction head

h_d = delivery head

We know that the work done by the pump per second

$$= \frac{\rho g A L N}{60} \times [h_s + h_d)$$

$$= K \times L (h_s + h_d)$$

$$\propto L \times (h_s + h_d) \quad \text{—— (1)}$$

but from figure (1) area of indicator diagram

$$= AB \times BC = AB (BF + FC)$$

$$= L \times (h_s + h_d) \quad \text{—— (2)}$$

by eq (1) and (2)

work done by pump $\propto$ area of indicator diagram.

Ans-(2)

(a). Force exerted on flat vertical plate moving in the direction of jet with velocity u.

figure-(2) shows a jet of water striking a flat plate moving with a uniform velocity away from the jet.

V = Velocity of jet

a = area of jet = $\frac{\pi}{4} d^2$

U = Velocity of flat plate

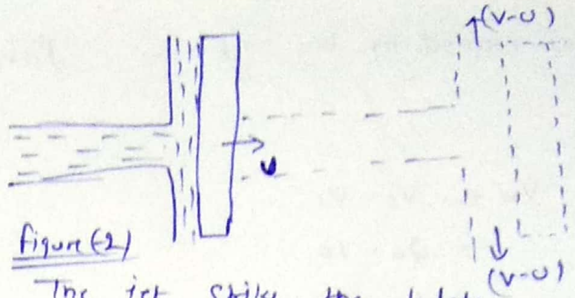


Figure (2)

actual velocity of jet by which the jet strikes the plate is = $(V - U)$ (Relative velocity of jet with respect to plate)

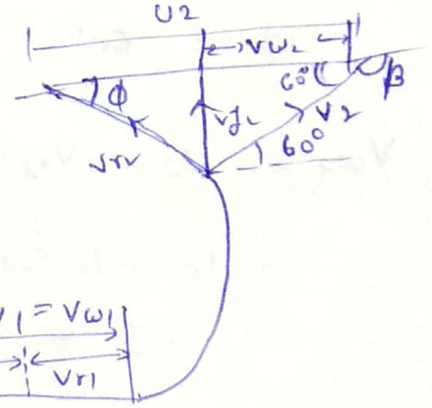
Force exerted by jet on the moving plate in the direction of jet

= mass of water striking/sec × [initial velocity − final velocity]

$= m' \, [V_{r1} - V_{r2}]$

$= \rho a (V-U) \, [(V-U) - 0]$ {final velocity is zero along x direction}

$= \rho a (V-U)^2$



(b). given that:

→ $d = 50mm = 0.05m$

$a = \frac{\pi}{4} d^2 = 0.001963 \, m^2$

$V_1 = 20 \, m/s$

$U_1 = 10 \, m/s$

$V_1 = V_{w1}$

$V_{r1} = V_{r2}$ {No losses in energy is given during the flow on the blade}

jet and vane are moving in same direction

$\alpha = 0$

$\beta = 180 - 60 = 120^0$

$U_1 = U_2 = 10 \, m/s$

U_2

Force exerted by the jet $= \rho a V_{r1} (V_{w1} - V_{w2})$ {-ve sign is taken as β is an obtuse angle}

$V_{r1} = V_1 - U_1$

$= 20 - 10$

$= 10$ m/s

$\angle GEF = 180 - [60 + \phi] = (120 - \phi)$

Applying the sine rule in ΔEFG

$$\frac{V_{r2}}{\sin 60} = \frac{U_2}{\sin(120 - \phi)} = \frac{V_2}{\sin \phi}$$

$$\frac{10}{\sin 60} = \frac{10}{\sin(120 - \phi)}$$

$\phi = 60°$

$V_{w2} = U_2 - V_{r2} \cos \phi$

$= 10 - 10 \cos 60°$

$= 10 - 5 = 5$ m/s

$\therefore F_x = 1000 \times 0.001963 \times 10 [20 - 5]$

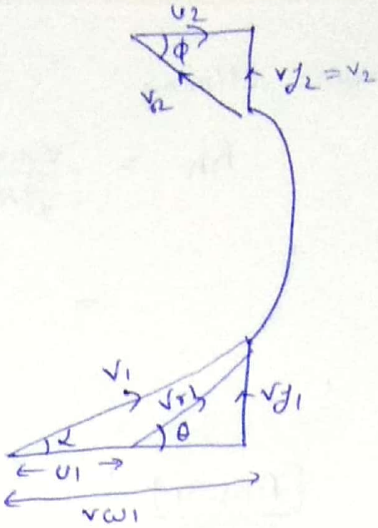
$= 294.45$ N

work done/s by jet $= F_x \times U$

$= 294.45 \times 10$

$= 2944.5$ W

(Ans-3)



Given that

$N = 450$ Rpm

$H = 120$ m

$D_1 = 1.2$ m

flow area $= \pi D_1 B_1$

$= 0.4 m^2$

$\alpha = 20°$

$\theta = 60°$

$V_{w2} = 0$

blade velocity at inlet $= U_1 = \frac{\pi D_1 N}{60} = \frac{\pi \times 1.2 \times 450}{60} = 28.27$ m/s

from Inlet Velocity Triangle

$\tan 20° = \frac{V_{f1}}{V_{w1}} =$

$V_{f1} = 0.364 V_{w1}$

and also $\tan\theta = \frac{V_{f1}}{V_{w1} - U_1} = \frac{0.364 V_{w1}}{V_{w1} - 28.27}$ $\{V_{f1} = 0.364 V_{w1}\}$

$\tan 60° = \frac{0.364 V_{w1}}{V_{w1} - 28.27}$

$V_{w1} = 35.79$ m/s

and $V_{f1} = 13.027$ m/s

(i) Volume flow rate $= \pi D_1 B_1 V_{f1}$

$= 0.4 \times 13.022 = 5.211 \; m^3/s$ Ans.

(ii) work done/sec $= \rho Q [V_{w1} U_1]$

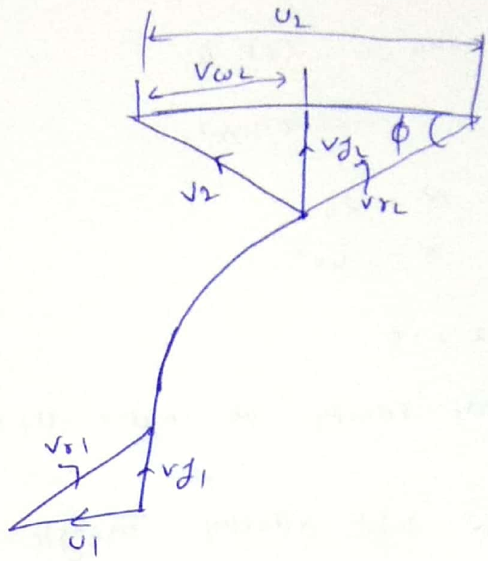
$= 1000 \times 5.211 \; [35.79 \times 28.27]$

$= 5272402$ Nm/s

(iii) Hydraulic efficiency

$$\eta_h = \frac{V_{w1}u_1}{gH} = \frac{35.79 \times 28.82}{9.81 \times 120} = 0.8595$$

$$= 85.95\% \text{ Ans}$$



[Ans-4]

Given :-

$Q = 0.118 \; m^3/s$

$N = 1450$ r.p.m

$H_m = 25m$

$D_2 = 250 \; mm = 0.25m$

$B_2 = 50mm = 0.05m$

$\eta_{man} = 75\% = 0.75$

Vane angle at outlet $= \phi$

$$u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times 0.25 \times 1450}{60} = 18.98 \; m/s$$

discharge $Q = \pi D_2 B_2 V_{f2}$

$$V_{f2} = \frac{Q}{\pi D_2 B_2} = \frac{0.118}{\pi \times 0.25 \times 0.05} = 3.0 \; m/s$$

$$\eta_{man} = \frac{gH_m}{V_{w2}u_2} \quad \frac{9.81 \times 25}{V_{w2} \times 18.98}$$

$$V_{w2} = \frac{9.81 \times 25}{0.75 \times 18.96} = 17.23$$

from outer velocity Triangle

$$\tan\phi = \left(\frac{V_{f2}}{u_2 - V_{w2}}\right) = \left(\frac{3}{18.98 - 17.23}\right) = 1.7134$$

Q-(5) Given that

D = 0.8 m

N = 1000 rpm

Tangential Velocity of wheel $U = \frac{\pi D N}{60} = \frac{\pi \times .8 \times 1000}{60} = 41.887902$ m/s

H = 400 m

$\phi = 15^\circ$

$Q = .150\ m^3/s$

Velocity of jet at inlet $V_1 = C_v\sqrt{2gH} = 1\sqrt{2 \times 9.81 \times 400}$

$V_1 = 88.589$ m/s

(i) Power available at the nozzle is given by equation

$$W.P = \frac{W \times H}{1000} = \frac{\rho \times Q \times g \times H}{1000} = \frac{1000 \times 9.81 \times .150 \times 400}{1000}$$

$= 588.6$ KW

(2) Hydraulic efficiency is given by equation

$$h_h = \frac{2(V_1 - U)(1 + \cos\phi) \times U}{V_1^2}$$

$$= \frac{2(88.59 - 41.8879)(1 + \cos 15^\circ) \times 41.8879}{88.589^2}$$

$$= \frac{2 \times 46.7021 \times 1.9659 \times 41.8829}{88.589^2}$$

$$= \frac{7688.05741}{88.589^2}$$

$$= 0.9796$$

$$h_H = 97.96\,\%$$