BITS, PILANI-DUBAI CAMPUS, ACADEMIC CITY, DUBAI
SECOND SEMESTER 2012-2013
ME C332 PRIME MOVERS AND FLUID MACHINES

Comprehensive Examination

DATE: 10-06-13

DURATION: 3hrs MAXIMUM MARKS: 35 WEIGHTAGE: 35%

Notes: Steam tables are allowed.

Highlight all your answers by enclosing in boxes. Assume any missing data suitably and mention the same at the appropriate place in your answer. All the parts of the same question should be answered together.

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1. Define, give expression and explain the significance of the following Non dimensional numbers Euler number, Froude number and Mach number **3**

2. a. Explain the following efficiencies of the hydraulic turbines. Hydraulic efficiency, Mechanical efficiency, Volumetric efficiency and Overall efficiency.
   b. Draw the main and operating characteristics of Pelton wheel and Francis turbine and explain the salient points. **4**

3. The following data were obtained from a test on a Pelton wheel. Head at the base of the nozzle=32m, discharge of water from penstock in to the nozzle=0.18m^3/sec, area of the nozzle jet = 7500 sq.mm, discharge of water from the nozzle=0.18m^3/sec, power available at the output of the shaft=44kW, mechanical efficiency=94%.Calculate the power lost in the nozzle, power lost in the runner and power lost in mechanical friction. **4**

4. A centrifugal pump has the following characteristics. Outer diameter of the impeller =800mm, width of the vanes at the outlet =100mm, angle of impeller vanes at the outlet=40°.The impeller runs at 550 rpm and delivers 0.98 m^3/sec of water under an effective head of 35m.A 500kW motor is used to drive the pump. Determine the manometric, mechanical and overall efficiencies of the pump. Assume water enters the impeller vanes radially at the inlet. **4**

5. At a stage of a reaction turbine, the mean blade ring diameter is 1 m and turbine runs at 50rps.The blades are designed for 50% reaction with exit angle of 30 and inlet angle of 50.The turbine is supplied with steam of 60000kg/hr with an absolute velocity of 300m/sec and assuming a stage efficiency of 85% determine the power output from the turbine. Also calculate the isentropic enthalpy drop in the stage in (kJ/kg) and Percentage increase in the relative velocity through the blades. **4**

6. Prove from the fundamentals for a velocity compounded impulse turbine having two rows of moving blades with a row of fixed blades in between the optimum blade speed ratio is $\cos\alpha_1/4$, the maximum efficiency is $\cos^2\alpha_1$ and the maximum work is $8v^2$. **4**

7. An impulse turbine of the Delavel type is to develop 250kW with the steam consumption of 8kg/kW-hr. Steam being initially at 12 bar and dry saturated .the exhaust pressure is 1 bar. If the diameter at the throat of each nozzle is 6.25 mm find the number of nozzles required. Assuming 15% of the total enthalpy drop is lost in the diverging part of the nozzle, find the diameter at the exit of the nozzle and the quality of steam. **4**

8. Determine the size of the cylinder of a double acting compressor of 36.765 kW of indicated power in which air is drawn at 1 bar and compressed to 16 bar according to $PV^{1.25} = C$. The compressor runs at 300 rpm and the piston speed is 180 m/min. Take the clearance ratio as 5%. Also calculate the isothermal efficiency of the compressor. **4**

9. Air at a temperature of 17°C flows in to the centrifugal compressor running at 20000rpm. Using the following data slip factor=0.8,work input factor=1, isentropic efficiency =70%, outer diameter of blade tip =50cm. assuming the absolute velocities of air entering and leaving the compressor are same find the temperature rise of air passing through compressors and the static pressure ratio. Take Cp for air =1 kJ/.kg-K and γ for air=1.4. **4**

III yr. Mechanical Engg

ME C332 PMFM Comprehensive Examinations

Date 10-6-13 Scheme of Valuation

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(3) Given:-

$H = 32m$ $Q = 0.18\ m^3/sec$ from penstocks. Area of Nozzle $= 7500\ mm^2$

Q from the Nozzle $= 0.18\ m^3/sec$ $P_4 = 44\ kW$ $\eta_{mech} = 94\%$

Power lost in the nozzle = $\left.\begin{array}{l}\text{power at the}\\ \text{inlet of the nozzle}\end{array}\right\}$ − power at the outlet of Nozzle.

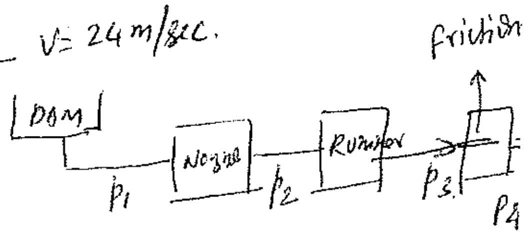
$= p_1 - p_2$

$p_1 = WQH = \frac{9810 \times 0.18 \times 32}{1000} = 56.51\ kW$

$p_2 = \frac{1}{2}(\rho Q) v^2$ $V = \frac{Q}{A} = \frac{0.18}{7500 \times 10^{-6}}$ $V = 24\ m/sec.$

$p_2 = 51.84\ kW$

$p_1 - p_2 = 4.67.$



Power lost in runner $= p_2 - p_3$.

$51.84 - 46.81$

$5.03\ kW$

$\eta_{mech} = \frac{p_4}{p_3}$

$p_3 = \frac{44}{0.94}$

$p_3 = 46.81\ kW$

power lost in friction $= \left.\begin{array}{l}p_3 - p_4\\ 46.81 - 44\end{array}\right\} = 2.81\ kW$

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(4) Centrifugal pump

Given $D_2 = 800mm$ $N = 550\ rpm$

$B_2 = 100mm.$ $Q = 0.98\ m^3/sec$

$\beta_2 = 40$ $H = 35m$

$P_{motor} = 500\ kW$

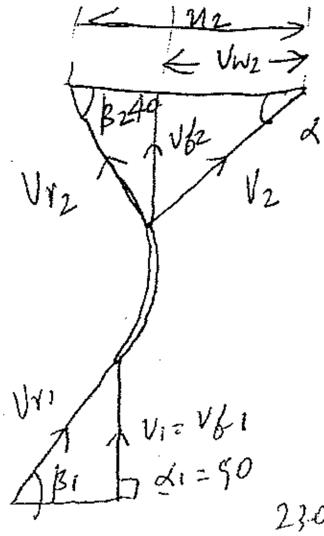
$Q = \pi D_2 B_2 \times V_{f2}$

$0.98 = \pi \times 0.8 \times 0.1 \times V_{f2}$

$V_{f2} = 3.9\ m/sec$

To find η_{mano}, η_{mech} and $\eta_{overall}$.

$$\eta_{mano} = \frac{gH}{V_{w_2} u_2} \times 100$$



$$u_2 = \frac{\pi D_2 N}{60} = \frac{\pi \times 0.8 \times 550}{60}$$

$$\boxed{u_2 = 23.04 \text{ m/sec}}$$

$$\tan\beta_2 = \frac{V_{f2}}{u_2 - V_{w2}}$$

$$\tan 40 = \frac{3.9}{23.04 - V_{w2}}$$

$$23.04 - V_{w2} = 4.65$$

$$\boxed{V_{w2} = 18.39 \text{ m/sec}}$$

$$\eta_{mano} = \frac{9.81 \times 35}{18.39 \times 23.04} \times 100$$

$$\boxed{\eta_{mano} = 81.04\ \%}$$

$$\text{Shaft power} = wQH_m$$

$$= \frac{9810 \times 0.98 \times 35}{1000}$$

$$= 336.5 \text{ kW}$$

$$\eta_0 = \frac{\text{Shaft power}}{\text{Motor power}}$$

$$= \frac{336.5}{500} \times 100$$

$$\boxed{\eta_0 = 67.3\ \%}$$

$$\eta_0 = \eta_{mech} \times \eta_{mano}$$

~~$\eta_0 = 0.673 \times 0.8104$~~

~~$\boxed{\eta_0 = 0.545}$~~

$$\eta_{mech} = \frac{\eta_0}{\eta_{mano}} = \frac{67.3}{81.04}$$

$$\boxed{\eta_{mech} = 83.05\ \%}$$

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(5) Reaction turbine

$D = 1\text{m}$

$N = 50$ rps.

50% reaction

$\beta_2 = 30$

$\beta_1 = 50$

$\dot{m} = 60 \times 10^3$ kg/hr

$\eta_{stage} = 85\ \%$

$V_{f1} = V_{f2}$

To find P, ΔH, $\frac{V_{r2} - V_{r1}}{V_{r1}} \times 100$

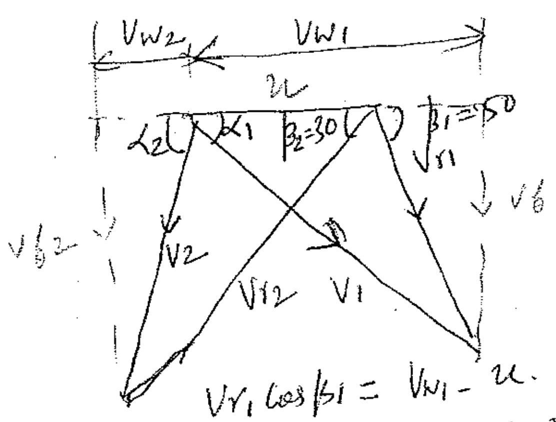
$\alpha_1 = 30 = \beta_2$

$\alpha_2 = 50 = \beta_1$

$u = \pi D N = \pi \times 1 \times 50$

$$\boxed{u = 157.1 \text{ m/sec}}$$

$V_1 = 300$ m/sec.



$$\text{power output} = \frac{\dot{m}\,[V_{w1} + V_{w2}]\,u}{1000} \text{ kW}$$

$$= \frac{\dot{m}\,[V_{r1}\cos\beta_1 + V_{r2}\cos\beta_2]\,u}{1000}$$

$$V_{r1}\cos\beta_1 = V_{w1} - u.$$

$$V_{r1} = \frac{V_1\cos\alpha_1 - u}{\cos\beta_1}$$

$$= \frac{300 \times \cos 30 - 157.1}{\cos 50}$$

$$\boxed{V_{r1} = 159.78 \text{ m/sec}}$$

$$p = \frac{\frac{60 \times 10^3}{3600} \times \left[159.78 \cos 50 + 300 \cos 30\right] \times 157.1}{1000}$$

$$\boxed{p = 949.2 \text{ kW}}$$

We have $\eta_s = \frac{(\Delta h)_{act}}{(\Delta h)_{isent}}$

$\Delta h_{isent} = (\Delta h)_{act} / \eta_s$

$= \text{Workdone} \times$

$= \frac{56.95 \times}{0.85}$

$$\boxed{(\Delta h)_{isen} = 67 \text{ kJ/kg}}$$

% increase in relative velocity $= \left(\frac{V_{r2} - V_{r1}}{V_{r1}}\right) \times 100$

$= \frac{300 - 159.78}{159.78} \times 100$

$$\boxed{87.8\%}$$

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(8) Double acting Compressor:

$p = 36.765$ kW

$p_1 = 1$ bar

$p_2 = 16$ bar

$pV^{1.25} = C$

$N = 300$ rpm

$2LN = 180$ m/min

$\frac{V_c}{V_s} = 5\%$

$\eta_{iso} =$

To find D, L and η_{iso}

$$p = \frac{n}{n-1} p_1 V_{a1} \left[\left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} - 1\right]$$

$$36.765 = \frac{1.25}{0.25} \times 100 \times V_{a1} \times \left[16^{\frac{0.25}{1.25}} - 1\right]$$

$$\boxed{V_{a1} = 0.09922 \text{ m}^3/\text{sec}}$$

$$\text{Stroke Volume/cycle} = \frac{V_{a1} \times 60}{N \times 2 \times \eta_v}$$

$$\eta_v = 1 - \frac{V_c}{V_s}\left[\left(\frac{p_2}{p_1}\right)^{\frac{1}{n}} - 1\right]$$

$$\boxed{\eta_v = 0.5905}$$

$$V_s = \frac{0.09922 \times 60}{300 \times 2 \times 0.5905}$$

$$\boxed{V_s = 0.0168 \text{ m}^3}$$

$2LN = 180$

$L = \frac{180}{2 \times 300}$

$$\boxed{L = 0.3 \text{ m}}$$

$$\eta_{iso} = \frac{p_{iso}}{p_{act}}$$

$$\frac{\pi D^2}{4} \times L = 0.0168$$

$$\boxed{D = 0.267 \text{ m}}$$

$$p_{iso} = \ln\left(\frac{p_2}{p_1}\right)$$

$$\frac{n}{n-1}\left\{\left[\frac{p_2}{p_1}\right]^{\frac{0.25}{1.25}} - 1\right\}$$

$$\eta_{iso} = \frac{2.77}{3.71} \times 100$$

$$\boxed{\eta_{iso} = 74.82\%}$$

(9) Given

$T_1 = 17°C = 290 K$ $\quad C_p = 1\ kJ/kg\text{-}K$

$N = 20000$ rpm $\quad \gamma = 1.4$

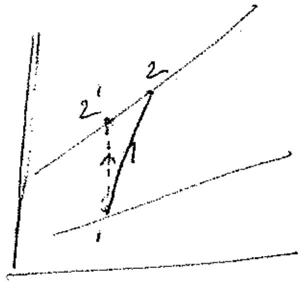
$D_2 = 50$ cm $\quad$ Slip factor $= 0.8 = \phi_s$.

$\eta_{isent} = 70\%$. $\quad$ Work factor $= 1$

Sol $\quad U_2 = \frac{\pi D N}{60} = \frac{\pi \times 0.5 \times 20000}{60}$ $\quad \boxed{U_2 = 523.6\ m/sec}$

Work done/kg of air $= U_2^2 \times \phi_s = 523.6^2 \times 0.8$

$\boxed{\text{Workdone/kg of air} = 219.32\ kJ/kg.}$



Work done is also given by $= C_p(T_2 - T_1)$

$219.32 = 1\ (T_2 - T_1)$

$T_2 - T_1 = 219.32.$

$T_2' - T_1 = (T_2 - T_1) \times 0.7 = 219.32 \times 0.7$

$\boxed{T_2' = 443.52\ K}$

$\eta_i = \frac{T_2' - T_1}{T_2 - T_1}$

$T_2 - T_1 = \frac{T_2' - T_1}{0.7}$

$\frac{p_2}{p_1} = \left(\frac{T_2'}{T_1}\right)^{\frac{\gamma}{\gamma-1}} = \left(\frac{443.52}{290}\right)^{\frac{1.4}{0.4}}$

$\boxed{\frac{p_2}{p_1} = 4.42}$

$\frac{V_1^2}{2} + h_1 = \frac{V_2^2}{2} + h_2$

$\frac{V_2^2}{2} = \frac{V_1^2}{2} + (h_1 - h_2)$

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7) $P = 250$ kW $\quad p_1 = 12$ bar $\quad p_3 = 1$ bar $\quad d_2 = 6.25$ mm $\quad$ 15% Loss in diverging part.

Steam $= 8$ kg/kw-hr $\quad x_1 = 1$

$\frac{p_2}{p_1} = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}} = \left(\frac{2}{2.135}\right)^{\frac{1.135}{0.135}}$

$\dot m = \frac{A_2 V_2}{v_2}$ $\quad h_2 = 2690$

$h_1 = 2782.7$ kJ/kg

$p_2 = 12 \times 0.577$ $\quad x_3 = 0.862$ $\quad h_3 = 2370$ (from chart)

$V_2 = \sqrt{2000\ (2782.7 - ~~2370~~\ 2690)}$

$p_2 = 6.93$ bar

$\boxed{V_2 = ~~908.52\ m/sec~~}$

$v_2 = 0.3\ m^3/kg.$

$\boxed{p_2 \simeq 7\ bar.}$

$\dot m = \frac{\pi}{4} \times (6.25 \times 10^{-3})^2 \times ~~430.6~~ / 0.3$

$\boxed{V_2 = 430.6\ m/sec}$

Steam consumption $= \frac{250 \times 8}{3600} = 0.555$ kg/sec

$\boxed{~~\dot m = 0.0186\ kg/sec~~}$

$\boxed{\dot m = 0.044\ kg/sec}$

$V_3 = \sqrt{V_2^2 + 2000(h_2 - h_3)}$

No of Nozzle $= ~~28.86~~$

$\boxed{13\ \text{nozzles}}$

$\boxed{V_3 = 854.1\ m/sec} = \sqrt{430.6}$

BITS, PILANI-DUBAI CAMPUS, ACADEMIC CITY, DUBAI
SECOND SEMESTER 2012-2013

ME C332 PRIME MOVERS AND FLUID MACHINES

TEST 2(Open book)

DATE: 13-05-13

DURATION: 50 MINUTES MAXIMUM MARKS: 15 WEIGHTAGE: 15%

(Text book, photo copy of EDD notes and hand written class notes are allowed)

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1. 20kg/min of steam flows through a convergent divergent nozzle. The condition of steam supplied is 12 bar, 200°C and the discharge pressure is 1 bar. The expansion is supersaturated up to the throat and is in thermal equilibrium afterwards. Calculate the diameter of the nozzle at the throat and the exit. **5**

2. Find out the maximum efficiency and maximum work and the corresponding speed ratio of a three stage impulse turbine with frictionless symmetrical blading and axial discharge in the final stage if the nozzle angle of the first stage moving blade is 20° and the blade velocity is 120m/sec.

   At a stage of a Parson's reaction turbine the velocity of steam striking the moving blades is 350m/sec and the mean rotor diameter is 1.6m.The blade speed ratio (ρ) is 0.8.Determine the blade inlet angle if the blade outlet angle is 20°. Find the diagram efficiency. **5**

3. Steam with an absolute velocity of 300m/sec is supplied through a nozzle to a single stage impulse turbine. The nozzle angle is 25°.The mean diameter of the blade rotor is 100cm and it has a speed of 2000rpm. Find suitable blade angles for zero axial thrust. Take blade velocity coefficient as 0.9 and steam flow rate as 10kg/sec. calculate the power developed by the turbine in kW. **5**

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III yr. Mech. Engg

ME C332 PMFM Test 2 13-5-2013

(2)

$\eta_{max} = \cos^2\alpha_1$

$\eta_{max} = 0.883$

$\rho = \frac{\cos\alpha_1}{6}$

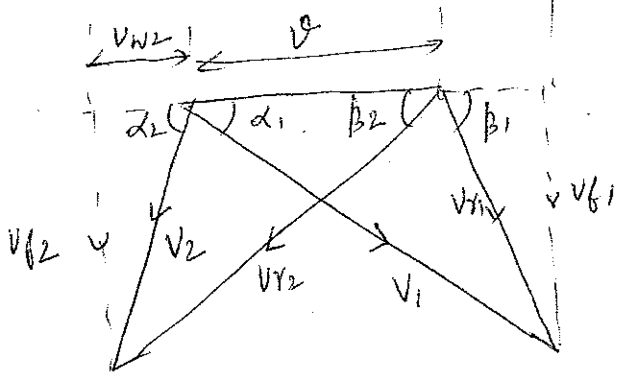
$\rho = 0.157$

$W_{max} = 18v^2$

$= 18 \times 120^2$

$W_{max} = 259.2 \frac{kJ}{kg}$.

parson's reaction turbine



Given

$V_1 = 350 m/sec$

$D = 1.6 m$

$\rho = 0.8$

$\frac{v}{V_1} = 0.8$

$v = 0.8 \times 350$

$v = 280 m/sec$

$\beta_2 = 20° = \alpha_1$

To find

β_1 and η.

$\tan\beta_1 = \frac{V_{f1}}{V_{w1} - v} = \frac{350 \sin 20}{350\cos 20 - 280}$

$\beta_1 = 67.78°$

$\eta = \frac{[V_{w1} + V_{w2}] v}{\text{Energy Supplied}} \times 100$

$V_{w2} = V_2 \cos\alpha_2$

$= V_{r1} \cos\beta_1$

$= V_1 \cos\alpha_1 - v$

$V_{w2} = 350\cos 20 - 280$

$V_{w2} = 48.89 m/sec$

$E = \text{Energy Supplied} = \frac{V_1^2}{2} + \frac{(V_{r2}^2 - V_{r1}^2)}{2}$

$= \frac{2V_1^2 - V_{r1}^2}{2}$

$E = 1,14,140.8$

$W.D = [V_{w1} + V_{w2}] v$

$W.D =$ ~~1,14,140.8~~ 105778.4

$\eta = \frac{105778.4}{114140.8} \times 100$

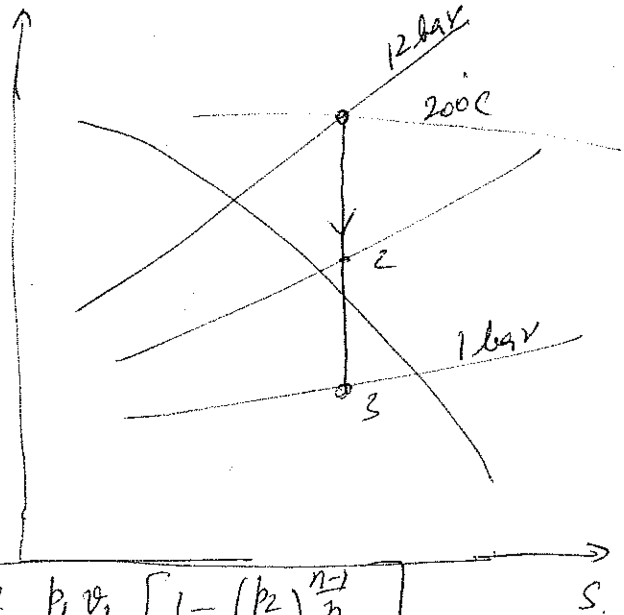
$\eta = 92.67\ \%$

① . Given

$\dot{m} = 20\ kg/min$

$p_1 = 12\ bar$, $T_1 = 200°C$

$p_3 = 1\ bar$



$$\frac{p_2}{p_1} = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}} = \left(\frac{2}{2.3}\right)^{\frac{1.3}{0.3}} = 0.5457$$

$$\boxed{p_2 = 6.55\ bar}$$

$$V_2 = \sqrt{2\frac{n}{n-1} p_1 v_1 \left[1 - \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}\right]}$$

$$V_2 = \sqrt{2 \times \frac{1.3}{0.3} \times 12 \times 10^5 \times 0.1692 \times \left[1 - (0.5457)^{\frac{0.3}{1.3}}\right]}$$

12 bar, 200°C from tables

$v_1 = 0.1692\ m^3/kg$

~~$V_2 = 151.5\ m/sec$~~ $\boxed{V_2 = 479.1\ m/sec}$

$\frac{N}{m^2} \times \frac{m^3}{kg} = \frac{kg\ m \times m^3}{sec^2 \times m^2 \times kg}$

$$\dot{m} = \frac{A_2 V_2}{v_2}$$

$$v_2 = v_1 \left[\frac{p_1}{p_2}\right]^{\frac{1}{n}} = 0.1692 \left[\frac{12}{6.55}\right]^{\frac{1}{1.3}}$$

$$\boxed{v_2 = 0.2696\ m^3/kg}$$

$$T_2 = T_1 \left[\frac{p_2}{p_1}\right]^{\frac{n-1}{n}} = 473 \times [0.5457]^{\frac{0.3}{1.3}}$$

$T_2 = 411.3K$

$\boxed{T_2 = 138.3°C}$

$$\frac{20}{60} = \frac{A_2 \times 479.1}{0.2696}$$

$\boxed{A_2 = 1.876 \times 10^{-4}} = \frac{\pi D_2^2}{4}$

$\boxed{D_2 = 15.45\ mm.}$

~~h_2 for $p_2 = 6.55\ bar$, $T_2 = 138.3°C$.~~

If the expansion is in equilibrium

$S_1 = S_3 = S_{f3} + x_3 S_{fg3}$ (1 bar)

$6.587 = 1.303 + x_3 \times 6.057$

$\boxed{h_1 = 2814.4\ kJ/kg}$ $\boxed{x_3 = 0.8723}$

$$V_3 = \sqrt{2000(h_1 - h_3)}$$

$h_3 = 417.5 + 0.8723 \times 2257.9$

$\boxed{h_3 = 2387.24\ kJ/kg}$

$$\dot{m} = \frac{A_3 V_3}{v_3} \qquad = \sqrt{2000 \times (2814.4 - 2387.24)}$$

~~$V_3 = 1307.14\ m/sec$~~

$\boxed{V_3 = 924.3\ m/sec}$

$v_3 = x_3 v_{g3} = 0.8723 \times$ ~~1.1622~~ 1.6938

$\boxed{v_3 = }$ ~~$0.1424\ m^3/kg$~~ 1.478

$$\frac{20}{60} = \frac{A_3 \times 924.3}{\cancel{0.1424}\ 1.478}$$

$\boxed{D_3 = 2.61\ mm}$

(3). $V_1 = 300$ m/sec

$\alpha_1 = 25^\circ$

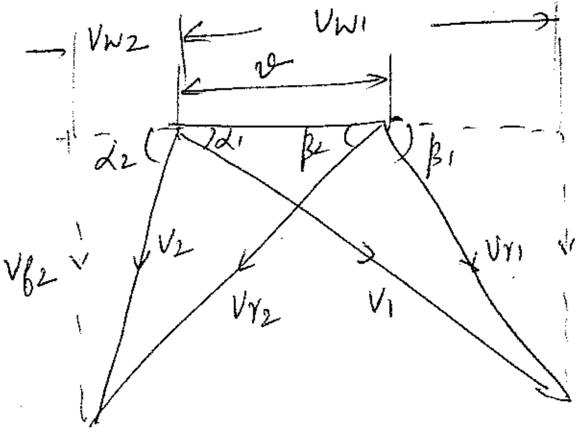
$D = 100$ cm

$N = 2000$ rpm $k = 0.9$

$\dot{m} = 10$ kg/sec

To find β_1, β_2

power



$v = \frac{\pi D N}{60} = \frac{\pi \times 0.1 \times 2000}{60}$

~~$v = 10.47$ m/sec~~

$v = 104.72$

$\tan\beta_1 = \frac{V_{f1}}{V_{w1} - v}$

$\tan\beta_1 = \frac{V_1 \sin\alpha_1}{V_1 \cos\alpha_1 - v} = \frac{300 \sin 25}{300 \cos 25 - \sout{10.47}\ 104.72} = \sout{0.48498}\ 0.758$

~~$\beta_1 = 25.87$~~

$\beta_1 = 37.18$ ✓

$\sin\beta_1 = \frac{V_{f1}}{V_{r1}}$

$V_{r1} = \frac{V_{f1}}{\sin\beta_1} = \frac{300 \sin 25}{\sin \sout{25.87}\ 37.18}$

~~$V_{r1} = 290.54$ m/sec~~

$V_{r1} = 209.81$

$V_{r2} = k V_{r1}$

$= 0.9 \times \sout{290.54}\ 209.81$

~~$V_{r2} = 261.49$ m/sec~~

$V_{r2} = 188.83$ ✓

$\sin\beta_2 = \frac{V_{f2}}{V_{r2}}$

for zero axial thrust $V_{f1} = V_{f2}$

$V_{f2} = 300 \sin 25 = 126.79$ m/sec

$\beta_2 = \sin^{-1}\left[\frac{126.79}{\sout{261.49}\ \sout{209.81}\ 188.83}\right] = 0.6715$

~~$\beta_2 = 29$~~ ~~37.18~~

$\beta_2 = 42.18^\circ$

$V_{w1} = 300 \cos 25$

$V_{w1} = 271.89$

The power Developed $= \dot{m}\left[V_{w1} + V_{w2}\right] v$

$= \dot{m}\left[V_{r1}\cos\beta_1 + V_{r2}\cos\beta_2\right] v$

$= 10 \times \left[\sout{290.54}\ 209.81 \cos \sout{25.87}\ 37.18 + \sout{261.49 \cos 29}\right] \times 10.47$

$= 10 \times \left[209.81 \times \cos 37.18 + 188.83 \times \cos 42.18\right] \times 104.72$

$P = 321.6$ kW

~~$P = 51.32$ kW~~

BITS, PILANI-DUBAI, ACADEMIC CITY, DUBAI
SECOND SEMESTER 2012-2013

ME UC332 PRIME MOVERS AND FLUID MACHINES

TEST 1

DATE: 18-03-13

DURATION: 50 MINUTES **MAXIMUM MARKS: 15** **WEIGHTAGE: 15%**

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1. Define Unit speed and Specific speed of a turbine and explain the use of these parameters. A turbine develops 8MW under a head of 50 m at 135 rpm. What is the specific speed of the turbine? What would be its normal speed and output under a head of 20 m? **4**

2. Explain how hydraulic turbines are classified.
Explain the difference between the Francis turbine and the Kaplan turbine with respect to its construction, operation and performance. **5**

3. Single jet Pelton turbine is required to drive a generator to develop 10MW. The available head at the nozzle is 760m.Assuming electrical generator efficiency of 95%, Pelton wheel overall efficiency of 87%, coefficient of velocity for the nozzle 0.97, mean bucket velocity 0.46 of jet velocity, outlet angle of the buckets is 15° and the blade velocity coefficient (K) as 0.85 of the inlet find a. the diameter of the jet, b. the flow rate of water, and c. the force exerted by the jet on the buckets **6**

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III yr - Mechanical Engg.

PRIME MOVERS AND FLUID MACHINES

Test 1 18-3-13 Scheme of Valuation

(1) unit speed & Sp. speed - Definitions and use of the Parameters - (1½)

Given $p = 8000$ kW
$H = 50$ m
$N = 135$ rpm

$$N = \frac{N\sqrt{P}}{H^{5/4}} = \frac{135\sqrt{8000}}{50^{5/4}}$$

$$\boxed{N = 90.82 \text{ rpm}}$$ → (1)

unit speed should be same

$$\frac{N}{\sqrt{H}} = \frac{N_1}{\sqrt{H_1}} \quad N_1 = \frac{N \times \sqrt{H_1}}{\sqrt{H}} = \frac{135 \times \sqrt{20}}{\sqrt{50}} = \boxed{N_1 = 85.4 \text{ rpm}}$$

unit power should be same

$$\frac{P}{H^{3/2}} = \frac{p_1}{H_1^{3/2}} \quad p_1 = p \times \left(\frac{H_1}{H}\right)^{3/2} = 8000 \times \left(\frac{20}{50}\right)^{3/2}$$

$$\boxed{p_1 = 2023.9 \text{ kW}}$$ (1½)

(2) Classification of turbines - (2)

Construction - (1)

Working - (1)

Performance - (1)

(3) Given

$P_g = 10000\ kW$

$H = 760\ m$

$\eta_{gen} = 95\%$

$\eta_0 = 87\%$

$C_v = 0.97$

$\frac{u}{V_1} = 0.46$

$\beta = 15^\circ$

$k = 0.85$

To find

d, Q, Force.

$P = \frac{10000}{0.95} = 10526.32\ kW$

$\eta_0 = \frac{P}{wQH}$

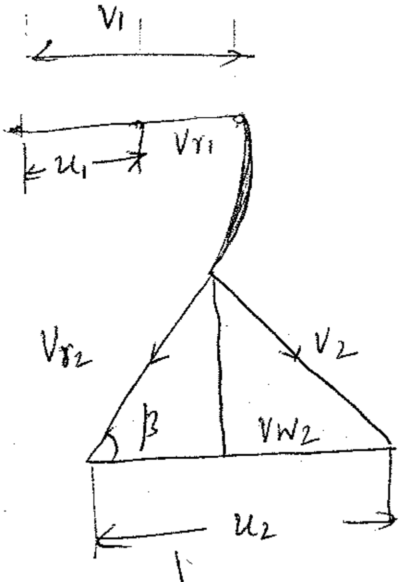
$0.87 = \frac{10526.32 \times 10^3}{9810 \times Q \times 760}$

$\boxed{Q = 1.623\ m^3/sec}$ → (2)

$Q = \frac{\pi}{4} \times d_1^2 \times C_v \sqrt{2gH}$ ($V_1 = 118.45$)

$1.623 \times 10^{-3} = \frac{\pi}{4} \times d_1^2 \times 118.45$

$\boxed{d_1 = 13.2\ cm}$ → (1)



(1)

$V_{w1} = V_1 = 118.45$

$u_1 = u_2 = 0.46 \times V_1$

$u_1 = 54.5\ m/sec$

$\boxed{V_{r1} = 63.95}$

$V_{r2} = k V_{r1}$

$= 0.85 \times 63.95$

$\boxed{V_{r2} = 54.36}$

$V_{w2} = u_2 - V_{r2} \cos\beta$

$= 54.5 - 54.36 \times \cos 15$

$\boxed{V_{w2} = 1.99\ m/sec}$

$F = \rho Q [V_{w1} - V_{w2}]$

$F = 1000 \times 1.63 \times [118.45 - 1.99]$

$\boxed{F = 189.8\ kN}$ → (2)

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BITS, PILANI-DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
SECOND SEMESTER 2012-2013

ME UC332 PRIME MOVERS AND FLUID MACHINES

QUIZ2 (29-04-13)

DURATION: 20 MINUTES MAXIMUM MARKS: 10 WEIGHTAGE: 5%
Answer all the questions

Name of the student: ----------------------------------- Id.: ---------------------------

1. Write down the fundamental equation of a centrifugal pump?

2. What do you mean by priming in centrifugal pump and how it is done?

3. What is critical pressure ratio in steam nozzles? Give an expression for the critical pressure ratio in terms of index of expansion.

4. A centrifugal pump is designed to run at a speed of 1000 rpm and develops a total head of 25m. What would be the total head developed when the speed changes to 1500rpm if the overall efficiency is the same.

5. What is Wilson line and what is the significance of it in steam nozzles?

6. Name the three types of impellers that are commonly employed in centrifugal pumps.

7. Explain what degree of under cooling in steam nozzle is.

8. A centrifugal pump works under a head of 20m and the blade velocity at the outlet is 40m/sec. Assuming a manometric efficiency of 75% determine the velocity of whirl at the outlet of the blades.

9. Steam expands in a nozzle from 5bar to 1 bar. The initial velocity is 100m/sec. The isentropic enthalpy drop for the steam is 200kJ/kg and the nozzle efficiency is 85%. Estimate the final velocity of the steam.

10. Explain what nozzle efficiency is.

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BITS, PILANI-DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
SECOND SEMESTER 2012-2013

ME UC332 PRIME MOVERS AND FLUID MACHINES

QUIZ2 **(29-04-13)**

DURATION: 20 MINUTES MAXIMUM MARKS: 10 WEIGHTAGE: 5%
Answer all the questions

Name of the student: ----------------------------------- Id.: ---------------------------

1. Write down the fundamental equation of a centrifugal pump?

$$\frac{V_2^2 - V_1^2}{2g} + \frac{V_{r1}^2 - V_{r2}^2}{2g} + \frac{u_2^2 - u_1^2}{2g} = H_m + \Delta H_m$$

2. What do you mean by priming in centrifugal pump and how it is done?

Removing the air pockets is priming. It is done by filling the water up to delivery valve before starting the pump.

3. What is critical pressure ratio in steam nozzles? Give an expression for the critical pressure ratio in terms of index of expansion.

$$\left(\frac{p_2}{p_1}\right)_{critical} = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$$

4. A centrifugal pump is designed to run at a speed of 1000 rpm and develops a total head of 25m. What would be the total head developed when the speed changes to 1500rpm if the overall efficiency is the same.

$$H \propto N^2$$

$$\frac{H_1}{N_1^2} = \frac{H_2}{N_2^2}$$

$$\frac{25}{1000^2} = \frac{H_2}{1500^2}$$

$$H_2 = 56.25\,m$$

5. What is Wilson line and what is the significance of it in steam nozzles?

Wilson line gives the limit of super saturated flow in Nozzles. The pr at which the condensation would start is determined by this line.

6. Name the three types of impellers that are commonly employed in centrifugal pumps.

a) Shrouded (or) closed type impeller

b) Semi-open type impeller

c) Open type impeller.

7. Explain what degree of under cooling in steam nozzle is.

$(T_{sat} - T_{actual})$ for supersaturated flow is degree of under cooling.

8. A centrifugal pump works under a head of 20m and the blade velocity at the outlet is 40m/sec. Assuming a manometric efficiency of 75% determine the velocity of whirl at the outlet of the blades.

$$\eta_m = \frac{gH_m}{V_{w_2} u_2}$$

$$0.75 = \frac{9.81 \times 20}{V_{w_2} \times 40}$$

$$V_{w_2} = 6.54 \text{ m/sec}$$

9. Steam expands in a nozzle from 5bar to 1 bar. The initial velocity is 100m/sec. The isentropic enthalpy drop for the steam is 200kJ/kg and the nozzle efficiency is 85%. Estimate the final velocity of the steam.

$$V_2 = \sqrt{V_1^2 + 2(h_1 - h_2) \times 10^3 \times 0.85}$$

$$= \sqrt{100^2 + 2(200) \times 10^3 \times 0.85}$$

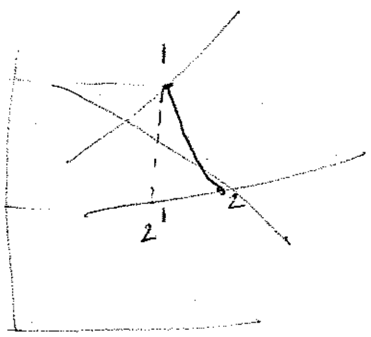
$$V_2 = 591.6 \text{ m/sec}$$

591.6 m/sec

10. Explain what nozzle efficiency is.

$$\eta_N = \frac{(\Delta h)\ actual}{(\Delta h)\ isentropic}$$

$$\eta_N = \frac{h_1 - h_2}{h_1 - h_2'}$$



BITS, PILANI-DUBAI, DUBAI
SECOND SEMESTER 2012-2013
ME UC332 PRIME MOVERS AND FLUID MACHINES

A

QUIZ1

1-04-2013

DURATION: 20 MINUTES MAXIMUM MARKS: 10 WEIGHTAGE: 5%

Answer all the questions (10*1 = 10 marks)

Name: **Id No. :**

---

1. A pelton turbine produces 20 MW while running at a speed of 1000rpm. If the overall efficiency of the turbine is 80%, calculate the discharge through the turbine.

2. Draw the inlet and outlet velocity diagram for a Kaplan turbine runner and represent the various velocity components and the angles.

3. State the name of the turbine you will recommend for the following cases.
High head and small qty of water –
Medium head and medium qty of water –
Small head and large quantity of water –

4. A single cylinder double acting reciprocating pump lifts 100 liters of water per second against a static head of 40m. If the slip is 5% estimate the coefficient of discharge of the pump.

5. State the condition for the maximum efficiency and give the expression for the max efficiency in terms of K & β for a Pelton wheel.

6. What do you mean by a mixed flow turbine? Name a practical turbine in which mixed flow takes place.

7. Find out whether separation will occur or not in the reciprocating pump if the atmospheric pressure is 10.3 m of water, the suction head is 7m, the maximum values of acceleration head and the frictional head in the suction are 3.3m and 3m of water respectively. The vapor pressure head for water may be taken as 2.6m of water.

8. Draw the speed versus discharge curve at different gate openings of a Kaplan turbine

9. How many blades are generally used in a Kaplan turbine runner? What are the reasons?

10. Give an expression for the acceleration head of a reciprocating pump in terms of length and area of the pipes, piston area, crank angle and crank radius.

BITS, PILANI-DUBAI, DUBAI
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A

QUIZ1

1-04-2013

DURATION: 20 MINUTES MAXIMUM MARKS: 10 WEIGHTAGE: 5%
Answer all the questions (10*1 = 10 marks)

Name: **Id No. :**

---

1. A pelton turbine produces 20 MW while running at a speed of 1000rpm. If the overall efficiency of the turbine is 80%, calculate the discharge through the turbine.

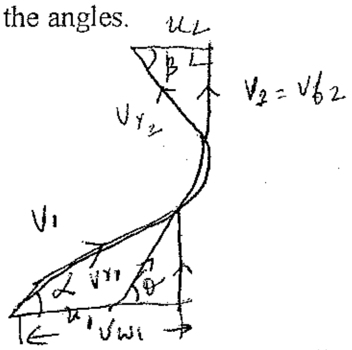
$P = 2000$ kW
$N = 1000$ rpm

$\eta_0 = \frac{P}{WQH}$

$Q =$

$0.8 = \frac{2000 \times 10^3}{9810 \times Q \times H}$

2. Draw the inlet and outlet velocity diagram for a Kaplan turbine runner and represent the various velocity components and the angles.



3. State the name of the turbine you will recommend for the following cases.
High head and small qty of water – Pelton
Medium head and medium qty of water – Francis
Small head and large quantity of water – Kaplan.

4. A single cylinder double acting reciprocating pump lifts 100 liters of water per second against a static head of 40m. If the slip is 5% estimate the coefficient of discharge of the pump.

$Q_a = 100$ lit/sec
$H = 40$ m
$\text{slip} = \left(\frac{Q_t - Q_a}{Q_t}\right) \times 100$

$1 - C_d = 0.05$

$C_d = 0.95$

5. State the condition for the maximum efficiency and give the expression for the max efficiency in terms of K & β for a Pelton wheel.

Condition

$u = \frac{V}{2}$

$\text{Max } \eta = \frac{1 + K\cos\beta}{2}$

6. What do you mean by a mixed flow turbine? Name a practical turbine in which mixed flow takes place.

→ Radial entry and axial exit

— Francis turbine.

7. Find out whether separation will occur or not in the reciprocating pump if the atmospheric pressure is 10.3 m of water, the suction head is 7m, the maximum values of acceleration head and the frictional head in the suction are 3.3m and 3m of water respectively. The vapor pressure head for water may be taken as 2.6m of water.

To avoid separation

$H_a = 10.3$ $h_{vap} = 2.6$

$h_s = 7m$

$h_{as} = 3.3$

$h_{fs} = 3$

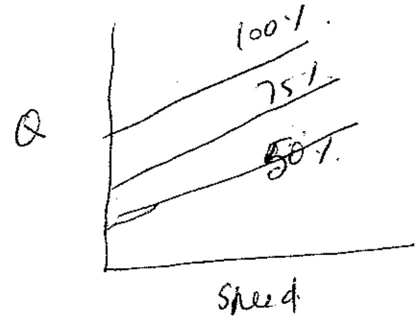
The pr at the beginning of suction

$= H_{atm} - h_s - h_{as} > h_{vap}$

$10.3 - 7 - 3.3 = 0$

Since it is less than h_{vap}, separation would occur.

8. Draw the speed versus discharge curve at different gate openings of a Kaplan turbine



9. How many blades are generally used in a Kaplan turbine runner? What are the reasons?

4 to 6

Less no of blades are used so that we can have large area of flow and large Qty of water to be able to flow through the turbine.

10. Give an expression for the acceleration head of a reciprocating pump in terms of length and area of the pipes, piston area, crank angle and crank radius.

$h_{as} = \frac{l_s}{g} \frac{A}{a_s} \omega^2 r \cos\theta$