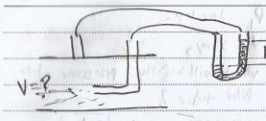
15 March 2014 শনিবার ১ চৈত্র, ১৪২০ বাং ১৩ জমা আউঃ ১৪৩৫ হিঃ জুপিটার পাবলিকেশনস



$V = \sqrt{2gh\left(\frac{S_m}{S} - 1\right)}$

Sp. Gravity S_m = Oil or fluid in Manometer

Sp. Gravity S = Flowing fluid

$S_m = .91$

$S_{air} = .002$

$\therefore V = 29.85 \text{ m/s}$ Ans

For sphere

$\frac{\theta}{\theta_i} = e^{-Bi\,Fo} = e^{-\frac{ht}{\rho cr}}$ for sphere

$Bi = \frac{h_c r}{k}$

$\therefore \alpha = \frac{k}{\rho c}$ $\therefore Fo = \frac{\alpha t}{r^2} = \frac{kt}{\rho c r^2}$

প্রতিভাবান ব্যক্তিরাই ধৈর্যধারণ করতে পারে। - স্টেডম্যান

জুপিটার পাবলিকেশনস রবিবার ২ চৈত্র, ১৪২০ বাং ১৪ জমা আউঃ ১৪৩৫ হিঃ March 2014 16

35th BCS Written Exam

Mechanical Problems Solution

3(b) A steel ball [$c = .46$ kJ/kg-k, $k = 35$ W/m-kJ] 5.0 cm in diameter & initially at a uniform temp. of 450°C is suddenly placed in a controlled environment in which the temp is maintained at 100°C. The convective heat transfer coefficient is 10 W/m²k. Calculate the time required for the ball to attain a temp. of 150°C.

Ans:- Given, $D = 5 \text{ cm} = .05 \text{ m}$

$c = .46$ kJ/kg-k

$h = 10$ W/m²k

$k = 35$ W/m-kJ

$\rho = 7800$ kg/m³

$T_i = 450°C = 723$ k

$T_\infty = 100°C = 373$ k

$T_2 = 150°C = 423$ k

We know, Transient heat conduction

$\frac{T_2 - T_\infty}{T_i - T_\infty} = \frac{423 - 373}{723 - 373} = e^{-\frac{10 \times t}{7800 \times .46 \times .05}}$

কুসংস্কার মানুষকে বানায় বোকা, আর সন্দেহ তাকে করে পাগল। - টমাস ফুলার

17 March 2014 সোমবার ৩ চৈত্র, ১৪২০ বাং ১৫ জমা আউঃ ১৪৩৫ হিঃ জুপিটার পাবলিকেশনস

$\Rightarrow 0.143 = e^{-.056t}$

$\Rightarrow \ln(.143) = \ln e^{-.056t}$

$\Rightarrow -1.945 = -.056t$

$\Rightarrow t = 34.73$ sec

Ans:- 34.73 sec

(c) Calculate the net radiant interchange per unit area for two large planes at Temp. of 540°C & 315°C respectively. Assume that the emissivity of the hot & cold plates are 0.9 & 0.7 respectively.

Given, $T_1 = 540°C = 813k$, $\varepsilon_1 = 0.9$

$T_2 = 315°C = 588k$, $\varepsilon_2 = 0.7$

$\sigma = 5.67 \times 10^{-8}$ W/m²k⁴

We know, for long Plates large Plates :-

$\frac{Q_{1-2}}{A} = \sigma F_{12}\left(T_1^4 - T_2^4\right)$, $F_{12} = \frac{1}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$

$= 5.67 \times 10^{-8} \times .65\left(813^4 - 588^4\right) = 0.65$

ভালো কাপড় আড়াল তৈরি করতে পারে কিন্তু বোকা কথায় তার বোকামি প্রকাশ করে দেয়। - ঈশপ

জুপিটার পাবলিকেশনস মঙ্গলবার ৪ চৈত্র, ১৪২০ বাং ১৬ জমা আউঃ ১৪৩৫ হিঃ March 2014 18

$\frac{Q_{12}}{A} = 11.695$ kW/m²

Ans:- 11.695 kW/m²

4(a) A reservoir 100m long & 100m wide is provided with a rectangular notch 2m long. Find the time required to lower the water level in the reservoir from 2m to 1m if $C_d = .6$.

Given, long = 100m, wide = 100m, height = 2m, $C_d = .6$, Notch $L_n = 2$m, $t = ?$

Total volume of water $V = 20000$ m³

Last volume of water $V_2 = 10000$ m³

time required = $\frac{V_1 - V_2}{Q}$

We know, discharge from a rectangular weir notch

$Q = \frac{2}{3} C_d \sqrt{2g}\, L H^{3/2}$

$= \frac{2}{3} \times 0.6 \times \sqrt{2 \times 9.81} \times 2 \times (2)^{3/2}$

$= 10 \text{ m}^3/\text{s}$

$\therefore t = \frac{10000}{10} = 1000 \text{ sec} = 16 \text{ min } 40 \text{ sec}$

যে পরিশ্রম করে, বিশ্রাম তারই জন্য আরামদায়ক। - ব্যটলার

Ans

(b) Two reservoirs are connected by three pipes laid in parallel. Their diameter are d, 2d, & 3d. What will be the discharge through each of the larger pipes, if the smallest pipe is discharging $1 m^3/s$.

Ans. Given, $Q_1 = 1 m^3/s$, $d_1 = d$

$Q_2 = ?$, $d_2 = 2d$

$Q_3 = ?$, $d_3 = 3d$

We know,

$Q = \rho A V$

$1 m^3/s = \frac{\pi d^2}{4} V$

$\Rightarrow V d^2 = 4/\pi$ ....(1)

[Let, $\rho = 1$ because only one type of fluid is working]

[V = velocity constant as parallel connection]

Similarly $Q_2 = \rho A_2 V$

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

$= \frac{\pi \, 4d^2}{4} V$ [Putting the value of (1)]

$= \pi \times 4/\pi$

$= 4 m^3/s$

Similarly $Q_3 = \rho A_3 V$

$= \frac{\pi (3d)^2}{4} \times V$

$= \frac{\pi}{4} 9 d^2 V$ [Putting the value of (1)]

$= \frac{\pi}{4} 9 \times \frac{4}{\pi}$

$= 9 m^3/s$

Ans; $(4 m^3/s$ & $9 m^3/s)$

5(c) A pelton wheel has a mean bucket speed of 12 m/s & is supplied with water at the rate of 750 litres/sec under head of 35 m. If the buckets deflect the jet through an angle of 160°, find the power & efficiency of the turbine. Take $C_v = .98$

Given, $u = 12 m/s$

$Q = 750$ lt/sec $= 0.75 m^3/s$

$\rho = 1000 kg/m^3$ (water) $h = 35 m$, $C_v = 0.98$

mass of water $m = Q \times \rho$

$= .75 \times 1000 = 750$ kg/s

$\theta = 160°$

We know, Power $P = m\{(V-u)(1+k\cos\phi)\}u$

Jet velocity $V = C_v \sqrt{2gh} = .98\sqrt{2 \times 9.81 \times 35}$

$= 25.68$ m/s

$u = 12$ m/s

$k = 1$ (neglecting friction in buckets)

$\cos\phi = \cos(180 - \theta)$

$\cos\phi = \cos(180° - 160°)$

$\cos\phi = \cos 20°$

So power is $P = 750 \times \{(25.68 - 12)(1 + \cos 20)\} 12$

$= 238816$ W

$= 238.81$ kW

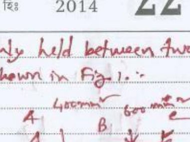
$\eta_{hy} = \frac{2u(V-u)(1+k\cos\phi)}{V^2} = \frac{2 \times 12 \cdot (13.68)(1.9397)}{(25.68)^2}$

$= .965$

$= 96.6$ %

Ans: 238.81 kW, 96.6 %

6(b) A steel rod ABC is firmly held between two rigid support A & C. As shown in Fig. 1. Find the stress developed in the two portions of the rod where it is heated through 15 K. Take $\alpha = 12 \times 10^{-6}/K$ & $E = 200$ GPa.



Given, $T = 15 K$, $\alpha = 12 \times 10^{-6}/K$

$E = 200$ GPa

$A_1 = 400 mm^2 = 4 \times 10^{-4} m^2$

$A_2 = 600 mm^2 = 6 \times 10^{-4} m^2$

$l_1 = 50$ cm $= .5$ m

$l_2 = 80$ cm $= .8$ m

~~Thermal stress $\frac{P}{A} = \sigma_{th} = \alpha T E = 12 \times 10^{-6} \times 15 \times 200 \times 10^9$~~

~~$= 36 \times 10^6$ Pa~~

$\delta l_{th_1} = l_1 \times \alpha T$

$= .5 \times 12 \times 10^{-6} \times 15$

$= 9 \times 10^{-5}$ m

$\delta l_{th_2} = l_2 \times \alpha T$

$= .8 \times 12 \times 10^{-6} \times 15$

$= 1.44 \times 10^{-4}$ m

~~δl_{AB}~~ ~~δl_{BC}~~

$\delta l_1 + \delta l_2 = \delta l_{th_1} + \delta l_{th_2}$

$\frac{PL_1}{A_1E} + \frac{PL_2}{A_2E} = 9\times10^{-5} + 1.44\times10^{-4}$

$P\left(\frac{.5}{4\times10^{-4}\times200\times10^{9}} + \frac{.8}{6\times10^{-4}\times200\times10^{9}}\right) = 2.34\times10^{-4}$

$P(1.292\times10^{-8}) = 2.34\times10^{-4}$

$P = 18111.4$ Pa
$= 18.11$ kPa

$\sigma_{AB} = \frac{P}{A_1} = \frac{18\times10^3}{4\times10^{-4}} = .45$ GPa

$\sigma_{BC} = \frac{P}{A_2} = \frac{18\times10^3}{6\times10^{-4}} = 30$ GPa

Ans: 45 GPa, 30 GPa

(7) (b) An engine works between the temp. limits of 1000°C & 0°C. What can be the max thermal efficiency of the engine.

Given $T_1 = 1000°C = 1273$ K
$T_2 = 0°C = 273$ K

max efficiency $\eta_{carnot} = 1 - \frac{T_2}{T_1}$
$= 1 - \frac{273}{1273}$
$= 78.55\%$

Ans.

(c) 0.1 m³ of air at a pressure of 1.5 bar is expanded isothermally to 0.5 m³. Calculate the final pressure & heat supplied during the process.

Given $V_1 = 0.1\,m^3$ $P_1 = 1.5 = 151.2$ kPa
$V_2 = 0.5\,m^3$ $P_2 = ?$

$P_1V_1 = P_2V_2$

$\therefore P_2 = \frac{P_1V_1}{V_2} = \frac{151.2\times10^3\times0.1}{0.5} = 30.24$ kPa

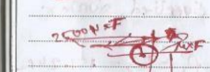
$P_1V_1 = P_2V_2 = 15120$ J $= 15.12$ kJ

$Q = W = 2.3 P_1V_1 \log\left(\frac{V_2}{V_1}\right)$
$= 24307$ J
$= 24.30$ kJ

Ans

(8) (c) Find the power transmitted by a belt over a pulley of 60cm diameter at 200 rpm. The coefficient of friction between the belt & pulley is 0.25, angle of lap 160° & max tension in the belt is 2500 N.

Given, Pulley dia D = 60cm = .6m
rpm n = 200 rpm
f = .25
θ = 160°
2500 N = T_1



T = (F − μF) × d/2
= 562.5 N·m

P = 2πNT/60
= 2 × 3.1416 × 200 × 562.5 / 60
= 11.78 kW

We know

$2.3 \log\left(\frac{T_1}{T_2}\right) = \mu\theta$
$= .25 \times \frac{160\times\pi}{180}$
$= 0.698$

$\therefore \ln\left(\frac{T_1}{T_2}\right) = 0.698$

$\frac{T_1}{T_2} = e^{0.698} = 2.01$

$\therefore T_1 = 2.01\times T_2$

$\therefore T_2 = T_1/2.01 = 1243.8$ N

Velocity $v = \frac{\pi d N}{60}$
$= \frac{3.1416\times.6\times200}{60}$
$= 6.28$ m/s

Power $P = (T_1 - T_2)\times6.28$
$= 7888.9 \approx 7889$ W
$\simeq 7.8$ kW Ans

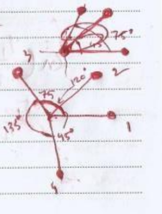
9(c) Four masses 200kg, 300kg, 240kg & 260kg are rotating in the same plane of a shaft. The corresponding radii of rotation are .2m, .15m, .25m, .3m & the angles between successive masses are 45°, 75° & 135°. Find the position & magnitudes of the balance mass required if its radius of rotation is .2m.

$m_1 = 200$ kg, $m_2 = 300$ kg, $m_3 = 240$ kg, $m_4 = 260$ kg

$r_1 = .2$ m, $r_2 = .15$ m, $r_3 = .25$ m, $r_4 = .3$ m

$\theta_1 = 0°$, $\theta_2 = 45°$, $\theta_3 = 120°$, $\theta_4 = 255$

$r_R = .2$ m



$m_1 r_1 = 40$ kg.m

$m_2 r_2 = 45$ kg.m

$m_3 r_3 = 60$ kg.m

$m_4 r_4 = 78$ kg

$\Sigma X = m_1 r_1 \cos 0° + m_2 r_2 \cos 45° + m_3 r_3 \cos 120° + m_4 r_4 \cos 255$

$= 21.63$

$\Sigma Y = m_1 r_1 \sin 0° + m_2 r_2 \sin 45° + m_3 r_3 \sin 120° + m_4 r_4 \sin 255$

$= 8.44$

$\therefore R = \sqrt{(-13.33)^2 + (28.63)^2} = 31.57$ kg.m

$m = R/r = 31.57/.2 = 157.85$ kg

$R = \sqrt{(21.63)^2 + (8.44)^2} = 23.21$

$m = R/r = 23.21/.2 = 116.05$ kg

$\tan\theta' = \frac{\Sigma Y}{\Sigma X} =$

$\theta' = 21.32$

$\therefore \theta = 180 + 21.32 = 201.32$

10(c) A Shaft of length .75m, Supported freely at the ends, is carrying a body of mass 90kg at .25m from one end. Find Natural frequency of Transverse vibration. Assume E = 200 GN/m² & Shaft Dia = 5cm

Given

for shaft traverse vibration

$A = \frac{\pi d^2}{4} = 1.96 \times 10^{-3}$ m²

$\delta = \frac{Wl^3}{3EI}$

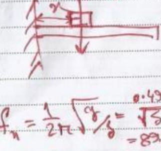
$W = 90 \times 9.81 = 882.9$ N

$I = \frac{\pi}{64}(d)^4 = 3 \times 10^{-6}$ m⁴

$\delta = \frac{W x^2 (3l - x)}{6EI}$

$= \frac{882.9 \times .25^2 (3 \times .75 - .25)}{6 \times 200 \times 10^9 \times 3 \times 10^{-6}}$

$= 3.06 \times 10^{-5}$ m



$f_n = \frac{1}{2\pi}\sqrt{g/\delta} = \frac{0.498}{\sqrt{\delta}} = 89.9$ Hz

$= 90$ Hz

Ans

Department

← Prep ←

Date

11(e) A 4-stroke diesel engine has a cylinder bore of 150mm & a stroke of 250mm. The crank shaft speed is 300rpm & the fuel consumption is 1.2kg/hr. having a calorific value of 39900 kJ/kg. The indicated mean effective pressure is 5.5bar. If the comp ratio is 15 & cut off is 1.8, calculate the $\eta_{ind\ thermal}$ & air standard efficiency.

Given, $d = 150$ mm $= .15$ m, $l = 250$ mm $= .25$ m

$n = 300$ rpm, $f = 1.2$ kg/hr

$P_m = 5.5$ bar $= 557.3 \times 10^3$ Pa, C.V $= 39{,}900$ kJ/kg

$A = \frac{\pi d^2}{4} = 0.01767$

$r = 15$

$\rho = 1.8$

We know, Indicated power

$I.P = \frac{100\ k P_m L A N}{60}$ $k = 1$

let, $\gamma = 1.4$

$= \frac{100 \times 1 \times 557.3 \times 10^3 \times .25 \times 0.01767 \times 300}{60}$

$= 1230.93$ kW

$\eta_{ith} = \frac{I.P}{m \times C.V} = \frac{1230.93 \times 10^3}{\frac{1.2}{3600} \times 39900 \times 10^3}$

$\eta_{air} = 1 - \frac{1}{r^{\gamma-1}}\left[\frac{\rho^\gamma - 1}{\gamma(\rho - 1)}\right] = 92.55\ \%$

Date . .

air standard efficiency

$$\eta_{air} = 1 - \frac{1}{\rho^{\gamma-1}}\left[\frac{\rho^{\gamma}-1}{\gamma(\rho-1)}\right]$$

$$= 1 - \frac{1}{15^{.4}}\left[\frac{1.8^{1.4}-1}{1.4(1.8-1)}\right]$$

$$= 1 - \frac{1}{15^{0.4}}\left(\frac{1.277}{1.12}\right)$$

$$= 1 - \frac{1.14}{15^{0.4}} = 0.614$$

$$= 61.4\ \%$$ Ans

Ans: ~~92.55 %~~
61.4 %

12-(b) A large vertical plate 4.0 m high is maintained at 60°C & exposed to atmospheric air at 10°C. Calculate the heat transfer if the plate is 1m wide.

Given, $H = 4m$, $T_1 = 60°C = 333K$
$W = 1m$, $T_\infty = 10°C = 283K$
$\therefore A = 4m^2$

Let, h = convective heat transfer coefficient = 5
$= 5 W/m^2K$

$\therefore$ We know

$Q = hA\,dT$
$= 5 \times 40 \times 50$
$= 10000\ W$
$= 10\ kW$ Ans:- 10kW