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Prelims Through Questions

for

ESE 2021

Mechanical Engineering

Day 3 of 11

Q.91 - Q.140

(Out of 500 Questions)

Machine Design + Power Plant Engineering

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Q.91 In a differential band brake, the diameter of drum is 600 mm and the width of band is 100 mm. If the normal pressure between the drum and the lining is limited to 0.3 N/mm^2 and the ratio of tight side tension to slack side tension is 2, the torque capacity is

(a) 2700 N-m (b) 1350 N-m

(c) 1350π N-m (d) 2700π N-m

91. (b)

$$\text{Radius of drum, } R = \frac{D}{2} = \frac{600}{2} = 300 \text{ mm}$$

$$\text{Width of band, } w = 100 \text{ mm}$$

As we know, $p_{max} = \frac{T_1}{Rw}$, where, T_1 = Tight side tension

$$0.3 = \frac{T_1}{300 \times 100}$$

$$\Rightarrow T_1 = 9000 \text{ N}$$

As given, $\frac{T_1}{T_2} = 2$

$$\Rightarrow \frac{9000}{2} = T_2$$

$$T_2 = 4500 \text{ N}$$

$$\text{Torque capacity, } T = (T_1 - T_2)R$$

$$= (9000 - 4500) \times 0.3 = 1350 \text{ N-m}$$

Q.92 A single plate clutch can transmit a torque of 440 N-m. The inner and outer diameter of friction lining is 20 cm and 30 cm respectively. What is the value of coefficient of friction according to uniform wear theory if the permissible pressure is 1 MPa?

(a) 0.112 (b) 0.224

(c) 0.386 (d) 0.286

92. (a)

$$T = \frac{1}{2}\mu W(R_o + R_i)$$

$$= \frac{1}{2}\mu \times \left[p_{per} \times 2\pi R_i (R_o - R_i)\right](R_o + R_i)$$

$[\because W = 2\pi R_i (R_o - R_i) P_{per}]$

$$T = \frac{1}{2}\mu \times \left[1 \times 10^6 \times 2\pi \times 10 \times \frac{(30-20)}{2} \times 10^{-4}\right]\frac{(30-20)}{2} \times 10^{-2}$$

$$440 = \frac{1}{2}\mu \times 100\pi \times 25$$

$$\mu = \frac{880 \times 7}{25 \times 100 \times 22} = \frac{0.4 \times 7}{25} = 0.112$$

Alternate solution:

$$T = \mu\, p_{per}\, r_i \times \pi(r_o^2 - r_i^2)$$

$$\Rightarrow \quad 440 = \mu \times 1 \times 0.1 \times \pi(150^2 - 100^2)$$

$$\mu = \frac{440}{0.1 \times \pi \times 12500} = \frac{440 \times 7}{0.1 \times 22 \times 12500} = \frac{14}{125} = 0.112$$

Q.93 Notch sensitivity factor is defined as the ratio of

(a) Actual stress to theoretical stress.

(b) Increase of actual stress over nominal stress to increase of theoretical stress over nominal stress.

(c) Theoretical stress to actual stress.

(d) Increase of theoretical stress over nominal stress to increase of actual stress over nominal stress.

93. (b)

$$\text{Notch sensitivity factor, } q = \frac{\text{Increase of actual stress over nominal stress}}{\text{Increase of theoretical stress over nominal stress}}$$

Notch sensitivity is defined as the susceptibility of a material to succumb to the damaging effects of stress raising notches in fatigue loading.

Q.94 A journal bearing of 60 mm diameter is subjected to a radial load of 25 kN. The shaft supported on the bearing is rotating at 1400 rpm. If the coefficient of friction is 3×10^{-3}, the heat generated is

(a) 154 W (b) 330 W

(c) 298 W (d) None of these

94. (b)

$$\mu = 3 \times 10^{-3}$$

$$\text{Radial load, } W = 25 \text{ kN} = 25000 \text{ N}$$

Now, $\text{Heat generated, } H_g = \mu WV$

$$= 3 \times 10^{-3} \times 25000 \times \frac{\pi \times 60 \times 1400}{60 \times 1000}$$

$$= 3 \times 25 \times \frac{22}{7} \times \frac{14}{10} = 330 \text{ W}$$

Q.95 A pair of straight teeth spur gears used to transmit power has module of 6 mm and face width of 60 mm. The pinion has 30 teeth. Assume external gearing. If the gear ratio is 3 : 1 and material combination factor is 1.25 N/mm^2, the wear strength is

(a) 40.50 kN (b) 20.25 kN

(c) 16.2 kN (d) 13.5 kN

95. (b)

Material combination factor, $K = 1.25\ \text{N/mm}^2$

$$\text{Ratio factor, } Q = \frac{2G}{G+1} = \frac{2\times 3}{3+1} = \frac{2\times 3}{4} = 1.5$$

[for external gearing arrangement]

$$\text{Wear strength, } S_w = D_p\, bKQ = (mt)\, b\, K\, Q$$
$$= (6 \times 30) \times 60 \times 1.25 \times 1.5$$
$$= 20250\ \text{N} = 20.25\ \text{kN}$$

Q.96 Which of the following methods can increase shock absorbing capacity of bolts?

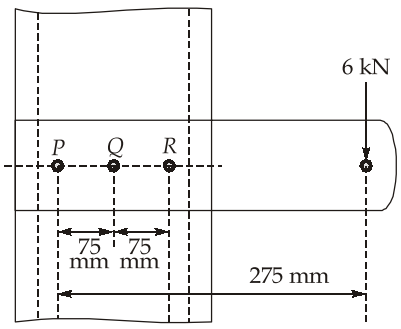
1. Reduce the shank diameter to core diameter of threads or even less.
2. Increase the length of shank portion of bolt.

(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

96. (c)

- The shock absorbing capacity of bolt can be increased, if the shank of bolt is turned down to a diameter equal to the root diameter of threads or even less. In this case, the shank is subjected to higher stress and hence, absorbs a greater proportion of strain energy and relieves the thread portion of high stress.
- The resilience of the bolt can also be increased by increasing its length. The strain energy absorbed by the shank is linearly propotional to its length.

Q.97 A steel plate fixed to a channel by means of three identical bolts, is subjected to a force of 6 kN. What will be the resultant shear force on bolt 'R'?

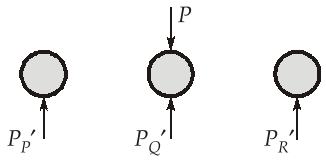


(a) 13 kN
(b) 8 kN
(c) 10 kN
(d) 6 kN

97. (c)

Primary shear force,

$$P_P' = P_Q' = P_R' = \frac{6}{3} = 2\ \text{kN}$$

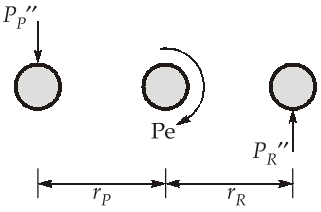


Secondary shear force, in bolt 'R'

$$\text{Pe} = \frac{P_R''}{r_R}\left(r_P^2 + r_R^2\right)$$

$$P_R'' = \frac{(Pe)r_R}{r_P^2 + r_R^2} \Rightarrow P_R'' = \frac{6 \times 200 \times 75}{75^2 + 75^2}$$

$$P_R'' = \frac{6 \times 200 \times 75}{2 \times 75^2} = \frac{6 \times 200}{150} = 8\ \text{kN}$$



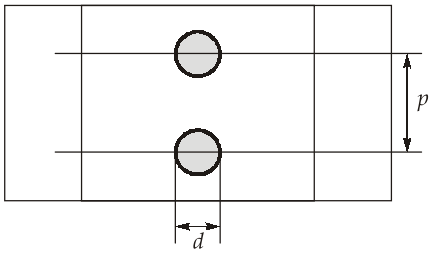
So, resultant shear force, $P_R = P_R' + P_R'' = 2 + 8 = 10\ \text{kN}$

Q.98 The tearing strength of plate having rivet holes is 20% lesser than the strength of solid plate. If the diameter of rivet hole is 25 mm, the pitch of the riveted joint is

(a) 31.25 mm (b) 125 mm

(c) 62.5 mm (d) None of these

98. (b)



$$\text{Tearing strength} = (1 - 0.2) \times \text{Strength of solid plate}$$

$$(p - d)t\sigma_t = 0.8 \times pt\sigma_t$$

$$(p - 25) = 0.8 \times p$$

$$p - 0.8p = 25$$

$$p = \frac{25}{0.2} = 125\ \text{mm}$$

Q.99 A ring flywheel of 600 mm diameter is mounted on a shaft rotating at mean angular velocity of 30 rad/s. The flywheel material has density of 7800 kg/m^3. What is the circumferential stress induced in the flywheel rim?

(a) 0.58 MPa (b) 0.79 MPa

(c) 0.83 MPa (d) 0.63 MPa

99. (d)

$$\text{Circumferential stress, } \sigma = \rho v^2 = \rho(R\omega)^2 = 7800 \times (0.3 \times 30)^2 \text{ N/m}^2$$

$$= \frac{7800 \times 81}{1000 \times 1000} \text{ N/mm}^2$$

$$\sigma = \frac{7.8 \times 8.1}{100} = 0.63 \text{ MPa}$$

Q.100 In velocity compounding, steam is passed through:

(a) fixed nozzle - moving blades - fixed blades - moving blades
(b) fixed nozzle - moving blades - fixed nozzles - moving blades
(c) moving blades - fixed nozzles - fixed blades - moving blades
(d) fixed blades - moving blades - fixed nozzles - moving blades

100. (a)

Q.101 Blow off cock in a boiler is used to:

(a) control the flow of steam from the boiler to the main pipe and to shut off the steam completely when required.
(b) empty the boiler when required and to discharge the mud, scale or sediments which are accumulated at the bottom of the boiler.
(c) put off fire in the furnace of the boiler when the level of water in the boiler falls to an unsafe limit.
(d) increase the temperature of saturated stream without raising its pressure.

101. (b)

- Blow off cock is used to empty the boiler whenever required and to remove the mud, scale or sediments accumulated at the bottom of the boiler.
- Fusible plug is used to put off the fire in the furnace of the boiler when the level of water in the boiler falls to an angle limit and thus avoids the explosion which may takes place due to overheating of the furnace plate.

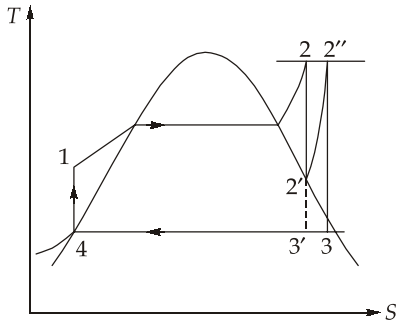
Q.102 The draught produced by a steam jet issuing from a nozzle placed in the ashpit under the fire grate of the furnace is called

(a) Induced steam jet draught
(b) Forced steam jet draught
(c) Chimney draught
(d) None of these

102. (b)

- Forced steam jet draught, here steam jerk is forcing the air and flue gases to flow through boiler hence it is forced steam jet draught.
- Induced stream jet draught, here steam jet is sucking the flue gases through boiler. This is employed in locomotive boilers.

Q.103 Considering the below T-s diagram of the Rankine cycle with reheat, which condition can improve the efficiency of the cycle slightly?



(a) The mean temperature of heat addition in process (1 - 2) should be higher than the mean temperature of heat addition in process (2′ – 2″).
(b) The mean temperature of heat addition in process (2′ – 2″) should be higher than the mean temperature of heat addition in process (1 - 2).
(c) The mean temperature of heat addition in process (2′ – 2″) should be equal to the mean temperature of heat addition in process (1 - 2).
(d) None of the above

103. (b)

$$\text{Efficiency} = \left[1 - \left(\frac{T_{mR}}{T_{mA}\uparrow}\right)\downarrow\right]\uparrow$$

Q.104 Consider the following statements regarding Jet condenser.
1. Jet condensers have direct contact between steam and cooling fluid.
2. Jet condensers have indirect heat exchange through metal interface and the two fluids do not come in direct contact to each other.
3. The circulating water requirement is much less in jet condenser as compared to other types of condensers.

Which of the statement(s) given above is/are incorrect?

(a) 2 only (b) 1, 2 and 3
(c) 1 and 3 only (d) 2 and 3 only

104. (a)

Jet condensers have direct contact between steam and cooling fluid thereby causing contamination of condensate. Due to direct contact of two fluids the circulating water requirement is much less in jet condenser as compared to other types of condensers. Space requirement and size of condenser etc. are also less with jet condensers. Surface condenser is advantageous over direct contact type condensers because any type of cooling fluid can be used in it and also there is no scope of contamination etc.

Q.105 Considers the following regarding fire tube boiler.

1. In fire tube boiler the hot products of combustion pass through the tubes, which are surrounded, by water.
2. For the same output the outer shell of fire tube boilers is much larger than the shell of water-tube boiler.

Which of the above statements is(are) correct?

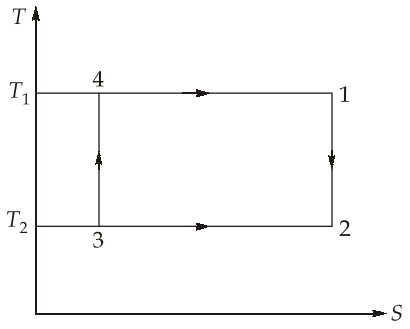
(a) 2 only (b) 1 only
(c) Both 1 and 2 (d) Neither 1 nor 2

105. (c)

- In fire tube boiler the hot products of combustion pass through the tubes, which are surrounded, by water.
- For the same output the outer shell of fire tube boilers is much larger than the shell of water-tube boiler.
- Water tube boilers require less weight of metal for a given size, are less liable to explosion, produce higher pressure, are accessible and can response quickly to change in steam demand.
- Water-tube boilers require lesser floor space. The efficiency of water-tube boilers is more.

Q.106 A steam cycle based on Carnot cycle principle is operating between 4 MPa and 10.13 kPa. Use the following steam properties:

Steam Pressure	Sat. Temp (K)	h_f (kJ/kg)	h_{fg} (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kgK)	s_g (kJ/kgK)
4.00 MPa	$T_1 = 523.33$	1087.40	1712.90	2800.30	2.7965	6.0685
10.13 MPa	$T_2 = 319.00$	192.89	2392.31	2585.20	0.6526	8.1466



What will be the efficiency of Carnot steam cycle?

(a) 32.03% (b) 29.02%
(c) 35.89% (d) 39.03%

106. (d)

The cycle efficiency is $\eta_c = \dfrac{(T_1 - T_2)}{T_1} \times 100 = \left(\dfrac{523.33 - 319.09}{523.33}\right) \times 100$

$= \left(\dfrac{204.24}{523.33}\right) \times 100 = 39.03\%$

Q.107 A shaft can safely transmit 90 kW while rotating at a given speed. If this shaft is replaced by a shaft of diameter double of the previous one and rotated at half the speed of the previous one, the power that can be transmitted by the new shaft will be:

(a) 90 kW (b) 180 kW

(c) 360 kW (d) 720 kW

107. (c)

$$\text{Power, } P = T \times \omega = \frac{T \times 2\pi N}{60}$$

and $$T = \frac{\pi}{16} d^3 \times \tau_{per} \quad \text{(material is same)}$$

$\therefore$ $$P \propto T \propto d^3$$

$$P \propto N$$

So, $$P \propto Nd^3$$

$$\frac{P_2}{P_1} = \frac{N_2 d_2^3}{N_1 d_1^3} = \frac{1}{2} \times 2^3 = 4$$

$$P_2 = 4P_1 = 4 \times 90 = 360 \text{ kW}$$

Q.108 Consider the following statements regarding design equations:

1. Gerber, Goodman and Soderberg equations are used in the design of the component when it is subjected to fatigue loading.
2. For completely reversed loading condition, strength criteria, Gerber, Goodman and Soderberg equations will give same result.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

108. (c)

Both the statements are true in case of completely reversed loading $\sigma_m = 0 \Rightarrow$ mean stress is zero.

So all design equation converted into

$$k_f \frac{\sigma_v}{\sigma_e} = \frac{1}{FOS}$$

$$k_f \sigma_v = \frac{\sigma_e}{FOS} \quad \text{(It is also representing strength criteria)}$$

Q.109 A pair of external mesh spur gears having 20 teeth pinion and 50 teeth gear with width 70 mm and module = 6 mm. The gear is made of plain carbon steel 45C8 (S_{ut} = 700 N/mm^2) and heat treated to a surface hardness of 300 BHN. The wear strength will be:

Take $k = 0.16\left(\frac{BHN}{100}\right)^2$

(a) 12.54 kN (b) 9.35 kN

(c) 14.93 kN (d) 17.28 kN

109. (d)

Given: $Z_p = 20;\ Z_g = 50$

width, $b = 70$ mm; module, $m = 6$ mm; BHN = 300

$$k = 0.16\left(\frac{BHN}{100}\right)^2$$

$$\Rightarrow \quad k = 0.16\left(\frac{300}{100}\right)^2$$

$$k = 1.44$$

Diameter of pinion $= d_p = mZ_p = 6 \times 20 = 120$ mm

$$Q = \frac{2Z_g}{Z_g + Z_p} = \frac{2(50)}{50+20} = \frac{2\times 5}{7} = \frac{10}{7}$$

The wear strength of the gear is,

$$S_w = bQ\, d_p K$$

$$= 70 \times \frac{10}{7} \times 120 \times 1.44$$

$$S_w = 17280 \text{ N}$$

$$S_w = 17.28 \text{ kN}$$

Q.110 Which of the following statements is correct with respect to selection of factor of safety?

1. Generally for components made up of ductile material, lesser factor of safety is used as compared to components made up of brittle material.
2. The factor of safety is independent from uncertainties in the magnitude of force acting on the component.
3. The factor of safety increases with increase in reliability of designed component.

(a) 1 only (b) 1 and 2

(c) 2 and 3 (d) 1 and 3

110. (d)

- In the ductile material, factor of safety is based on yield strength and in brittle material, factor of safety is based on ultimate tensile strength.
- Factor of safety depends upon uncertainties.

Q.111 Consider the following statements regarding pinch points in counter flow heat exchanger in Rankine cycle.

1. Pinch point is the point at which maximum temperature difference occurs between two fluids.
2. At pinch point thermal irreversibility of heat exchanger decreases.

Select the correct statement(s) using codes given below:

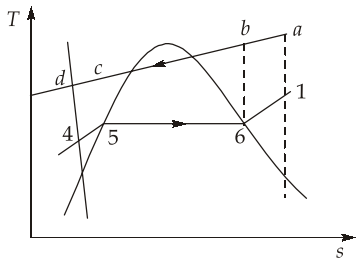
(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

111. (b)

The minimum temperature difference between the two fluids at c-5 and a-1 is shown in figure and the point where this occurs is called pinch point.

Too small a pinch point temperature difference causes a lower thermal (external) irreversibility and an increases in surface area resulting in a large expensive steam generator.



Q.112 Consider the following data related to axial flow compressor:

Mean blade velocity, u = 180 m/s; work input factor = 0.80; velocity of whirl at inlet, v_{w1} = 134 m/s, velocity of whirl at outlet, v_{w_2} = 34 m/s, air inlet temperature, T_1 = 27°C; Air exit temperature, T_2 = 327°C, specific heat of air, c_p = 1 kJ/kgK. What will be the number of stages for the compressor?

(a) 19 (b) 21

(c) 22 (d) 18

112. (b)

Theoretical work required per kg,

$$= c_p(T_2 - T_1)$$
$$= 1(327 - 27) = 300 \text{ kJ/kg}$$

Now, work done per stage $= u(v_{w_2} - v_{w_1}) \times$ work input factor

$$= 180(134 - 34) \times 0.8 \text{ J/kg}$$
$$= 14400 \text{ J/kg} = 14.4 \text{ kJ/kg}$$

Now number of stage, $$n = \frac{\text{Total work required}}{\text{Work required per stage}} = \frac{300}{14.4}$$

$$= 20.83 \simeq 21 \text{ stages}$$

Q.113 Consider the following statements regarding boiler in steam power plant:

1. Circulation ratio is defined as the ratio of mass flow rate of the saturated water through the down comer to the mass flow rate of the steam released from the boiler drum.
2. Forced circulation works below 150 bar boiler pressure whereas beyond 150 bar natural circulation is used.

Which of the above statements is/are INCORRECT?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

113. (b)

- Circulation ratio is defined as the ratio of mass flow rate of the saturated water through the down comer to the mass flow rate of the steam released from the boiler drum.
- The pressure difference depends on the height of the riser and the density difference between liquid and vapour difference. As the main boiler pressure increases the density difference decreases so normally natural circulation does not work beyond 150 bar whereas beyond a pressure of 150 bar we need to given the circulation from mechanical help in form of circulating pump called forced circulation.

Q.114 Consider the following data related to cooling tower:

Approach = 10°C, wet bulb temperature = 25°C, Hot water temperature at inlet = 42°C

What will be the approximate value of cooling tower efficiency?

(a) 53% (b) 41%

(c) 45% (d) 36%

114. (b)

$\therefore$ Approach = Cold water temperature at exit – wet bulb temperature

$\therefore$ 10°C = Cold water temperature at exit – 25°C

Cold water temperature = 35°C

Now, Range = Hot water temperature at inlet – cold water temperature at exit

$= 42 - 35 = 7°C$

$\therefore$ Cooling tower efficiency, $\eta = \dfrac{\text{Range}}{\text{Range} + \text{Approach}} \times 100$

$= \dfrac{7}{(7+10)} \times 100\% = 41.17\% \simeq 41\%$

Q.115 Which one of the following relationship corresponds to that of Parson's turbine?

α_1 = absolute velocity angle at inlet,

α_2 = absolute velocity angle at exit,

β_1 = blade angle at inlet,

β_2 = blade angle at exit,

V_1 = absolute velocity at inlet,

V_2 = absolute velocity at exit,

V_{r1} = relative velocity at inlet,

V_{r2} = relative velocity at exit,

(a) $\alpha_1 = \beta_1, \alpha_2 = \beta_2, V_1 = V_{r_1}, V_2 = V_{r_2}$

(b) $\alpha_1 = \beta_2, \alpha_2 = \beta_1, V_1 = V_{r_2}, V_2 = V_{r_1}$

(c) $\alpha_1 = \alpha_1, \beta_1 = \beta_2, V_1 = V_2, V_{r_1} = V_{r_2}$

(d) None of the above

115. (b)

In Parson's turbine,

$\alpha_1 = \beta_2, \alpha_2 = \beta_1$

$V_1 = V_{r2}, V_2 = V_{r1}$

Q.116 Consider the following statements regarding electrostatic precipitator:

1. Electrode composed of rows of electrically grounded vertical parallel plates is called the discharge electrode.
2. Electrode consists of wires, carries a unidirectional negatively charged high voltage current from an external DC source, is called collection electrode.

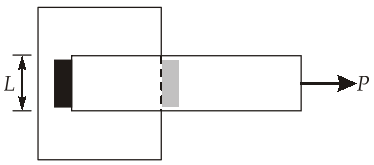
Select the correct statement using codes given below:

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

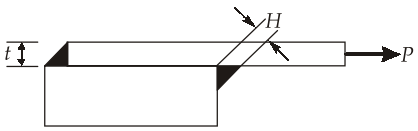
116. (d)

The principal components of an ESP are two sets of electrodes insulated from each other. The first set is composed of rows of electrically grounded vertical parallel plates, called the collection electrodes, between which the dust laden gas flows. The second set of electrodes consists of wires, called the discharge (or) emitting electrodes that are centrally located between each pair of parallel plates. The wires carry a unidirectional, negatively charged high voltage current from an external dc source.

Q.117 For the double fillet welds shown in figure, determine the shear stress (τ_{fillet}), where P = 9000 N; t = 1.0 cm; L = 5 cm



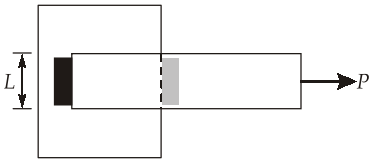
Top view



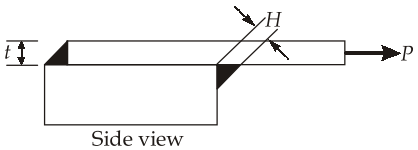
Side view

(a) 10.43 MPa (b) 12.73 MPa
(c) 11.21 MPa (d) 14.80 MPa

117. (b)



Top view



Side view

Substitute the given information in eq. to determine the (τ_{fillet}) as

$$\tau_{fillet} = \frac{P}{2A_{fillet}} = \frac{9000\,N}{1.414(0.01\,m)(0.05\,m)}$$

$$= 12729844.41\ N/m^2 = 12.73\ MPa$$

Q.118 Consider the following statements regarding fatigue:

1. It is the phenomenon of failure or fracture under fluctuating stresses.
2. It is phenomenon of failure or fracture under static stresses.
3. It is phenomenon of decrease in resistance of material under variable or cyclic loading.

Which of the above statements is/are correct?

(a) 1 only (b) 1 and 2
(c) 3 only (d) 1 and 3

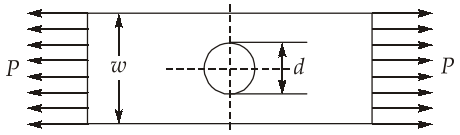
118. (d)

It is phenomenon of failure or fracture under fluctuating stresses or fatigue stresses having a magnitude less than yield strength (for ductile material) or ultimate strength (for brittle material)

OR

It can also defined as the decrease in resistance of material under variable or cyclic loading.

Q.119 Which of the following statements is true regarding given geometry?



(a) Theoretical stress concentration factor (k_t) is independent from $\left(\frac{d}{w}\right)$ ratio.

(b) Theoretical stress concentration factor (k_t) value increases as the $\left(\frac{d}{w}\right)$ ratio increases.

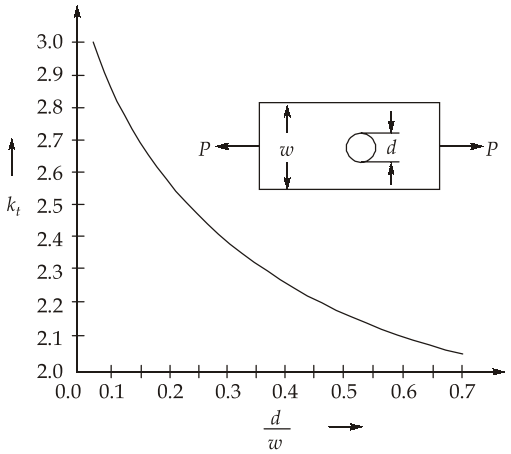
(c) Theoretical stress concentration factor (k_t) value decreases as the $\left(\frac{d}{w}\right)$ ratio increases.

(d) None of these

119. (c)

The variation of theoretical stress concentration can be observed from given graph,

with respect to the $\frac{d}{w}$ ratio



as $\frac{d}{w} \uparrow \Rightarrow k_t \downarrow$

and $\frac{d}{w} \downarrow \Rightarrow k_t \uparrow$

Q.120 A body is subjected to pure torsion having yield strength of 300 MPa and Poisson's ratio 0.5. The yield shear strength of the body according to maximum strain energy theory in MPa is

(a) 153 MPa (b) 200 MPa

(c) 173 MPa (d) 300 MPa

120. (c)

For pure torsion, $\sigma_1 = \tau, \sigma_2 = -\tau$

According to maximum strain energy theory,

$$\Rightarrow \quad \sigma_1^2 + \sigma_2^2 - 2\mu\sigma_1\sigma_2 = S_{yt}^2$$

$$\Rightarrow \quad \tau^2 + \tau^2 - 2\mu(\tau)(-\tau) = S_{yt}^2$$

$$\tau = S_{ys}$$

$$S_{ys} = \frac{S_{yt}}{\sqrt{2(1+\mu)}}$$

$$S_{yt} = 300 \text{ MPa}, \mu = 0.5$$

$$S_{ys} = \frac{300}{\sqrt{1.5\times 2}} = 173.20 \text{ MPa} \simeq 173 \text{ MPa}$$

Q.121 In forced circulation boilers 30% of water is converted into vapour and remaining is recirculated with the help of pump. Then what will be the circulation ratio for the given boiler?

(a) $\frac{7}{3}$ (b) $\frac{10}{3}$

(c) $\frac{3}{7}$ (d) $\frac{3}{10}$

121. (b)

Suppose $\dot{m}$ amount of total water flow.

$$m_v = 0.3\,\dot{m}$$

$$m_l = 0.7\,\dot{m}$$

$$\text{Circulation ratio, } CR = \frac{m_v + m_l}{m_v} = 1 + \frac{m_l}{m_v} = 1 + \frac{0.7}{0.3} = \frac{10}{3}$$

Q.122 In a power plant, the efficiencies of the electric generator, turbine (mechanical), boiler, cycle and the overall plant are 0.9, 0.9, 0.95, 0.4 and 0.27702 respectively. What percentage of the total electricity generated is consumed in running the auxiliaries?

(a) 80% (b) 90%

(c) 10% (d) 20%

122. (c)

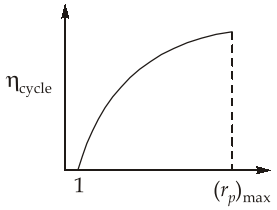
$$\eta_{Overall} = \eta_{Boiler} \times \eta_{Turbine(mech)} \times \eta_{Generator} \times \eta_{Cycle} \times \eta_{auxialiary}$$

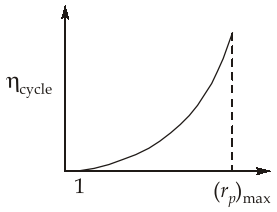
$$\eta_{auxialiary} = \frac{0.27702}{0.9 \times 0.9 \times 0.95 \times 0.4} = 0.9$$

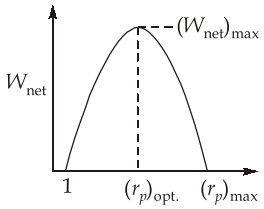
% of total electricity generated is consumed by auxiliaries,

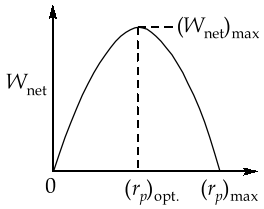
$$= (1 - \eta_{auxialiary}) \times 100\%$$
$$= (1 - 0.9) \times 100\% = 0.1 \times 100 = 10\%$$

Q.123 Which of the following curves are related to gas turbine power plant?

1.


2.


3.


4.


Select the correct answer using the codes given below:

(a) 1 and 3 (b) 2 and 3
(c) 1 and 4 (d) 2 and 4

123. (a)

- Till pressure ratio becomes 1 from zero cycle efficiency is zero and when it starts increasing from 1 cycle efficiency also increases parabolically.
- Initially net workout is zero when pressure ratio is zero and as pressure ratio increases work starts increasing and becomes maximum and then (W_{net}) starts decreasing.

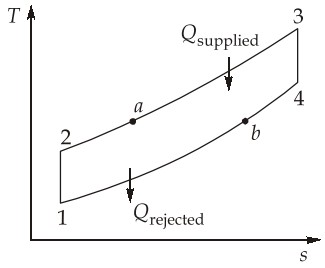
Q.124 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists in case of regeneration cycle in gas power plant:

List-I	**List-II**
A. Heat supplied	**1.** Increases
B. Heat rejected	**2.** Decreases
C. Work output	**3.** Remains unchanged
D. Cycle efficiency	**4.** Can't say

Codes:

	A	**B**	**C**	**D**
(a)	2	1	3	1
(b)	1	2	4	4
(c)	2	2	3	1
(d)	1	2	4	3

124. (c)



Regeneration cycle is shown in figure. In this cycle heat addition starts at point *a* instead of point 2 from combustion chamber so heat supplied decreases and similarly heat rejection to the surrounding started at point b instead of point 4 so heat rejection also decreases. In the cycle mean temperature of heat addition increases and mean temperature of heat rejection decreases so efficiency of cycle increases.

$$\eta = \left(1 - \left(\frac{T_{mR}\downarrow}{T_{mA}\uparrow}\right)\downarrow\right)\uparrow$$

Q.125 Consider the following statements regarding the use of condenser in steam power plant:

1. Reduction in the condenser pressure decreases the mass flow rate of steam through the condenser for the same power output of the turbine but it is limited by material conditions.
2. Condenser is used to recover high quality feedwater in the form of condensate and feed it back to the steam generator without any further treatment.

Which of the above statement is/are incorrect?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

125. (a)

- A condenser by decreasing the pressure, increases the plant efficiency and reduces the steam flow for a given output but it is limited by the temperature at which cooling water is available.
- To recover high quality feedwater in the form of condensate and feed it back to the steam generator without any further treatment.

Q.126 A sodium-mercury-steam tertiary cycle is used. All three cycles are combined coupled in series then what will be the efficiency of coupled (combined) tertiary cycle? (If $\eta_1 = 0.5$, $\eta_2 = 0.4$ and $\eta_3 = 0.4$)

(a) 0.92 (b) 0.82
(c) 0.74 (d) 0.66

126. (b)

Efficiency of combined tertiary cycle, $\eta = [1 - (1 - \eta_1)(1 - \eta_2)(1 - \eta_3)]$

$= 1 - (1- 0.5)(1- 0.4)(1- 0.4)$

$= 1 - 0.5 \times 0.6 \times 0.6 = 1 - 0.18 = 0.82$

Q.127 To prevent vapour lock and cavitation problems from occurring in the pump, the deaerator is installed

(a) at the basement
(b) at a sufficient height from the basement
(c) at the same level as the condenser
(d) at a site close to the boiler

127. (b)

Q.128 For 50% reaction axial compressor stage, following statements are given:

1. Velocity triangles at the entry and exit of the rotor are symmetrical.
2. The whirl or swirl component of absolute velocity at the entry of rotor and at the entry of stator are same.

Which of the above statement is/are correct?

(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

128. (a)

Q.129 In a boiler, the subcooled liquid enters at enthalpy 200 kJ/kg and exits at 10 bar pressure with quality of steam as 0.9. Enthalpy of saturated liquid and saturated vapour at 10 bar is 700 kJ/kg and 1700 kJ/kg respectively. What will be the efficiency of boiler?

Take steam generation rate = 6.3 tone/hr

Coal consumption = 0.7 tone/hr

Calorific value of coal = 30 MJ/kg

(a) 70%
(b) 62%
(c) 50%
(d) 42%

129. (d)

Energy added to water in boiler,

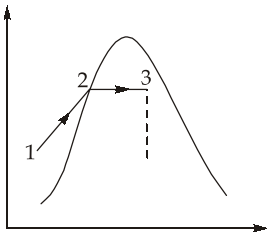
$$Q_s = h_3 - h_1$$

$$h_3 = h_f + xh_{fg}$$

$$= 700 + 0.9(1700 - 700) = 1600 \text{ kJ/kg}$$

$$Q_s = h_3 - h_1 = 1600 - 200$$

$$Q_s = 1400 \text{ kJ/kg}$$



$$\text{Mass of steam/kg of fuel} = \frac{6.3}{0.7}$$

$$= 9 \text{ kg steam/kg of fuel}$$

$$\text{Now, boiler efficiency, } \eta_B = \frac{m_s \times (h_3 - h_1)}{m_f \times CV} \times 100\% = \frac{9 \times 1400}{30000} \times 100\%$$

$$\eta_B = 42\%$$

Q.130 Which of the following statement is incorrect regarding air preheater?

(a) Air preheater is used to decreases the efficiency of the boiler

(b) Air preheater does not affect the amount of fuel required in the furnace

(c) Air preheater is used to preheat the air coming out of the furnace

(d) All of the above

130. (d)

- Air preheater increases the boiler efficiency by reducing the heat supplied.
- Air preheater reduces the quantity of fuel required in the furnace.
- Air preheater is used to preheat the cold air entering to the furnace.

Q.131 Choose the correct statements:

1. For impulse turbine the pressure drop takes place in nozzles only.
2. For reaction turbine pressure drop takes place in both fixed and moving blades.
3. Compounding is done in impulse turbine to reduce the speed of rotor.
4. For reaction turbines blade shape is aerofoil type.
5. In impulse turbine, efficiency of velocity compounded is greater than pressure compounded.

(a) 1, 2, 3 and 4 (b) 2, 3 and 5

(c) 1, 2 and 3 (d) 1, 2 and 5

131. (a)

Q.132 Water (c_p = 4 kJ/kgK) is fed to a boiler at 30°C, the enthalpy of vaporization at 5 bar pressure is 2000 kJ/kg vapour exits from the boiler at 0.9 quality as steam. Enthalpy at the entry and exit of the economizer is 200 kJ/kg and 600 kJ/kg. If water exits as saturated liquid from the economizer then what will be the fraction of total heat added through the economizer.

(a) 75% (b) 24%

(c) 18.18% (d) 20%

132. (c)

Total heat added, $Q = (h_3 - h_1)$

$h_3 = h_2 + xh_{fg}$

Given: $h_1 = 200$ kJ/kg

$h_2 = h_f = 600$ kJ/kg

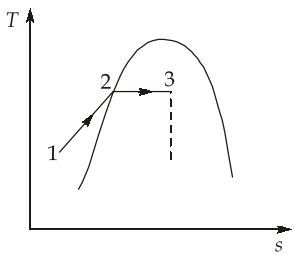
$h_{fg} = 2000$ kJ/kg

Now, $h_3 = 600 + 0.9(2000)$

$= 600 + 1800 = 2400$ kJ/kg

Heat added in economizer, $Q_{Eco} = h_2 - h_1$

$= 600 - 200 = 400$ kJ/kg



Fraction of total heat added in economizer, $\%f = \frac{Q_{Eco}}{Q} \times 100 = \frac{400}{2200} \times 100\%$

$= 18.18\%$

Q.133 Consider the following statements in the context of high pressure boilers:

1. The tendency of scale formation is eliminated due to high velocity of water through tubes.
2. The heat transfer coefficient is increased by increasing the velocity of water through the tubes.
3. The steam can be raised quickly to meet the variable load.
4. Use of high pressure and high temperature steam is economical.

(a) 1, 2 and 4 (b) 2 and 3
(c) 1, 2 and 3 (d) 1, 2, 3 and 4

133. (d)

As in high pressure boilers velocity of water through tubes is high which results in high value of Reynolds number. As heat transfer coefficient depends on Reynolds number so with increase in velocity of water heat transfer coefficient increases.

For flow through pipes:

Heat transfer coefficient, $h = a(\text{Re})^{0.8}(\text{Pr})^{b}$

Direction (Q.134 to Q.140): The following questions consists of two statements, one labelled as **Statement (I)** and the other labelled as **Statement (II)**. You have to examine these two statements carefully and select your answers to these items using the codes given below:

Codes:

(a) Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are true but Statement (II) is not a correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

Q.134 **Statement (I):** Endurance limit of the object in case of fatigue loading in a true sense, is exactly a property of material like ultimate tensile strength in case of static loading.

Statement (II): Endurance limit of the object in case of fatigue loading depends on the type of materials.

134. (d)

The endurance limit, in a true sense, is not exactly a property of material like ultimate tensile strength. It is affected by factors such as size of the component, shape of component, the surface finish, temperature and the notch sensitivity of the material.

Q.135 **Statement (I):** When the same material is used for pinion and gear, the beam strength of pinion is less than that of gear.

Statement (II): The Lewis form factor is always less for gear as compared with pinion.

135. (c)

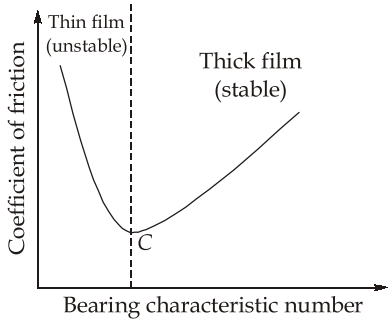
Lewis form factor for pinion is less compared to gear. So, the beam strength of pinion is less than that of gear when the same material is used for both gears.

Q.136 Statement (I): In impulse turbine the pressure drop occurs only in nozzles and there is no pressure drop in both fixed and moving blade.
Statement (II): Reaction turbines have complete admission of steam or steam being admitted all around the rotor through fixed blade ring.

136. (b)

Q.137 Statement (I): In order to avoid seizure, the operating value of bearing characteristic number should be atleast 5 to 6 times the bearing modulus.
Statement (II): Coefficient of friction is maximum at point corresponding to bearing modulus.

137. (c)
Coefficient of friction is minimum at point corresponding to bearing modulus, i.e. , point C. The bearing should not be operated near the bearing modulus.



A slight drop in speed (N) or a slight increase in load (P) will reduce the value of bearing characteristic number, resulting in boundary lubrication.

Q.138 Statement (I): In Rankine cycle, for high pressure boilers, more than 40% of the total heat is absorbed in the superheaters.
Statement (II): As boiler pressure increase, the latent heat decreases and so the heat absorbed in the evaporator decreases and the fraction of the total heat is absorbed in the superheater increases.

138. (a)
As the pressure increases, the latent heat decreases and so the heat absorbed in the evaporator decreases and the fraction of the total heat absorbed in the superheater increases. In high pressure boilers more than 40% of the total heat is absorbed in the superheaters.

Q.139 Statement (I): The amount of matter indicates whether the coal will burn with a short or long flame and whether the coal will tend to produce smoke or not.
Statement (II): The volatility of the coal determines the amount of smoke produced due to burning of the coal.

139. (b)
The amount of volatile matter indicates whether the coal will burn with a short or long flame and whether it will tend to produce smoke. The more volatile the coal, the more it will smoke.

Q.140 Statement (I): In cascade condensers, vapour condenses in condenser by rejecting heat to external fluid and the temperature of external fluid may remain constant.

Statement (II): During condensation of vapours in condenser evaporation of another fluid is possible in some special conditions.

140. (a)

In condensers the refrigerant vapour condenser by rejecting heat to an external fluid, which acts as a heat sink. Normally the external fluid does not undergo any phase change, except in some special cases such as in cascade condensers, where the external fluid (another refrigerant) evaporates.

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