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Important Questions for GATE 2022

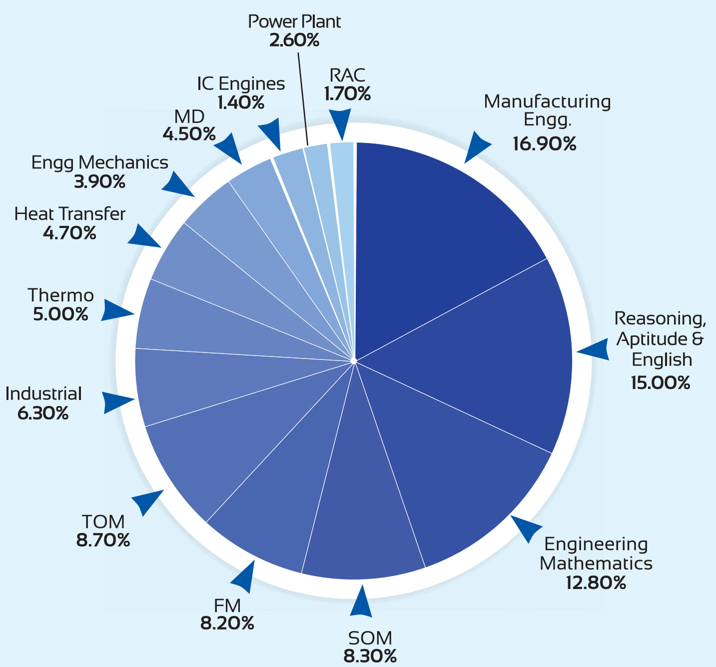
MECHANICAL ENGINEERING

Day 5 of 8

Q.101 - Q.125 (Out of 200 Questions)

Manufacturing Engineering + IC Engines

SUBJECT-WISE WEIGHTAGE ANALYSIS OF GATE SYLLABUS



Subject	Average % (last 5 yrs)
Manufacturing Engineering	16.90%
Reasoning, Aptitude & English	15.00%
Engineering Mathematics	12.80%
Strength of Materials	8.30%
Theory of Machines	8.70%
Fluid Mechanics & Hydraulic Machines	8.20%
Industrial Engineering	6.30%
Thermodynamics	5.00%
Heat Transfer	4.70%
Engineering Mechanics	3.90%
Machine Design	4.50%
Internal Combustion Engines	1.40%
Power Plant Engineering	2.60%
Refrigeration & Air Conditioning	1.70%
Total	**100%**

Manufacturing Engineering + IC Engines

Q.101 Which of the following is a quick acting clamp?
(a) Hinged clamp
(b) Cam operated clamp
(c) Bridge clamp
(d) Edge clamp

Q.102 A turning tool of geometry:
0°, 0°, 10°, 8°, C_e, 75°, 0 (mm) is to be used at a feed of 0.07 mm/rev.
The end cutting edge angle (C_e) to obtain an surface roughness (R_a) of 3 μm under ideal condition is______ degree. [Correct upto 1 decimal place]

Q.103 During turning with HSS tool of specification 0° - 15° - 6° - 6° - 8° - 60° - 1 mm (ORS) on a mild steel tube at a cutting speed of 150 m/min and a feed rate of 0.4 mm/rev. The thickness of chip was measured to be 0.8 mm. If thickness of shear zone is 9 microns, the shear strain and rate of shear strain rate are, respectively
(a) 2.8, 3.7×10^5 s^{-1}
(b) 2.93, 2.7×10^5 s^{-1}
(c) 2.321, 2.7×10^5 s^{-1}
(d) 2.321, 3.7×10^5 s^{-1}

Q.104 For a turning operation using a ceramic cutting tool, if the cutting speed is increased by 50%, the feed rate should be decreased by _____% to obtain a constant tool life.
Given tool life equation is $VT^n f^y d^x = C$
Take, $n = 0.5$, $y = 0.6$

Q.105 A metal has the following flow curve equation

$$\sigma_f = 850\epsilon^{0.3}$$

where σ_f is in MPa. A part made of this metal is stretched to 150 mm from an initial length of 100 mm. The flow stress at the new length and the average flow stress that the metal has been subjected to during the deformation are, respectively,
(a) 648 MPa, 498 MPa
(b) 748 MPa, 598 MPa
(c) 648 MPa, 598 MPa
(d) 748 MPa, 398 MPa

Q.106 A circular hole of 20 mm diameter is to be produced in a sheet of 4 mm thickness. The clearance allowance between the punch and the die is 3%. The required punch and die diameter for this punching operation are, respectively
(a) 20 mm, 19.76 mm
(b) 20.24 mm, 19.88 mm
(c) 20.24 mm, 20 mm
(d) 20 mm, 20.24 mm

Q.107 A hole with 50 mm diameter and 60 mm depth is to be drilled in mild steel component. The cutting speed is 70 m/min and feed rate is 0.25 mm/rev. If drill point angle is 118° and over-travel is 3 mm, the time required to drill the hole is ___________ minutes. [Correct upto 1 decimal place]

Q.108 A multi-pass cold rolling operation is to be used to reduce the thickness of a plate in a reversing 2 high mill. The following data is provided for the rolling operation:
h_o = 5 cm, h_f = 2.5 cm, R = 350 mm, μ = 0.16. If the draft is to be equal on each pass, the minimum number of passes required is ___________.

Q.109 The grinding wheel in a centerless grinding operation has a diameter of 200 mm and the regulating wheel diameter is 125 mm. The grinding wheel rotates at 3000 rev/min and the regulating wheel rotates at 200 rev/min. The inclination angle of the regulating wheel is 2.5°. The through feed rate of cylindrical workparts that are 25 mm in diameter and 175 mm long is equal to _______ Parts/minute. (Correct to one decimal place)

Q.110 During an orthogonal machining process shear force and shear velocity were calculated as 300 N and 140 m/min, respectively, the shear energy completely appears as heat and 90% of which travels with the chip while 10% flows to the workpiece. The average temperature at shear plane is____.

Take: Density of material = 2700 kg/m^3
Undeformed chip thickness = 0.7 mm
Width of cut = 2 mm
Specific heat of material = 500 J/kgK
Cutting velocity = 200 m/min
Environment temperature = 25°C

(a) 100°C
(b) 125°C
(c) 75°C
(d) 150°C

Q.111 A rolling operation is performed using rolls of diameter 800 mm rotating at 120 rpm to reduce the thickness of 30 mm thick plate to 20 mm. The roll strip contact length for this operation is _________. [Correct upto 1 decimal place]

Q.112 The following true stresses produce the corresponding true plastic strains for an alloy.

True stress (MPa)	True strain
415	0.15
485	0.25

The value of true stress necessary to produce a true plastic strain of 0.21 is

(a) 564 MPa
(b) 459 MPa
(c) 395 MPa
(d) 429 MPa

Q.113 In an orthogonal machining process, the following observations were made:

Rake angle of tool = 10°
Cutting force = 312 N
Thrust force = 185 N
Depth of cut = 0.24 mm
Chip thickness = 0.48 mm

The ratio of the force components along the directions parallel and normal to the shear plane is

(a) 0.6
(b) 0.45
(c) 0.69
(d) 0.8

Q.114 Wrinkling in deep drawing is caused when

P. blank holder force is low

Q. thin sheet is drawn

R. thickness-to-diameter ratio of the blank is reduced

(a) Only P (b) only Q

(c) P, Q and R (d) P and R

Q.115 A cylindrical workpiece is forged in an open die. The workpiece is 60 mm in diameter and 30 mm high. The height after forging is 15 mm. The coefficient of friction at the die-work interface is 0.20. The flow curve equation for the workpiece is defined as,

$\sigma_f = 800\ \varepsilon^{0.2}$

where σ is in MPa. The forging force (in MN) at the end of the stroke is closest to

(a) 4.3 (b) 8.5

(c) 5.8 (d) 6.7

Q.116 The following data from an orthogonal cutting test is available:

Rake angle = 15°

Chip thickness ratio = 0.383

Uncut chip thickness, t = 0.5 mm

Width of cut, b = 3 mm

Yield stress of material in shear = 280 N/mm^2

Average coefficient of friction on the tool face = 0.7

The tangential force on the tool face in______N.

Q.117 In a hot extrusion process, steel at 800°C, with an initial diameter of 100 mm is extruded to a final diameter of 20 mm. If the extrusion constant is 250 MPa, what is the extrusion ratio and the force required (in MN)?

(a) 25, 6.32 (b) 5, 6.32

(c) 5, 0.25 (d) 25, 0.25

Q.118 The thickness of a 25 mm thick and 250 mm wide copper plate is to be reduced in a single pass in a two-high rolling mill to 80%. The roll diameter is 1 m. The work material has a strength coefficient of 250 MPa and the strain hardening exponent is 0.2. The roll torque required to accomplish this reduction is______kNm. (Correct upto three decimal places)

Q.119 In which of the following productions, jigs and fixtures are used?

(a) Piece wise production (b) High mass production

(c) Batch production (d) None of these

Q.120 Which one of the following is not correct regarding Compression-Ignition Engines?

(a) Initial cost is higher due to higher cost of higher injection pressure system (400 to 2200 bar).

(b) Lower or negligible CO and HC emissions due to lean mixture.

(c) Mixture preparation occur external (carburettor and manifold injection, port injection) and internal during compression stroke.

(d) Thermal efficiency is higher due to mainly higher compression ratio

Q.121 A four stroke petrol engine has a compression ratio of 10.5, takes air at 90 kPa and 40°C, and is repeated 2500 times per minute. Using constant specific heats (c_p = 1.005 kJ/kg.K, c_v = 0.718 kJ/kg·K, and γ = 1.4) at room temperature, if the cycle is to produce 900 J/cycle, then the rate of heat input is________kW. [Correct upto 1 decimal place]

Q.122 An ideal diesel engine has a compression ratio of 20 and uses air as the working fluid. The state of air at the beginning of the compression process is 95 kPa and 20°C. If the maximum temperature in the cycle is not to exceed 2200 K.

[Take γ for air = 1.4 and c_p for air = 1.005 kJ/kgK] then the thermal efficiency is given by:

(a) 34.9% (b) 56.9%
(c) 63.5% (d) 67.9%

Multiple Select Question (MSQ)

Q.123 Which of the following statements is/are correct for forward or direct extrusion process?

(a) High friction force must be overcome.
(b) High friction forces are present but mechanically simple and uncomplicated.
(c) Low scrap or material waste (only 5-6% of billet weight).
(d) Simple but the material must slide along the chamber wall.

Q.124 Which of the following statements is/are correct in respect of electro discharge machining process?

(a) M.R.R. increases with decreasing resistance.
(b) M.R.R. increases with decreasing capacitance.
(c) M.R.R. increases with increasing capacitance.
(d) M.R.R. increases with optimum spark gap then decreased with increasing spark gap.

Q.125 The thermal efficiency of any air standard cycle increases if

(a) Maximum pressure increases.
(b) Minimum pressure decreases.
(c) Maximum pressure decreases.
(d) Minimum pressure increases.

■■■■

Detailed Explanation

101. **(b)**

Quick clamping by cam is very effective and very simple in operation. The cam type clamping system is used for clamping through some interior parts, where other simple system will not have access.

102. **(10.186)(10.1 to 10.3)**

$$\text{Approach angle, } \lambda = 75°$$

$$\text{Side cutting edge angle, } C_s = 90° - \lambda$$
$$= 90° - 75° = 15°$$

Mean surface roughness,

$$R_a = 3\ \mu m$$
$$= 3 \times 10^{-3}\ mm$$

$$\text{Maximum height of roughness, } H_{max} = 4R_a$$
$$= 4 \times 3 \times 10^{-3} = 12 \times 10^{-3}\ mm$$

As we know,

$$H_{max} = \frac{f}{\tan C_s + \cot C_e}$$

$$12 \times 10^{-3} = \frac{0.07}{\tan 15 + \cot C_e}$$

$$\tan 15 + \cot C_e = 5.8333$$

$$\cot C_e = 5.5654$$

$$\Rightarrow \quad C_e = 10.186°$$

So, end cutting edge angle, $C_e = 10.186°$

103. **(c)**

$$t = f\sin\lambda = 0.4 \sin 60° = 0.346\ mm$$

$$r = \frac{t}{t_c} = \frac{0.346}{0.8} = 0.43$$

$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha} = \frac{0.43\cos 15°}{1 - 0.43\sin 15°} = 0.467$$

$$\phi = \tan^{-1}(0.467) = 25°$$

$$\text{Shear strain, } \gamma = \tan(\phi - \alpha) + \cot\phi$$
$$= \tan(10°) + \cot 25°$$
$$= 2.321$$

$$\text{Shear strain rate, } \dot{\gamma} = \frac{\cos\alpha}{\cos(\phi - \alpha)} \times \frac{V}{\Delta y} = \frac{\cos 15°}{\cos 10°} \times \frac{150/60}{9 \times 10^{-6}}$$
$$= 2.7 \times 10^5\ s^{-1}$$

104. (50)(47 to 52)

$$\frac{C^{1/n} d_1^{-x/n} f_1^{-y/n}}{V_1^{1/n}} = \frac{C^{1/n} d_2^{-x/n} f_2^{-y/n}}{V_2^{1/n}}$$

$d_1 = d_2$

$$\left(\frac{V_2}{V_1}\right)^{1/n} = \left(\frac{f_2}{f_1}\right)^{-y/n}$$

$$\left(\frac{1.5V_1}{V_1}\right)^{2} = \left(\frac{f_1}{f_2}\right)^{1.2}$$

$$\frac{f_1}{f_2} = (1.5^2)^{1/1.2} = 1.96 \simeq 2$$

$$\Rightarrow \quad f_2 = \frac{f_1}{2}$$

Feed has to be reduced by 50%.

105. (a)

$$\text{True strain, } \epsilon = \ln\left(\frac{150}{100}\right) = 0.405$$

$$\text{Flow stress, } \sigma_f = 850(0.405)^{0.3} = 648.1 \text{ MPa}$$

$$\text{Average flow stress, } \sigma_{f,\text{ avg}} = \frac{\sigma_f}{1+n} = \frac{648.1}{1.3} = 498.5 \text{ MPa}$$

106. (d)

Hole diameter, d = 20 mm
Sheet thickness, t = 4 mm
Clearance, C = 3% of t
Punch diameter, d = 20 mm
Die diameter = $d + 2C$

$$= 20 + 2 \times \frac{3}{100} \times 4 = 20.24 \text{ mm}$$

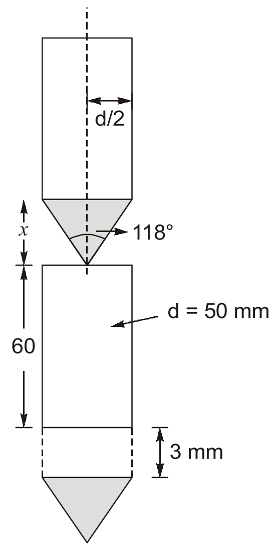
107. (0.7)(0.6 to 0.8)

Given:
V = 70 m/min
D = 50 mm
f = 0.25 mm/rev
L = 60 mm

Spindle speed, $$N = \frac{1000V}{\pi D} = \frac{1000 \times 70}{\pi \times 50}$$
$$= 445.633 \text{ rev/min}$$

Breakthrough distance,

$$x = \frac{50}{2\tan 59°}$$
$$x = 15.02 \text{ mm}$$



Total length of drill travel, $L = 60 + 15.02 + 3$

$L = 78.02$ mm

Time for drilling the hole $= \dfrac{78.02}{0.25 \times 445.633} = 0.7$ min

108. (3) (3 to 3)

Maximum draft, $(\Delta h)_{max} = \mu^2 R$

$= (0.16)^2 \times 350 = 8.96$ mm

Minimum number of passes $= \dfrac{(\Delta h)_{required}}{(\Delta h)_{max}} = \dfrac{50-25}{8.96} = 2.79 = 3$ passes.

109. (19.57)(19.4 to 19.7)

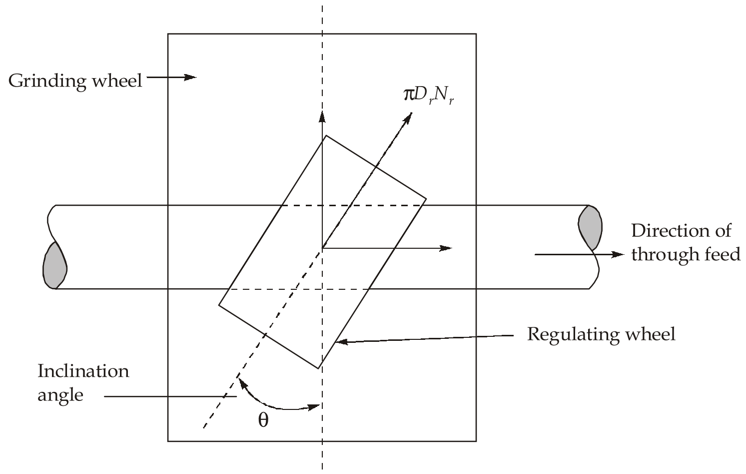
Given: $D_g = 200$ mm, $D_r = 125$ mm, $N_g = 2000$ rpm, $N_r = 200$ rpm, $\theta = 2.5°$, $d_{wp} = 25$ mm, $l_{wp} = 175$ mm

The regulating wheel decides the through feed because of its inclination.

$$f_r = \pi D_r N_r \sin\theta$$

$$f_r = \pi \times 125 \times 200 \times \sin 2.5° = 3425.86 \text{ mm/min}$$

Parts through feed rate $= \dfrac{f_r}{l_{wp}} = \dfrac{3425.86}{175} = 19.57$ parts/min



110. (b)

Given: $F_s = 300$ N, $V_s = 140$ m/min $= 2.333$ m/s, $k = 90\% = 0.9$, $\rho = 2700$ kg/m^3, $t = 0.7$ mm, $b =$ 2 mm,

$C_p = 500$ J/kgK, $V = 200$ m/min $= 3.333$ m/s

Equating amount of heat received by chip from the shear zone and the heat contained by chip.

$$kF_s V_s = c_p (bt)\rho V(T_s - T_\infty)$$

$$\frac{0.9 \times 300 \times 2.333}{500 \times (2 \times 0.7 \times 10^{-6}) \times 2700 \times 3.333} = T_s - 25°C$$

$$T_s = 25 + 99.996$$

$$T_s = 124.996°C \simeq 125°C$$

111. **(63.3) (62.8 to 63.8)**

Given: D = 800 mm; h_i = 30 mm; N = 120 rpm; h_o = 20 mm

$$\cos\alpha = 1-\frac{\Delta h}{D} = 1-\frac{(30-20)}{800}$$

$$\Rightarrow \quad \alpha = 9.0987° \text{ or } 0.15828 \text{ radian}$$

$$L = R\alpha = 400 \times 0.15828$$

$$\Rightarrow \quad L = 63.3 \text{ mm}$$

112. **(b)**

$$\sigma_T = k\epsilon_T^n$$

$$415 = k(0.15)^n \quad \text{...(i)}$$

$$485 = k(0.25)^n \quad \text{...(ii)}$$

$$\Rightarrow \quad \frac{485}{415} = \left(\frac{0.25}{0.15}\right)^n$$

Taking log both sides and solving we get n = 0.3

$$\Rightarrow \quad k = 733.2$$

$$\therefore \quad \sigma_T = 733.2\ \epsilon_T^{0.3}$$

$$\Rightarrow \quad \sigma_T = 733.2\ (0.21)^{0.3}$$

$$\Rightarrow \quad \sigma_T = 459 \text{ MPa}$$

113. **(a)**

Given: α = 10°, F_c = 312 N, F_T = 185 N, $d = t$ = 0.24 mm, t_c = 0.48 mm

$$r = \frac{t}{t_c} = \frac{0.24}{0.48} = 0.5$$

$$\tan\phi = \frac{r\cos\alpha}{1-r\sin\alpha} = \frac{0.5\cos 10°}{1-0.5\sin 10°} = 0.539$$

$$\Rightarrow \quad \phi = 28.33°$$

$$F_s = F_c\cos\phi - F_T\sin\phi$$

$$= 312\cos(28.33°) - 185\sin(28.33°)$$

$$= 186.84 \text{ N}$$

$$F_n = F_c\sin\phi + F_T\cos\phi$$

$$= 312\sin 28.33° + 185\cos 28.33°$$

$$= 310.90$$

$$\therefore \quad \frac{F_s}{F_n} = \frac{186.84}{310.90} = 0.6$$

114. **(c)**

115. **(c)**

From volume consistency,

$$\pi(30)^2 \times 30 = \pi r_f^2 \times 15$$

$$\therefore \quad r_f = 42.42 \text{ mm}$$

True strain at the end of of the stroke

$$\varepsilon = \ln\left(\frac{30}{15}\right) = 0.69$$

$$\sigma_f = 800 \times (0.69)^{0.2} = 742.78 \text{ MPa}$$

Force at the end of the stroke,

$$F = \sigma_f \pi r_f^2 \left(1 + \frac{2\mu r_f}{3h_f}\right)$$

$$= 742.78 \times \pi \times (42.42)^2 \left(1 + \frac{2 \times 0.2 \times 42.42}{3 \times 15}\right) \times 10^{-6}$$

$$= 5.78 \text{ MN}$$

116. (857.432) (849 to 865)

$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha} = \frac{0.383\cos 15°}{1 - 0.383\sin 15°} = 0.41$$

$$\phi = 22.34°$$

$$\tan\beta = 0.7 \Rightarrow \beta = 35°$$

$$F_C = \text{Cutting force} = \frac{\tau_s bt}{\sec(\beta - \alpha)\cos(\phi + \beta - \alpha)\sin\phi}$$

$$= \frac{280 \times 3 \times 0.5}{\sec(35° - 15°)\cos(22.34° + 35° - 15°)\sin 22.34°}$$

$$= 1404.74 \text{ N}$$

$$\tan(\beta - \alpha) = \frac{F_t}{F_c}$$

$$F_t = F_c \times \tan(35° - 15°)$$

$$= 1404.74 \times \tan(20°)$$

$$= 511.28 \text{ N}$$

Tangential force on tool face = $F = F_c \sin\alpha + F_t \cos\alpha$

$$F = 1404.74 \sin 15° + 511.28 \cos 15°$$

$$= 857.432 \text{ N}$$

117. (a)

$$\text{Extrusion ratio, } \varepsilon_r = \frac{A_o}{A_f} = \left(\frac{100}{20}\right)^2 = 25$$

(Where, A_o is the initial area and A_f is the final area)

Force required, $F = kA_o \ln \varepsilon_r$ (Where, k is the extrusion constant)

$$= 250 \times \frac{\pi}{4}(0.1)^2 \ln 25 = 6.32 \text{ MN}$$

118. (48.225) (48.000 to 48.600)

$$\text{Contact strip length, } L = \sqrt{R\Delta h} = \sqrt{500 \times (1 - 0.8) \times 25} = 50 \text{ mm}$$

$$\text{True strain, } \epsilon = \ln\left(\frac{25}{20}\right) = 0.223$$

Average flow stress, $\sigma_f = \dfrac{k \in^n}{n+1}$

(where, k is strength coefficient and n is the strain hardening exponent)

$$\text{Average flow stress, } \sigma_f = \frac{250 \times (0.223)^{0.2}}{1.2} = 154.32 \text{ MPa}$$

$$\text{Rolling torque, } T = Fa = \sigma_f \times bL \times \frac{L}{2}$$

$$= 154.32 \times \frac{250}{1000} \times \frac{50}{1000} \times \frac{50}{2000} \times 10^3$$

$$= 48.225 \text{ kN-m}$$

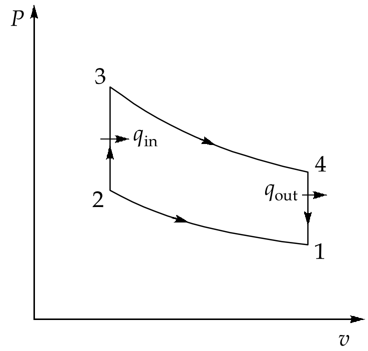
119. (c)

Fully automatic machines dedicated to mass production machines. Machines with jigs and fixture are mostly used in batch-production and machines without jigs and fixture are used for piece production.

120. (c)

In case of Compression-Ignition Engines mixture preparation occur inside engine cylinder.

121. (61.515)(60 to 62.3)



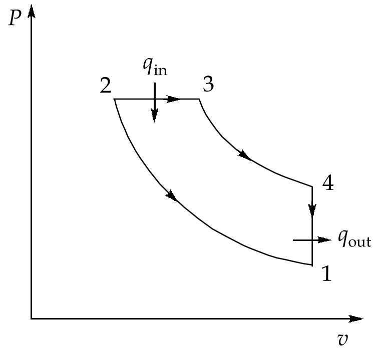
$$\eta_{th} = 1 - \frac{1}{r^{\gamma-1}} = 1 - \frac{1}{10.5^{1.4-1}} = 0.6096 = 61.0\%$$

$$\dot{W}_{net} = \frac{900 \times 2500}{1000 \times 60} = 37.5 \text{ kW}$$

The rate of heat addition is then

$$\dot{Q}_{in} = \frac{\dot{W}_{net}}{\eta_{th}} = \frac{37.5\text{kW}}{0.6096} = 61.515 \text{ kW}$$

122. **(c)**



The properties of air at room temperature are c_p = 1.005 kJ/kgK, c_v = 0.718 kJ/kgK, R = 0.287 kJ/kgK and γ = 1.4

$$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1} = (293\text{K})(20)^{0.4} = 971.1\text{K}$$

Process 2-3: constant pressure heat addition,

$$\frac{P_3V_3}{T_3} = \frac{P_2V_2}{T_2} \Rightarrow \frac{V_3}{V_2} = \frac{T_3}{T_2} = \frac{2200\text{ K}}{971.1\text{ K}} = 2.265 \qquad \text{(given } T_3 = 2200\text{ K)}$$

Process 3-4: isentropic expansion,

$$T_4 = T_3\left(\frac{V_3}{V_4}\right)^{\gamma-1} = T_3\left(\frac{2.265V_2}{V_4}\right)^{\gamma-1} = T_3\left(\frac{2.265}{r}\right)^{\gamma-1}$$

$$= (2200)\left(\frac{2.265}{20}\right)^{0.4} \qquad [\because V_4 = V_1]$$

$$= 920.6\text{ K}$$

$$q_{in} = h_3 - h_2 = c_p(T_3 - T_2) = (1.005)(2200 - 971.1) = 1235.04\text{ kJ/kg}$$

$$q_{out} = u_4 - u_1 = c_v(T_4 - T_1) = (0.718)(920.6 - 293) = 450.6\text{ kJ/kg}$$

$$w_{net,\,out} = q_{in} - q_{out} = 1235 - 450.6 = 784.4\text{ kJ/kg}$$

$$\eta_{th} = \frac{w_{net,out}}{q_{in}} = \frac{784.4\text{ kJ/kg}}{1235.04\text{ kJ/kg}} = 63.5\%$$

123. **(a, b, d)**

124. **(a, c, d)**

125. **(a, b)**

■■■■