IAT_2 Answer Key

18ME62_Design of Machine Elements - II

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USN :

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DEPARTMENT OF MECHANICAL ENGINEERING
II - INTERNAL ASSESSMENT

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Subject: DESIGN OF MACHINE ELEMENTS II (18ME62)
Faculty: Mr Manikandan

Date: 24 Jun 2021
Time: 09:00 AM - 10:00 AM
Max Marks: 50

Instructions to Students :

1. Answer all the questions.
2. Usage of machine design data handbook is permitted

Answer All Questions

Q.No		Marks	CO	PO	BT/CL
1	It is required to transmit 25 kW of power from a shaft running at 1000 rpm to a parallel shaft with a speed reduction ratio of 2.5:1. The centre distance of the shaft is to be 300 mm. The material used for pinion is steel ($\sigma_d = 200\ N/mm^2$, $BHN = 250$) and for the gear is cast iron ($\sigma_d = 180\ N/mm^2$ $BHN = 200$). Considering class-II gear with tooth profile 20° Full depth involute, design the spur gear and check for dynamic and wear load.	25	CO3	PO1,PO2,PO6	L3
2	A cone clutch has a semi cone angle of 15° and is used to transmit 10 kW at 1500 rpm. The width of the face is 1/4th of the mean diameter of friction lining. The normal intensity of pressure between the the contact surface is 0.12 MPa and coefficient of friction is 0.2, Assuming uniform wear, design the clutch dimensions. Take C40 steel and FOS = 2.5	25	CO4	PO1,PO2,PO4	L3

1 It is required to transmit 25 kW of power from a shaft running at 1000 rpm to a parallel shaft with a speed reduction ratio of 2.5:1. The centre distance of the shaft is to be 300 mm. The material used for pinion is steel ($\sigma_d = 200\ N/mm^2$, $BHN = 250$) and for the gear is cast iron ($\sigma_d = 180\ N/mm^2$ $BHN = 200$). Considering class-II gear with tooth profile 20° Full depth involute, design the spur gear and check for dynamic and wear load.

$P = 25kW \quad i = 2.5 \quad \sigma_{01} = 200 N/mm^2 \quad 20° F.D.I$

$n_1 = 1000 rpm \quad a = 300 mm \quad \sigma_{02} = 180 N/mm^2$

Lewis equation for 20° F.D.I

$$y = 0.154 - \frac{0.912}{Z}$$

Assume $Z_1 = 20$ (teeth on pinion)

$$Z_2 = iZ_1 = 2.5 \times 20 = 50$$

$$y_1 = 0.154 - \frac{0.912}{20} = 0.1083$$

$$y_2 = 0.154 - \frac{0.912}{50} = 0.1357$$

1) Identification of weaker member

	σ	y	$\sigma \cdot y$	Remarks
Pinion (01)	200	0.1083	21.68	Weaker
Gear (02)	180	0.1357	24.48	

Pinion is weaker member and Design is based on pinion

2) Design

(i) F_t from Power

$$F_t = \frac{9550\, P C_s}{n r} \times 1000$$

$P = 25\,kW$

$C_s = 1.5$

$n_1 = 1000\,rpm$

$r_1 = \frac{171.42}{2} = 85.71\,mm$

$$a = \frac{d_1 + d_2}{2}$$

$2 \times 300 = d_1 + d_2$

$d_1 + d_2 = 600$

$3.5 d_1 = 600$

$d_1 = 171.42\,mm$

$\Rightarrow d_2 = 428.55\,mm$

$$\frac{d_2}{d_1} = 2.5$$

$d_2 = 2.5 d_1$

$$F_t = \frac{9550 \times 25 \times 1.5}{\cancel{1000} \times 85.71} \times \cancel{1000}$$

$F_t = 4178.33\,N.$

(ii) Lewis equation based F_t

$$F_t = \sigma b y p k_v$$

Pinion, $F_t = \sigma_{01} \cdot b \cdot y_1 p k_v$

Assume $b = 10m$

$$y_1 = 0.154 - \frac{0.912\, m}{171.42}$$

$$y_1 = 0.154 - 5.3 \times 10^{-3} m$$

$m Z_1 = d_1$

$\Rightarrow Z_1 = d_1/m = \frac{171.42}{m}$

Pitch Incidentally, $p = \pi m$

$$V_m = \frac{\pi d_1 n_1}{60000} = \frac{\pi \times 171.42 \times 1000}{60000} = 8.975 m/s > 7.5 m/s$$

$$k_v = \frac{4.5}{4.5 + v_m} = \frac{4.5}{4.5 + 8.998} \Rightarrow k_v = 0.3339$$

$$F_t = (200)(10m)(0.157 - 5.3\times10^{-3}m)(\pi m)\,0.339$$

$$4178.33 = 2097.95m^2\,(0.157 - 5.3\times10^{-3}m)$$

$$4178.33 = 323.085m^2 - 11.119m^3$$

$$11.119m^3 - 323.08m^2 + 4178.33 = 0$$

a

b

$$m \begin{cases} \to 28.59 \\ \to \underline{3.86} \\ \to -3.40 \end{cases}$$

From Table 23.1

Module = 4 mm

Facewidth b = 40mm.

(iii) Check for stress

$$\sigma_{all} = \sigma_{01} \cdot K_v = 200 \times 0.3339 = 66.78\, N/mm^2$$

$$\sigma_{ind} = \frac{F_t}{b y_1 p} = \frac{4178.33}{40 \times 0.1328 \times 4\pi} = 62.3\, N/mm^2$$

$y_1 = 0.154 - 5.3 \times 10^{-3} \times 4$
$= \underline{\underline{0.1328}}$

$p = \pi \times 4$

$\sigma_{ind} < \sigma_{all} \Rightarrow$ Design safe.

$\therefore$ Actual no: of teeth on pinion $= Z_1 = \dfrac{d_1}{m} = \dfrac{171.42}{4} = 42.85 \simeq 44$ teeth

" " " " Gear $Z_2 = \dfrac{d_2}{m} = \dfrac{428.55}{4} = 107.13 \simeq 108$ teeth

$Z_1 = 44$
$Z_2 = 108$

4) Dynamic and wear load

$$F_d = F_t + \frac{21 v_m (F_t + bC)}{21 v_m + \sqrt{F_t + bC}}$$

For class II gear finish with $m = 4$ mm.

$$e = 0.025$$

For pinion : steel
For gear : C.I

Table : for e (0.025) $\Rightarrow C = 192.14$ N/m

$$F_d = 4178.33 + \frac{21 \times 8.975 (4178.33 + 40 \times 192.14)}{21 \times 8.975 + \sqrt{4178.33 + 40 \times 192.14}}$$

$$F_d = 3238.21 \text{ N}$$

Wear load

$$F_w = d_1 Q b K$$

BHN Pinion : 250
BHN Gear : 200
$\Big\}$ $K = 0.8211$

$d_1 = 171.48\,mm$

$$Q = \frac{2Z_2}{Z_1+Z_2} = \frac{2\times108}{44+108} = 1.421$$

$b = 10m = 40\,mm$

$$F_w = 171.48\times 1.421\times 40\times 0.8211$$

$$F_w = 8003.19\,N$$

For safe design

$$F_w > F_d$$

$$8003.19 > 3238.81 \quad \text{True}$$

Design Safe

---x---

A cone clutch has a semi cone angle of 15° and is used to transmit 10 kW at 1500 rpm. The width of the face is 1/4th of the mean diameter of friction lining. The normal intensity of pressure between the the contact surface is 0.12 MPa and coefficient of friction is 0.2, Assuming uniform wear, design the clutch dimensions. Take C40 steel and FOS = 2.5

$\alpha = 15^\circ$ $\quad N = 10 kW$ $\quad b = \frac{1}{4} D_m = 0.25 D_m$

$n = 1500 rpm$

$p = 0.12 N/mm^2$

$\mu = 0.2$

Assume Uniform wear (given)

1) Torque Transmitted

$$M_t = 9550 \times 1000 \times \frac{10}{1500}$$

$$M_t = 66.663 \times 10^3 \ N\text{-}mm$$

Axial Force,

$$F_a = \pi p D_m b \sin\alpha$$

$$= \pi \times 0.12 \times D_m \times 0.25 D_m \times \sin 15^\circ$$

$$F_a = 0.02439 D_m^2$$

Also

$$M_t = \frac{\mu F_a D_m}{2 \sin\alpha}$$

$$66.663 \times 10^3 = \frac{0.2 \times 0.02439 D_m^2 \times D_m}{2 \sin 15}$$

$$\Rightarrow D_m = \sqrt[3]{\frac{66.663 \times 10^3 \times 2 \sin 15^\circ}{0.2 \times 0.02439}}$$

$$D_m = 191.965 \text{ mm} \simeq 192 \text{ mm}$$

Dimensions of cone clutch

Face width $b = \frac{D_m}{4} = \frac{192}{4} = 48\,\text{mm}$

Outer dia of cone $D_2 = D_m + b\sin\alpha$

$= 192 + 48\sin 15$

$= 204.42 \simeq 204\,\text{mm}$

Inner dia of cone $D_1 = D_m - b\sin\alpha$

$= 192 - 48\sin 15^\circ$

$= 179.57$

$\simeq 180\,\text{mm}$

Actual axial load $F_a = 0.02439\,D_m^2$

$= 0.02439 \times (192)^2$

$F_a = 899.112\,\text{N}$