TUSHAR BAJAJ
190103111

ME 322
ASSIGNMENT-6 (Set-4)

Question 1)

→ Two basic types of bearing failure -

i) Breakage of parts like races and cages
→ due to overload or misalignment of bearing
→ cages fail due to centrifugal force acting on the balls.

ii) Surface destruction
→ abrasive wear: contamination due to dust, foreign particles, rust / spatter
→ corrosive wear: corrosion due to water or moisture.
→ Pitting: load exceeds surface endurance strength of the bearing, causing pit formation.
→ Scoring: due to breakdown of lubricant film causing excessive friction and thus heating of bearing.

Question 2)

→ Advantages of oil over grease:

i) more effective in carrying frictional heat.
ii) feeds more easily into contact areas of bearing under load.
iii) more effective in flushing out dirt, corrosion and foreign particles from the bearing.

Advantages of grease over oil:

i) Grease lubricated bearings are simple housing design.
ii) less maintenance cost
iii) better sealing against rust
iv) less possibility of leakage

Question 3)

→ Precautions to be taken during mounting of rolling contact bearing:

i) Mounting to be carried out in dust free and dry environment.

ii) Burrs should be removed before assembling.

iii) Clean with white spirit and a clean cloth.

iv) Never apply direct blows on bearing surface.

v) Bearings should never be heated by direct flame (induction heating).

Question 4)

→ Preloading of cylindrical roller bearing is obtained by:

i) Roller bearing is mounted on a taper shaft or sleeve, which causes the inner race to expand and remove radial clearance.

ii) Outer race is fitted in the housing bore by an interference fit. It causes the outer race to contract and remove the radial clearance.

Question 5)

→ ISO plan   Bore diameter → 75mm

XXXX → ~~Bore~~ $\frac{\text{Bore diameter}}{5} = \frac{75}{5} = 15$mm

XX15

type of rolling contact bearing

1 → Extra light series
2 → Light series
3 → Medium series
4 → Heavy series

used to find dynamic load capacity and static load capacity.

Eg: for 6315, $d = 75 mm$, $D = 160 mm$,
B (axial width) $= 37 mm$

$C = 112000 N$, $C_0 = 72000 N$

C ↓ dynamic load capacity

C_0 ↓ static load capacity.

Question 6)

→ Advantages of needle bearings :

i) They can be used to replace sleeve bearings with little or no changes in design as they have a small outer diameter.

ii) Compact and lightweight compared to other types of bearing.

iii) Large load carrying capacity compared to their size.

iv) Large load carrying capacity particularly at low peripheral speeds.

Question 7)

⇒ Pitting is a surface fatigue failure, which occurs when load on the bearing part exceeds the surface endurance strength.

→ Main cause of failure of antifrictional bearings.

→ Characterised by "pits" which continue to grow resulting in complete destruction of bearing surface.

→ depends upon Hertz' contact stress and number of stress cycles.

• <u>Scoring</u>: It is a stick-slip ~~a~~ phenomenon, in alternate welding and shearing takes place rapi at high spots.

→ Excessive surface pressure
→ High surface speed
→ Inadequate supply of lubricant

} → Breakdown of lubricant film.

This results in excessive frictional heat and overheating at contacting surfaces.

Question 8)

→ Types of fits used in bearings:

→ a) Interference fit :- (press fit / friction fit)
joints held by frictional force after being forced / pushed together.

b) Shrink fit: Interference fit obtained by relative size change after assembly. Achieved by heating or cooling one component before assembly.

c) Tolerance fit: Tolerance ring is press fitted b/w ~~to~~ two mating components without any adhesive.

d) Grease fit: (zerk fitting / Alemite fitting)
grease fed under high pressure into a bearing using a grease gun.

Question 9)

→ <u>Design for cyclic loads and speeds</u>

Let work per cycle is divided into x elements.

$P_1, P_2, \ldots\ldots P_x$ be loads.

$n_1, n_2, \ldots\ldots n_x$ be speeds during these elements.

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...ing first element, life L_1 corresponding to load P_1 is given by

$$L_1 = \left(\frac{C}{P_1}\right)^3 \times 10^6 \text{ rev.}$$

In 1 rev^n $\longrightarrow$ $\left(\frac{1}{L_1}\right)$ or $\left(\frac{P_1^3}{C^3} \times \frac{1}{10^6}\right)$ life is consumed.

1^{st} element $\rightarrow$ N_1 revolutions

So, life consumed by 1^{st} element $\rightarrow$ $\frac{N_1 P_1^3}{10^6 C^3}$

So, life consumed by complete cycle $\rightarrow$ $\frac{\Sigma N_i P_i^3}{10^6 C^3}$

P_e $\rightarrow$ equivalent load for complete work cycle.

here, $N = N_1 + N_2 + \dots + N_x$.

$$\Rightarrow \frac{N P_e^3}{10^6 C^3} = \frac{\Sigma N_i (P_i)^3}{10^6 C^3}$$

$$\Rightarrow N_1 P_1^3 + N_2 P_2^3 + \dots + N_x P_x^3 = N P_e^3$$

$$P_e = \sqrt[3]{\frac{N_1 P_1^3 + N_2 P_2^3 + \dots}{N_1 + N_2 + \dots}}$$

$$P_e = \sqrt[3]{\frac{\Sigma N P^3}{\Sigma N}}$$

If load varies continuously with time

$$P_e = \left[\frac{1}{N} \int P^3 \, dN\right]^{1/3}$$

Question 10)

→ Selection of tapper roller bearings:

Inner race → cone   Outer race → cup.

Thrust component (F_a) due to Radial load (F_r).

$$F_a = \frac{0.5 F_r}{Y}$$

Y → Thrust selection factor

Y taken as 1.5

and
$$\begin{cases} P = F_r & ; \text{ when } (F_a/F_r) \le e \\ P = 0.4 F_r + Y F_a & ; \text{ when } (F_a/F_r) > e \end{cases}$$

values of Y, e and designation of single-row taper roller bearings are taken from table.

Assumptions
- → Zero clearance in operation
- → Without preload
- → Both bearings exactly identical

→ Line of action of the resultant reaction makes an angle with the axis of bearing.

This reaction can be resolved into radial and ~~load~~ axial components.

Thus, Taper roller bearings are suitable for carrying combined axial and radial loads.

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...stion 11)

→

Gear	Axial Load (N)	Radial Load (N)	% time engagement
1^{st}	3250	4000	3%
2^{nd}	500	2750	7%
3^{rd}	50	2750	25%
4^{th}	-	2750	65%

$n = 1800$ rpm $\quad C_0 = 10900\,N \quad C = 17600\,N$

$L_h = 4000\,h$

→ Considering work cycle of 1 minute duration

$$N_1 = \frac{3}{100}(1800) = 54 \text{ rev.}$$

$$N_2 = \frac{7}{100}(1800) = 126 \text{ rev.}$$

$$N_3 = \frac{25}{100}(1800) = 450 \text{ rev.}$$

$$N_4 = \frac{65}{100}(1800) = 1170 \text{ rev.}$$

$$(N_1 + N_2 + N_3 + N_4) = 1800 \text{ rev.}$$

For first gear, $\frac{F_a}{F_r} = \frac{3250}{4000} = 0.8125$

$$\frac{F_a}{C_0} = \frac{3250}{10900} = 0.2981$$

From table 15-4 (V.B. Bhandari)

we have the value of e b/w 0.37 & 0.44.

$\therefore \frac{F_a}{F_r} > e \Rightarrow X = 0.56$

Linear interpolation $\Rightarrow Y = 1.2 - \left(\frac{1.2-1.0}{0.5-0.25}\right)(0.299-0.25)$

$= 1.16152$

So, $P_1 = XF_r + YF_a = 0.56(4000) + 1.6152(3250)$

$= 6014.94\ N$

For second gear, $\frac{F_a}{F_r} = \frac{500}{2750} = 0.182$

$\frac{F_a}{C_o} = \frac{500}{10900} = 0.0458$

again from 15.4, e is b/w 0.24 & 0.27

$\because \frac{F_a}{F_r} < e \Rightarrow X = 1, Y = 0$

as $P_2 = F_r = 2750N$

For third gear, $\frac{F_a}{F_r} = \frac{50}{2750} = 0.0182$; $\frac{F_a}{C_o} = \frac{50}{10900} = 0.004587$

From table $e \leq 0.22$

$\because$ $\cancel{\frac{F_a}{F_r}}$ $\frac{F_a}{F_r} < e$ So, $X = 1$

$P_3 = F_r = 2750\ N$

For Fourth gear, $P_4 = 2750\ N$

so, $P_e = \sqrt[3]{\frac{N_1P_1^3 + N_2P_2^3 + N_3P_3^3 + N_4P_4^3}{N_1 + N_2 + N_3 + N_4}}$

$= \sqrt[3]{\frac{54(6014.94)^3 + 126(2750)^3 + 450(2750)^3 + 1170(2750)^3}{1800}}$

$= 2988.9032$

$\because L_{10} = \left(\frac{C}{P}\right)^3 = \left(\frac{17600}{2988.9032}\right)^3 = 204.1749$

$$L = \frac{60\, n\, L_h}{10^6} = \frac{60(1200)(4000)}{10^6}$$

$$= 432 \text{ million rev.}$$

$$\because \left(\frac{L}{L_{10}}\right)^b = \left[\frac{\log_e\left(\frac{1}{R}\right)}{\log_e\left(\frac{1}{R_{90}}\right)}\right]$$

$b = 1.17$, $R_{90} = 0.9$

$L = 432$ million rev.

$L_{10} = 2017.1749$ million rev.

$$\left(\frac{432}{207.1749}\right)^{1.17} = \frac{\ln\left(\frac{1}{R}\right)}{\ln\left(\frac{1}{0.9}\right)}$$

$R = 0.77630$

$$\boxed{R = 77.63\%}$$

Question 12)

→ Given $L_{10h} =$ ~~10~~ 10000 h

Considering one minute duration for work cycle

$n_1 = 1440$ rpm $\quad n_2 = 720$ rpm $\quad n_3 = 1440$ rpm

$F_{r_1} = 3000$ N $\quad F_{r_2} = 5000$ N $\quad F_{r_3} = 2500$ N

$1/4 \quad 1/3 \quad 1-(1/4 + 1/3) = 5/12$

$N_1 = \frac{1}{4}(1440) = 360$ rev.

$N_2 = \frac{1}{3}(720) = 240$ rev.

avg. speed of rotation $\Rightarrow n = N_1 + N_2 + N_3 = 1200$ rpm

$$P_e = 3\sqrt{\frac{N_1 P_1^3 + N_2 P_2^3 + N_3 P_3^3}{N_1 + N_2 + N_3}}$$

$$= 3\sqrt{\frac{360(3000)^3 + 240(5000)^3 + 600(2500)^3}{1200}}$$

$$= 3445.762\ N$$

$$\because L_{10} = \frac{60\, m\, L_{10h}}{10^6} = \frac{60(1200) \times 10000}{10^6}$$

$$= 720 \text{ million rev.}$$

$$\because C = P(L_{10})^{1/3} = 3445.762(720)^{1/3}$$

$$= 30883.70836\ N$$