GANPAT UNIVERSITY
B. Tech. VIII Mechatronics Engineering
Regular Examination April/June 2016
2MC804 Design of Mechanical Systems

[Time: 3 Hour] [Total marks: 70]

Instructions:
(1) All questions are compulsory.
(2) Right figure indicate full marks.
(3) Assume suitable data if necessary.
(4) Only scientific calculator is allowed.

SECTION-I

Que.1 Attempt the followings.

(a) Prove that the basic static capacity of the ball bearing is proportional to the square of ball diameter and number of balls. Also mention the assumptions taken for the prove. Start equation in which the basic static capacity of ball bearing is product of radial load and the value of M as per usual notations. [4]

(b) Select a suitable radial deep groove ball bearing for a life of 10000 hours. The following data are given for a belt drive system in which the pulley is placed centrally with the belt tensions acting vertically down word. The tight side tension in the belt is three times the tension in the belt of slack side. Diameter of the pulley = 0.3 m, shaft diameter = 0.025 m, power transmitted = 7.5 KW, speed = 720 rpm, load factor = 3. If you reduce the load factor to half, then write comment on your answer regarding the change in bearing selection. [8]

OR

Que.1 Attempt the followings.

(a) With neat sketch explain the boundary lubrication, mixed lubrication, and hydrodynamic lubrication. [4]

(b) Use the following data given for a hydrostatic thrust bearing: [8]
Shaft speed = 720 rev/min, supply pressure = 5 N/mm^2, shaft radius = 0.2 m, recess radius = 0.125 m, oil film thickness = 0.15 mm, viscosity of lubricant = 30 cP, specific gravity of lubricant = 0.86. Calculate: (i) load carrying capacity of the bearing (ii) flow required in lit/min, (iii) frictional power loss, (iv) pumping power loss, and (v) temperature rise. Assume that the total power loss in the bearing is converted into frictional heat.

Que.2 Attempt the followings.

(a) Derive the equation for equivalent dynamic load for bearing in which the bearing operate under the periodic load. [4]

(b) A single row deep groove ball bearing operates with the following work cycles: [8]

Sr. No.	Element time, %	Radial load, kN	Thrust load, kN	Radial factor	Thrust factor	Race rotating	Service factor	Speed in rpm
1	50	3.0	1.0	0.56	1.4	Inner	1.5	720
2	20	2.5	1.0	0.56	1.6	outer	2.0	1440
3	remaining	No load	No load	---	---	outer	---	720

If the desired rating life of the bearing is 15000 hours, with a reliability of 95 per cent, calculate the basic dynamic load rating of the bearing so that it can be selected from the manufacturer's catalogue based on 90 per cent reliability. If there are six such bearings in

the system, what is the probability that all bearings will survive for 15000 hours?

OR

Que.2 Attempt the followings.

(a) Explain causes of bearing failure and their remedies. [6]

(b) A ball bearing working under cyclic load. For first cycle bearing operates for 0.01296 L_{h10} million revolutions, for second cycle 0.03456 L_{h10} million revolutions and for third cycle 0.0162 L_{h10} million revolutions respectively. The basic dynamic capacity of the bearing is 30.7 KN and the total equivalent dynamic load is 6066.89 N. Determine the average speed of bearing and life of bearing with 95 % reliability. [6]

Que.3 Attempt the followings.

(a) Define optimum design. Explain three different forms of equations used in Johnson's method of optimum design in brief. [3]

(b) Design a tensile bar of length L = 200 mm to carry a tensile load of 5000 N for minimum cost, out of the following materials: [8]

Material	Mass density (Kg/m^3)	Material cost (Rs./N Weight)	Yield strength (MPa)
Steel	7500	16	130
AL-Alloy	3000	32	50
Titanium Alloy	4800	480	90
Magnesium Alloy	2100	32	20

SECTION - II

Que:4 Attempt the followings.

(a) A pair of bevel gears with 20° pressure angle consists of a 20 teeth pinion meshing with a 30 teeth gear. The module is 4 mm while the face width is 20 mm. The material for pinion and gear is steel 50C4 (S_{ut} = 600 N/mm^2). The gears are machined to meet the specifications of grade 8 and the surface hardness is 350 BHN. The pinion rotates at 600 rpm and receives power from the electric motor. The starting torque of the motor is 150% of the rated torque. Assuming a minimum factor of safety as 2, determine the rated power that the gear can transmit. For Grade 8, e = 16 + 1.25Φ. [9]

(b) Explain advantage, disadvantage and applications of worm gear. [3]

OR

Que:4 Attempt the followings.

(a) It is required to design a pair of spur gear with 20° full depth involute teeth based on Lewis equation. The velocity factor is to be used account for dynamic load. The pinion shaft is connected to a 10 kW, 1440 rpm motor. The starting torque of the motor is 150% of the rated torque. The speed reduction is 4:1. The pinion as well as the gear are made of plain carbon steel 40C8 (S_{ut} = 600 N/mm^2). The factor of safety can be taken as 1.5. Design the gears, specify their dimensions and suggest suitable surface hardness for the gears. [9]

(b) Explain gear tooth failure. [3]

Que:5 Attempt the followings.

(a) It is required to design a pair of spur gear with 20° full depth involute teeth consisting of a 20 teeth pinion meshing with a 50 teeth gear. The pinion shaft is connected to a 22.5 kW, 1440 rpm electric motor. The starting torque of the motor can be taken as 150% of the rated torque. The material of the pinion is plain carbon steel Fe410 (S_{ut} = 410 N/mm^2), while the gear is made of grey cast iron FG200 (S_{ut} = 200 N/mm^2). The factor of safety is 1.5. Design the gear based on Lewis equation and using velocity factor to account for the dynamic load. [9]

(b) Explain advantage of gear drive compare with other drive. [2]

OR

e:5 Attempt the followings.

(a) A 35 kW motor running at 1200 r.p.m. drives a compressor at 780 r.p.m through a 90° bevel gearing arrangement. The pinion has 30 teeth. The pressure angle of teeth is 14.5°. The wheels are capable of withstanding a dynamic stress, $\sigma_w = 140\left(\frac{280}{280+v}\right) MPa$, Where v is the pitch line speed in m/min. The form factor for teeth may be taken as $0.124 - \frac{0.686}{T_E}$, Where T_E is the number of teeth equivalent of a spur gear. The face width may be taken as ¼ of the slant height of pitch cone. Determine for the pinion, the module pitch, face width, addendum, dedendum, outside diameter and slant height. [11]

Que:6 Attempt the followings.

(a) A pair of parallel helical gears consists of a 20 teeth pinion meshing with a 50 teeth gear. The pinion rotates at 1000 rpm. The normal pressure angle is 20°, while the helix angle is 25°. The face width is 40 mm and the normal module is 4 mm. The pinion as well as gear the gear are made of steel 40C8 (S_{ut} = 660 N/mm^2) and heat treated to a surface hardness of 350 BHN. The service factor and the factor of safety are 1.5 and 2 respectively. Assume that the velocity factor accounts for the dynamic load and calculate the power transmitting capacity of gears. [10]

(b) Distinguish between parallel and crossed helical gear. [2]

Table 1: Radial and thrust factors for single –row deep groove ball bearing

F_a/C_0	$(F_a/VF_r) \le e$		$(F_a/VF_r) > e$		e
	X	Y	X	Y	
0.025	1	0	0.56	2.0	0.22
0.04	1	0	0.56	1.8	0.24
0.07	1	0	0.56	1.6	0.27
0.13	1	0	0.56	1.4	0.31
0.25	1	0	0.56	1.2	0.37
0.5	1	0	0.56	1.0	0.44

Table 2: Dimensions and basic capacities of single-row deep-groove ball bearings

Bearing No.	Principal Dimensions			Basic Capacity	
	Bore 'd' mm	Outside Diameter 'D' mm	Width 'B' mm	Static 'Co' N	Dynamic 'C' N
6005	25	75	16	6550	11200
6205	25	85	19	7800	14000
6305	25	100	25	11600	22500
6405	25	120	29	19300	35800

Table 3: Value of Lewis Form Factor

Z	Y	Z	Y	Z	Y	Z	Y	Z	Y	Z	Y
16	0.295	20	0.320	24	0.337	28	0.352	33	0.367	40	0.389
17	0.302	21	0.326	25	0.340	29	0.355	35	0.373	45	0.399
18	0.308	22	0.330	26	0.344	30	0.358	37	0.380	50	0.408
19	0.314	23	0.333	27	0.438	32	0.364	39	0.386		

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