Ref:Ex/ME/5/T/322/2023

Bachelor of Engg (Mechanical Engg). 3rd yr. 2nd Semester Exam 2022

Subject : Machine Design III Time : Three hours // Full marks : 100

Answer any five questions

All questions carry equal marks

1. It is required to design a chain drive with a duplex chain to connect a 15 kW, 1400 RPM electric motor to a transmission shaft running at 350 RPM. The operation involved in moderate shocks.
   i. Specify the number of teeth on the driving and driven sprocket.
   ii. Select at proper roller chain.
   iii. Calculate the PCDs of the driving and the driven sprockets.
   iv. Determine the number of chain links.
   v. Specify the correct center distance.
   Assume center distance is 40 times the pitch of the chain.
2. A ball bearing operates on the following work cycle :

Element No.	Radial Load (N)	Speed (RPM)	Element Time (%)
1	3000	720	30
2	7000	1440	50
3	5000	900	20

   The dynamic load carrying capacity of the bearing is 25 kN. Calculate the average speed of rotation, the equivalent radial load and the bearing life.
3. (a) A ball bearing is subjected to a radial force of 2500 N and an axial force of 1000 N. The dynamic load carrying capacity of the bearing is 7350 N. The shaft is rotating at 720 RPM. Calculate the life of the bearing.
   (b) A ball bearing subjected to a radial load of 3000 N is expected to have a satisfactory life of 10,000 hours at 650 RPM with a reliability of 92%. Calculate the dynamic load carrying capacity of the bearing so that it can be selected from manufacturer's catalogue.
4. Following data is given for a pair of parallel helical gears made of steel.
   Power transmitted = 22 kW.
   Speed of pinion = 700 RPM
   No. of teeth of the pinion = 35
   No. of teeth of the gear = 70
   Center distance = 290 mm
   Normal module = 5 mm
   Face width = 50 mm

[Turn over

Normal pressure angle = 20 degree
UTS = 600 N/mm^2
Surface hardness = 325 BHN
Grade of machining = Gr. 6
Service factor = 1.25
Calculate :

I. The helix angle.
II. The Beam strength
III. The wear strength
IV. The static load
V. The dynamic load by Buckinghan's equation.
VI. The effective load.
VII. The effective factor of safety against bending failure.
VIII. The effective factor of safety against pitting failure.

5. Write short notes on :
   a. Polygonal effect of chain
   b. failures of the chain
   c. Stribeck equation
   d. Lewis equation.
6. A pair of spur gear consist of a 24 teeth pinion, rotating at 1000 RPM and transmitting power to a 48 teeth gear. The module is 6 mm, while the face width is 60 mm. Both the gears are made of steel with an ultimate tensile strength of 450 N/mm^2. They are heat treated to a surface hardness of 250 BHN. Assume that velocity factor accounts for the dynamic load. Calculate Beam Strength, Wear Strength and the rated power that the gears can transmit. If service factor and factor of safety are 1.5 & 2 respectively.
7. A pair of straight bevel gear is mounted on shafts which are intersecting at right angles. The number of teeth on pinion and gear are 30,45 respectively. The pressure angle is 20 degree. The pinion shaft is connected to an electric motor developing 20 kW Rated power at 550 rpm. The service factor can be taken as 1.65. The pinion and the gear are made of steel (UTS = 570 N/mm2)) The gears are made of steel and the surface hardness is 300 BHN. The gears are manufactured in such a way that the error between two meshing teeth is limited to 22μm. assume module 6mm and face width 50mm . Determine the factor of safety against bending as well as pitting

Table 1 Dimensions and breaking loads of roller chains

ISO chain number	Pitch p (mm)	Roller diameter d_1 (mm)	Width b_1 (mm)	Transverse pitch p_t (mm)	Breaking load for single strand chain (kN)
06 B	9.525	6.35	5.72	10.24	10.7
08 B	12.70	8.51	7.75	13.92	18.2
10 B	15.875	10.16	9.65	16.59	22.7
12 B	19.05	12.07	11.68	19.46	29.5
16 B	25.40	15.88	17.02	31.88	65.0
20 B	31.75	19.05	19.56	36.45	98.1
24 B	38.10	25.40	25.40	48.36	108.9
28 B	44.45	27.94	30.99	59.56	131.5
32 B	50.80	29.21	30.99	58.55	172.4
40 B	63.50	39.37	38.10	72.29	272.2

Table 2 Power rating for simple roller chain

Pinion speed (r.p.m.)	Power (kW)				
	06 B	08 B	10 B	12 B	16 B
50	0.14	0.34	0.64	1.07	2.59
100	0.25	0.64	1.18	2.01	4.83
200	0.47	1.18	2.19	3.75	8.94
300	0.61	1.70	3.15	5.43	13.06
500	1.09	2.72	5.01	8.53	20.57
700	1.48	3.66	6.71	11.63	27.73
1000	2.03	5.09	8.97	15.65	34.89
1400	2.73	6.81	11.67	18.15	38.47
1800	3.44	8.10	13.03	19.85	—
2000	3.80	8.67	13.49	20.57	—

Table 3 Service factor (K_s)

Type of input power	Type of driven load		
	Smooth	Moderate shock	Heavy shock
(i) I.C. Engine with hydraulic drive	1.0	1.2	1.4
(ii) Electric motor	1.0	1.3	1.5
(iii) I.C. Engine with mechanical drive	1.2	1.4	1.7

Table 4. Tooth correction factor (K_2)

Number of teeth on the driving sprocket	K_2
15	0.85
16	0.92
17	1.00
18	1.05
19	1.11
20	1.18
21	1.26
22	1.29
23	1.35
24	1.41
25	1.46
30	1.73

F_a / C_0	$F_a / F_r \le e$		$F_a / F_r > e$		e
	X	Y	X	Y	
0.025	1	0	0.56	2.0	0.22
0.040	1	0	0.56	1.8	0.24
0.070	1	0	0.56	1.6	0.27
0.130	1	0	0.56	1.4	0.31
0.250	1	0	0.56	1.2	0.37
0.500	1	0	0.56	1.0	0.44

Take deformation factor (C) = 11400 N/mm^2 in all cases.

Table 1: Lewis Form factor (Y) , z = no of teeth pinion/gear

z	Y	z	Y	z	Y
15	0.289	27	0.348	55	0.415
16	0.295	28	0.352	60	0.421
17	0.302	29	0.355	65	0.425
18	0.308	30	0.358	70	0.429
19	0.314	32	0.364	75	0.433
20	0.320	33	0.367	80	0.436
21	0.326	35	0.373	90	0.442
22	0.330	37	0.380	100	0.446
23	0.333	39	0.386	150	0.458
24	0.337	40	0.389	200	0.463
25	0.340	45	0.399	300	0.471
26	0.344	50	0.408	Rack	0.484

Tolerances on adjacent pitch [$\Phi = m + 0.25\sqrt{d'}$]

Φ = tolerance factor, m = module, d' = p.c.d

Grade	e (microns)
1	0.80 + 0.06 ϕ
2	1.25 + 0.10 ϕ
3	2.00 + 0.16 ϕ
4	3.20 + 0.25 ϕ
5	5.00 + 0.40 ϕ
6	8.00 + 0.63 ϕ
7	11.00 + 0.90 ϕ
8	16.00 + 1.25 ϕ
9	22.00 + 1.80 ϕ
10	32.00 + 2.50 ϕ
11	45.00 + 3.55 ϕ
12	63.00 + 5.00 ϕ