Bachelor of Mechanical Engg (Part Time) Third yr. 2nd Semester Exam 2018

Machine Design III

Time : Three hours

Full Marks : 100

Answer any five questions

1. It is required to design a spur gears with 20 degree full-depth involute teeth consisting of 20 teeth pinion meshing with 50 teeth gear. The pinion shaft is connected to a 22.5 kW, 1450 rpm electric motor. speed reducer for a compressor running at 250 rpm driven by a 10 kW, 1000 rpm electric motor. The starting torque of the motor can be assumed to be 150% of the rated torque. The gear and pinion are made of carbon steel (S_{ut} = 410 MPa). The factor of safety is 1.5. Design the gears based on the Lewis equation and using velocity factor to account for the dynamic load. Mention the assumptions made in deriving Lewis equation.
2. It is required to design a chain drive to connect a 5 kW, 1400 rpm electric motor to a drilling machine. The speed reduction is 3:1. The center distance should be approximately 500 mm. (I) Select a proper roller chain for the drive (II) Determine the no of chain links (III) The specify the correct center distance The relevant design data is furnished in Tables 1 - 4.
3. A pair of helical gears consists of 24 teeth pinion rotating at 5000 rpm and supply 2.5 kw power to a gear. The speed reduction is 4:1. The normal pressure angle and helix angle are 20 degree and 23 degree respectively. Both gears are made of hardened steel (S_{ut} = 750 MPa). The service factor and factor of safety are 1.5 and 2 respectively. The error between the two gears is 8 μm.

   Calculate (i) the normal module assuming b = 10 m and pitch line velocity being 10 m/sec. (ii) The main dimensions of the gear (iii) Dynamic load using Buckingham equation and find factor of safety fore bending (iv) Calculate surface hardness for gear assuming a factor of safety of 2 for wear consideration
4. A pair of straight bevel gears is mounted on shafts, which are intersecting at right angles. The number of teeth on the pinion and gear are 30 and 45 respectively. The pressure angle is 20 degree. The pinion shaft is connected to an electric motor developing 15 kW rated power at 500 rpm. The service factor can be taken as 1.5. The pinion and gears are made of steel(S_{ut} = 560 MPa) and heat treated to a surface hardness of 340 BHN. The gears are manufactured in such a way that the error between two

meshing teeth is limited to 20 μm. The module and face width are 6 mm and 50 mm respectively. Determine the factor of safety against bending and pitting.

5. a) What is Wiebull distribution?

   b) A single row deep groove ball bearing is subjected to a radial force of 6 kN and a thrust force of 2 kN. The shaft rotates at 1200 rpm. The diameter of shaft is 40 mm.

   Estimate (i) the life of bearings with 90 % reliability.(ii) the reliability for 6000 hours of life. (iii) the system reliability.

6. (a) A single row deep groove ball bearing is subjected to a radial force of 8000 N and an axial force of 3000 N. The shaft rotates at 1200 rpm. The expected life L_{10h} of the bearing is 20000 hour. The minimum acceptable diameter of the shaft is 75 mm. Select a suitable bearing for this application.

   (b) Derive Stribeck equation for ball bearing with its assumption.

7. (a) A single row deep groove ball bearing has a dynamic load capacity of 40500 N and operates on the following work cycle:

   (I) Radial load of 5000 N at 700 rpm for 25% of the time.

   (II) Radial load of 10000 N at 500 rpm for 50% of the time.

   (III) Radial load of 7000 N at 400 rpm for the remaining 25% of the time. Calculate expected life of the bearing in hours

   (b) Write a short notes on different types of lubrication.

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

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1800	3.44	8.10	13.03	19.85	—
2000	3.80	8.67	13.49	20.57	—

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

Shaft diameter(mm)	Dynamic load capacity(N) C	Static load capacity(N) C_0	Desig nation
75	28600	20000	10615
	39700	26000	6015
	66300	40500	6215
	112000	72000	6315
	153000	114000	6415