Ref No : Ex/ME/5/T/322/2017

Bachelor of Mechanical Engg (Part Time) Third yr. 2nd Semester Exam 2017

Machine Design III

Time : Three hours

Full Marks : 100

Answer any five questions

1. It is required to design a spur gear speed reducer for a compressor running at 250 rpm driven by a 10 kW, 1000 rpm electric motor. The centre distance between the axes of the gear shafts should be exactly 250 mm. The starting torque of the motor can be assumed to be 150% of the rated torque. The gears are made of carbon steel (S_{ut} = 680 MPa). The pressure angle is 20 degree. The factor of safety is 1.6 for preliminary design based on the use of velocity factor. (i) Design the gears and specify their dimensions. (ii) Calculate the dynamic load by using Buckingham's equation assuming gears are manufactured in such a way that the error between the two meshing teeth is limited to 26 μm. (iii) Calculate the effective load. (iv) What is the actual factor of safety against bending failure? (v) Using the same factor of safety against wear failure, specify suitable surface hardness for the gears.
2. It is required to design a chain drive to connect a 12 kW, 1400 rpm electric motor to a centrifugal pump running at 700 rpm. Assume variable load with moderate shock, drop lubrication and 4 mm reduction in center distance to accommodate initial sag. The relevant design data is furnished in Tables 1 - 4. Design the chain drive and provide a proper roller chain along with its dimensions, determine the pitch circle diameters of driving and driven sprockets, the number of chain links and the correct centre distance between the axes of sprockets.

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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 ball bearing is operating on a work cycle consisting of three parts – a radial load of 3000 N at 1440 rpm for one quarter cycle, a radial load of 5000 N at 720 rpm for one half cycle, and radial load of 2500 N at 1440 rpm for the remaining cycle. The expected life of the bearing is 10000 hours. Calculate the dynamic load carrying capacity of the bearing.

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

7. (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) 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 5

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

Table 6 *Values of the Lewis form factor Y for 20° full-depth involute system*

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

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. 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	—