17.24 GEAR LUBRICATION

Proper lubrication of the gear teeth is essential for the satisfactory performance and durability of the gears. Gears are lubricated by grease, straight mineral oils or EP (extreme pressure) lubricants[9, 10]. Grease is used as lubricant for the gears of hand-operated mechanisms, where the pitch line velocity is low and the operation is intermittent. For medium velocities, the gears are enclosed in a box and dipped in a bath of mineral oil. This is known as *splash lubrication*. In some cases, gears are lubricated by spraying the lubricating oil, in which a jet of oil is directed towards the meshing teeth. When the pitch line velocities are medium, mineral oils of grades SAE 8O, SAE 90 or SAE 140 are used. For heavy duty applications, EP lubricants are used. EP lubricants are mineral oils with additives for the purpose of improving the performance of the oil. They are used in the automobile gear box and heavy duty industrial gearboxes. For splash or spray lubrication, the gearbox has additional features, like oil seals for the shaft, gaskets for the cover, plug for inserting the oil, a drain plug at the bottom and, sometimes, an oil level indicator too.

Short-Answer Questions

17.1 State applications of gear drives.
17.2 State any four advantages of gear drive over other types of drives.
17.3 State any two disadvantages of gear drive over other types of drives.
17.4 In a gear speed reducer, why is the diameter of an output shaft greater than input shaft?
17.5 In which gear drive is self-locking possible?
17.6 What is herringbone gear?
17.7 What are the advantages of cycloidal teeth gears?
17.8 What are the advantages of involute teeth gears?
17.9 State two important reasons for adopting involute curve for gear tooth profile.
17.10 What are the advantages of 14.5° full-depth involute teeth gears?
17.11 What are the advantages of 20° full-depth involute teeth gears?
17.12 What are the advantages of 20° stub involute teeth gears?
17.13 What is full depth involute gear tooth system?
17.14 What is the stub involute gear tooth system?
17.15 Why is the tangential component of gear tooth force called 'useful' component?
17.16 Why is the radial component of gear tooth force called 'separating' component?
17.17 What is pitting?
17.18 What is scoring?
17.19 What is the minimum number of teeth on spur gear? Why?
17.20 What is a 'hunting' tooth?
17.21 Why is the pinion weaker than the gear made of same material?
17.22 State two advantages of internal gears.
17.23 State two disadvantages of internal gears.
17.24 What are the advantages of planetary reduction gears as compared to ordinary gearboxes?
17.25 Where do you use grease as gear lubricant?
17.26 Where do you use oil as gear lubricant?

Problems for Practice

17.1 In a pair of spur gears, the number of teeth on the pinion and the gear are 20 and 100 respectively. The module is 6 mm. Calculate
(i) the centre distance;
(ii) the pitch circle diameters of the pinion and the gear;
(iii) addendum and dedendum;
(iv) tooth thickness and bottom clearance; and
(v) the gear ratio.
[*(i) 360 mm (ii) 120 and 600 mm, (iii) 6 and 7.5 mm, (iv) 9.4248 and 1.5 mm (v) 5*]

[9] IS 1277: Specifications for gear lubricants (regular).
[10] IS 1118: Specifications for gear lubricants-multipurpose (EP gear oils).

17.2 A pinion with 25 teeth and rotating at 1200 rpm drives a gear which rotates at 200 rpm. The module is 4 mm. Calculate the centre distance between the gears.

[*350 mm*]

17.3 A pair of spur gears with a centre distance of 495 mm is used for a speed reduction of 4.5: 1. The module is 6 mm. Calculate the number of teeth on the pinion and the gear.

[*30 and 135*]

17.4 A train of spur gears is shown in Fig. 17.47. Gear 1 is the driving gear and transmits 5 kW power at 720 rpm. The number of teeth on gears 1, 2, 3 and 4 are 20, 50, 30 and 60 respectively. The module for all gears is 4 mm. The gears have a 20° full-depth involute profile. Calculate the tangential and radial components of the tooth force between

(i) Gears 1 and 2 and

(ii) Gears 3 and 4

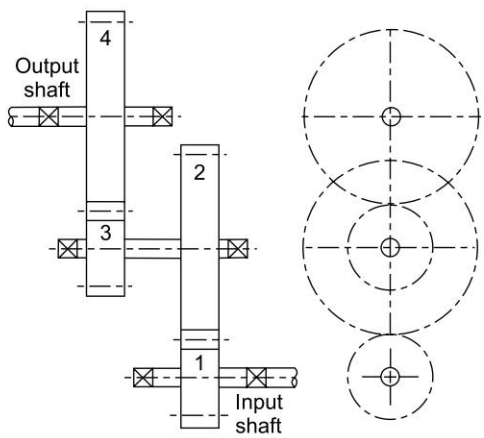

Fig. 17.47

[*(i) 1657.86 and 603.41 N*
(ii) 2763.11 and 1005.69 N]

17.5 A train of gears transmitting power from a 10 kW, 1440 rpm motor to a rope drum is shown in Fig. 17.48. The number of teeth on the various gears is as follows:

$z_1 = 20$ $z_2 = 100$ $z_3 = 25$

$z_4 = 150$ $z_5 = 25$ $z_6 = 150$

The module of gears 1 and 2 is 5 mm, while that of all other gears is 6 mm. The pressure angle is 20°. Calculate

(i) torques acting on shafts *A*, *B*, *C* and *D*;

(ii) tangential and radial components of tooth forces between gears 1 and 2, gears 3 and 4 and gears 5 and 6;

(iii) resultant reactions at bearings B_1 and B_2; and

(iv) resultant reactions at bearings C_1 and C_2.

[*(i) 66 314.56, 331 572.8, 1 989 436.79 and 11 936 620.73 N-mm (ii) 1326.29 and 482.73 N, 4420.97 and 1609.1 N, 26 525.82 and 9654.61 N (iii) 3678.56 and 2213.47 N (iv) 21 210.32 and 10856.55 N*]

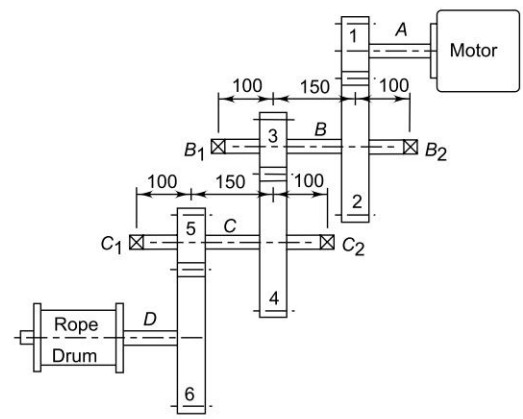

Fig. 17.48

17.6 A train of spur gears with 20° full-depth involute teeth is shown in Fig. 17.49. Gear 1 is the driving gear and transmits 50 kW power at 300 rpm to the gear train. The number teeth on gears 1, 2, 3 and 4 are 30, 60, 25 and 50 respectively, while the module for all gears is 8 mm. Gears 2 and 3 are mounted on the same shaft. Gear 1

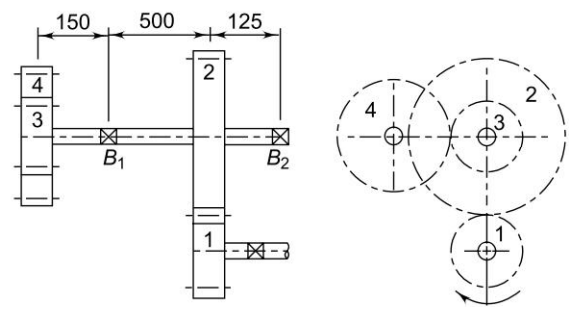

Fig. 17.49

is rotating in the clockwise direction when seen from the left side of the page. Calculate

(i) tangential and radial components of tooth forces between gears 1 and 2 and gears 3 and 4; and

(ii) resultant reactions at bearing B_1 and B_2.

[*(i) 13262.91 and 4827.31 N, 31830.99 and 11585.53 N, (ii) 43871.35 and 8693.44 N*]

17.7 The following data is given for a pair of spur gears with 20° full-depth involute teeth:

number of teeth on pinion = 24
number of teeth on gear = 56
speed of pinion = 1200 rpm
module = 3 mm
service factor = 1.5
face width = 30 mm

Both gears are made of steel with an ultimate tensile strength of. 600 N/mm^2. Using the velocity factor to account for the dynamic load, calculate

(i) beam strength;

(ii) velocity factor; and

(iii) rated power that the gears can transmit without bending failure, if the factor of safety is 1.5.

[*(i) 6066 N (ii) 0.3987 (iii) 4.86 kW*]

17.8 The pitch circle diameters of the pinion and gear are 100 and 300 mm respectively. The pinion is made of plain carbon steel 4OC8 (S_{ut} = 600 N/mm^2) while the gear is made of grey cast iron FG 300 (S_{ut} = 300 N/mm^2). The pinion receives 5 kW power at 500 rpm through its shaft. The service factor and factor of safety can be taken as 1.5 each. The face width of the gear can be taken as ten times that of the module. Assume that the velocity factor accounts for the dynamic load. Calculate

(i) module; and (ii) the number of teeth on the pinion and gear.

[*(i) 5 mm, (ii) 20 and 60*]

17.9 A steel pinion with 20° full depth involute teeth is transmitting 7.5 kW power at 1000 rpm from an electric motor. The starting torque of the motor is twice the rated torque. The number of teeth on the pinion is 25, while the module is 4 mm. The face width is 45 mm. Assuming that velocity factor accounts for the dynamic load, calculate

(i) the effective load on the gear tooth; and

(ii) the bending stresses in the gear tooth.

[*(i) 7863.79 N, (ii) 128.49 N/mm^2*]

17.10 A pair of spur gears with 20° pressure angle, consists of a 25 teeth pinion meshing with a 60 teeth gear. The module is 5 mm, while the face width is 45 mm. The pinion rotates at 500 rpm. The gears are made of steel and heat treated to a surface hardness of 220 BHN. Assume that dynamic load is accounted by means of the velocity factor. The service factor and the factor of safety are 1.75 and 2 respectively. Calculate

(i) wear strength of gears;

(ii) the static load that the gears can transmit without pitting; and

(iii) rated power that can be transmitted by gears.

[*(i) 6149.8 N, (ii) 840.41 N, (iii) 2.75 kW*]

17.11 A pair of spur gears consists 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 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

(i) beam strength;

(ii) wear strength; and

(iii) the rated power that the gears can transmit, if service factor and the factor of safety are 1.5 and 2, respectively.

[*(i) 18 198 N (ii) 11 517.12 N (iii) 8.24 kW*]

17.12 It is required to design a pair of spur gears with 20° full-depth involute teeth. The input shaft rotates at 720 rpm and receives 5 kW power through a flexible coupling. The speed of the output shaft should be 144 rpm. The pinion as well as the gear are made of steel Fe 410 (S_{ut} = 410 N/mm^2). The service factor for the application is 1.25. The gears are machined to meet the specifications of Grade 6.