THEORY OF MACHINE AND MECHANISM II

TUTORIAL NO: 2

TURNING MOMENT DIAGRAM AND FLYWHEEL

1. An engine flywheel has a mass of 6.5 tonnes and the radius of gyration is 2 m. If the maximum and minimum speeds are 120 r. p. m. and 118 r. p. m. respectively, find maximum fluctuation of energy.

2. A horizontal cross compound steam engine develops 80 kW at 240 r.p.m. The coefficient of fluctuation of energy as found from the turning moment diagram is to be 0.25 and the fluctuation of speed is to be kept within ± 1 % of the mean speed. Find the mass of the flywheel required, if the radius of gyration is 0.65 metres.

3. An engine runs at 100 rpm and a curve of the turning moment plotted on a crank angle base showed the following areas alternatively above and below the mean turning moment line: 780, 400, 520, 620, 260, 460, 340, 420 mm^2. The scale used were 1 mm = 400 N.m for torques axis and 1 mm = 1^0 for crank angle axis.

If the total fluctuation in speed is limited 2% of mean speed, determine the mass of flywheel necessary if the radius of gyration is 1.05 m.

4. The turning moment diagram for a multicylinder engine has been drawn to a scale of 1 mm = 4500 N-m vertically and 1 mm = 2.4° horizontally. The intercepted areas between output torque curve and mean resistance line taken in order from one end are 342, 23, 245, 303, 115, 232, 227, 164 mm^2, when the engine is running at 150 r.p.m. If the mass of the flywheel is 1000 kg and the total fluctuation of speed does not exceed 3% of the mean speed, find the minimum value of the radius of gyration.

5. A multi-cylinder engine is to run at a speed of 600 r.p.m. On drawing the turning moment diagram to a scale of 1 mm = 250 N-m and 1 mm = 3°, the areas above and below the mean torque line in mm^2 are : + 160, – 172, + 168, – 191, + 197, – 162. If the moment of inertia of the flywheel is 32.7 kg m^2, determine the coefficient of fluctuation of speed.

6. The torque delivered by a two stroke engine is represented by $T = (20000 + 9500sin2\theta - 5700cos2\theta\ N.m$, where θ is the angle turned by the crank from the inner dead center. If the resisting torque is constant, determine:

(a) The power developed,

(b) Moment of inertia of flywheel in kg m^2, if the total fluctuation of speed is not exceed 1% of mean speed which is 180 rpm, and

(c) The angular acceleration of flywheel when the crank has rotated through an angle of 45^0 from the inner dead center.

7. A certain machine requires a torque of (5000 + 500 sin θ) N-m to drive it, where θ is the angle of rotation of shaft measured from certain datum. The machine is directly coupled to an engine which produces a torque of (5000 + 600 sin 2θ) N-m. The flywheel and the other rotating parts attached to the engine has a mass of 500 kg at a radius of gyration of 0.4 m. If the mean speed is 150 r.p.m., determine :

(a) the fluctuation of energy,

(b) the total percentage fluctuation of speed, and

(c) the maximum and minimum angular acceleration of the flywheel and the corresponding shaft position.

8. A single cylinder double acting steam engine delivers 185 kW at 100 r.p.m. The maximum fluctuation of energy per revolution is 15 per cent of the energy developed per revolution. The speed variation is limited to 1 per cent either way from the mean. The mean diameter of the rim is 2.4 m. Find the mass and cross-sectional dimensions of the flywheel rim when width of rim is twice the thickness. The density of flywheel material is 7200 kg/m^3.

9. A single cylinder internal combustion engine working on the four stroke cycle develops 75 kW at 360 r.p.m. The fluctuation of energy can be assumed to be 0.9 times the energy developed per cycle. If the fluctuation of speed is not to exceed 1 per cent and the maximum centrifugal stress in the flywheel is to be 5.5 MPa, estimate the mean diameter and the cross-sectional area of the rim. The material of the rim has a density of 7200 kg/m^3.

10. A steam engine runs at 150 r.p.m. Its turning moment diagram gave the following area measurements in mm^2 taken in order above and below the mean torque line:
500, – 250, 270, – 390, 190, – 340, 270, – 250
The scale for the turning moment is 1 mm = 500 N-m, and for crank angle is 1mm = 5°.
The fluctuation of speed is not to exceed ± 1.5% of the mean, determine the cross-section of the rim of the flywheel assumed rectangular with axial dimension equal to 1.5 times the radial dimension. The hoop stress is limited to 3 MPa and the density of the material of the flywheel is 7500 kg/m^3.

ANSWERS

1. 67.859 kJ **2.** 936.77 kg **3.** 2598.45 kg
4. 3.7897 m **5.** 1.998 %
6. 376.991 kW, 3118.106 kg m^2, 3.0467 rad /s^2
7. 1204.167 N-m, 6.1%, 35.025° or 127.631°, 3.463 rad /s^2, 12.203 rad /s^2 (retardation)
8. 5271.87 kg; 440.71 mm; 220.35 mm **9.** 1.4663 m, 0.0444 m^2
10. 221.56 mm; 147.7 mm