THEORY OF MACHINE AND MECHANISM II

TUTORIAL NO: 1

ENGINE FORCE ANALYSIS

1. In a slider crank mechanism, the length of the crank and connecting rod are 100 mm and 400 mm respectively. The crank rotates uniformly at 600 r.p.m. clockwise. When the crank has turned through 45° from the inner dead centre, determine
(a) Velocity and acceleration of the slider,
(b) Angular velocity and angular acceleration of the connecting rod.

2. A petrol engine has a stroke of 120 mm and connecting rod is 3 times the crank length. The crank rotates at 1500 r.p.m. in clockwise direction. Determine:
(a) Velocity and acceleration of the piston, and
(b) Angular velocity and angular acceleration of the connecting rod, when the piston had travelled one-fourth of its stroke from I.D.C.

3. If the crank and the connecting rod are 300 mm and 1 m long respectively and the crank rotates at a constant speed of 200 r.p.m., determine:
(a) The crank angle at which the maximum velocity occurs, and
(b) Maximum velocity of the piston.

4. The following data refer to a steam engine: Diameter of piston = 240 mm; stroke = 600 mm; length of connecting rod = 1.5 m; mass of reciprocating parts = 300 kg; speed = 125 r.p.m.

Determine the magnitude and direction of the inertia force on the crankshaft when the crank has turned through 30° from inner dead centre.

5. A vertical petrol engine 150 mm diameter and 200 mm stroke has a connecting rod 350 mm long. The mass of the piston is 1.6 kg and the engine speed is 1800 r.p.m. On the expansion stroke with crank angle 30° from top dead centre, the gas pressure is 750 kN/m^2. Determine the net thrust on the piston.

6. A horizontal steam engine running at 120 r.p.m. has a bore of 250 mm and a stroke of 400 mm. The connecting rod is 0.6 m and mass of the reciprocating parts is 60 kg. When the crank has turned through an angle of 45° from the inner dead centre, the steam pressure on the cover end side is 550 kN/m^2 and that on the crank end side is 70 kN/m^2. Considering the diameter of the piston rod equal to 50 mm, determine:
(a) turning moment on the crank shaft, and
(b) thrust on the bearings.

7. A vertical single cylinder engine has a cylinder diameter of 250 mm and a stroke of 450 mm. The reciprocating parts have a mass of 180 kg. The connecting rod is 4 times the crank radius and the speed is 360 r.p.m. When the crank has turned through an angle of 45° from top dead centre, the net pressure on the piston is 1.05 MN/m^2. Calculate the effective turning moment on the crankshaft for this position.

8. The connecting rod of a gasoline engine is 300 mm long between its centers. It has a mass of 15 kg and mass moment of inertia of 7000 kg-mm^2. Its centre of gravity is at 200 mm from its

small end centre. Determine the dynamical equivalent two-mass system of the connecting rod if one of the masses is located at the small end centre.

9. If the crank and the connecting rod are 300 mm and 1 m long respectively and the crank rotates at a constant speed of 200 r.p.m. Plot the following graphs:
(c) Velocity and acceleration of the piston vs. crank position, and
(d) Angular velocity and acceleration of the connecting rod vs crank position.

10. Write a program to take all required input variables from the user and give output for the turning moment of the crank shaft.

ANSWERS

1. 5.228 m/s, 279.155 m/s^2; 11.285 rad/s, 686.181 rad/s^2
2. 9.014 m/s, 764.913 m/s^2; 32.885 rad/s, 6490.922 rad/s^2
3. 75º, 6.54 m/s
4. 14.897 kN
5. 7518.205 N
6. 3.929 kN.m, 11.976 N
7. 2365.97 N.m
8. 0.173 kg, 14.827 kg