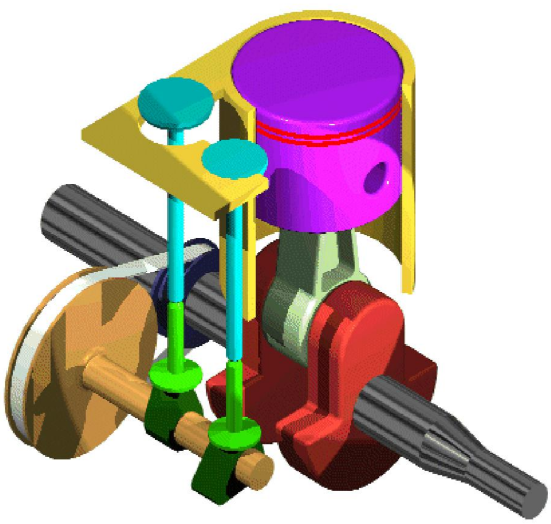
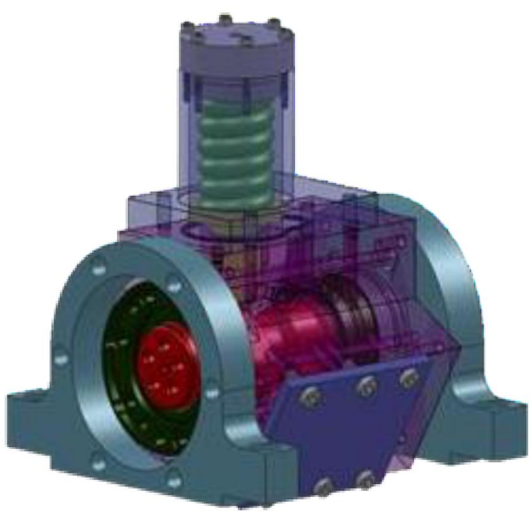
4

Cams and Follower





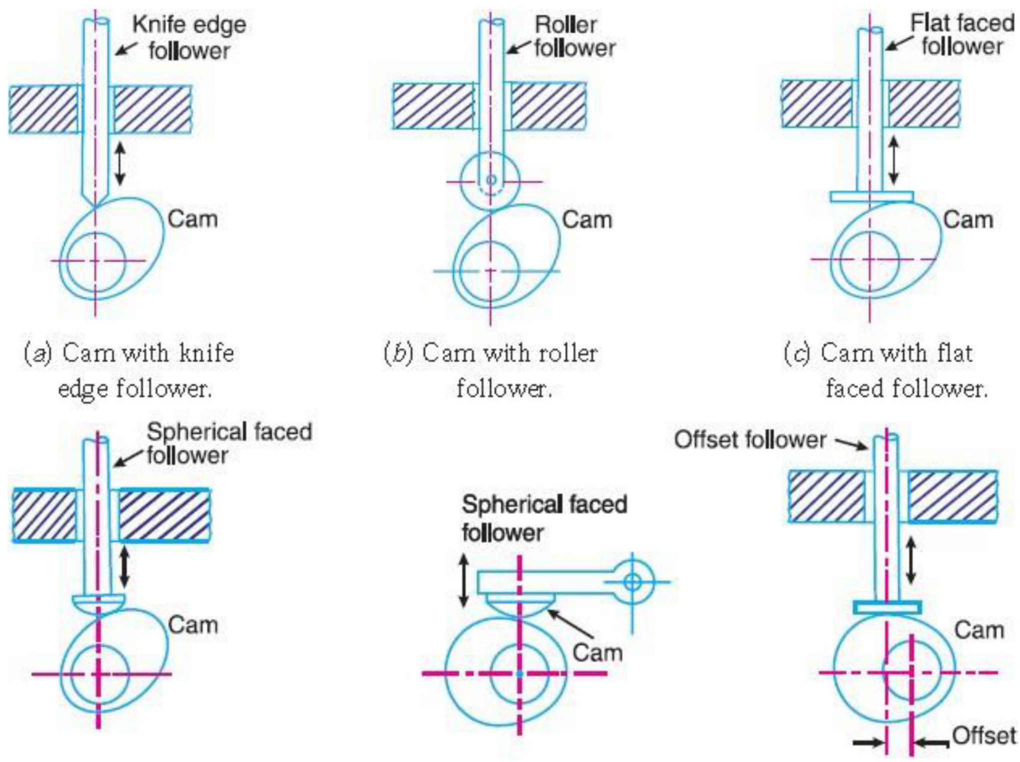
Course Contents

4.1 Introduction

- A cam is a rotating machine element which gives reciprocating or oscillating motion to another element known as follower.
- The cam and the follower have a line contact and constitute a higher pair. The cams are usually rotated at uniform speed by a shaft, but the follower motion is pre-determined and will be according to the shape of the cam. The cam and follower is one of the simplest as well as one of the most important mechanisms found in modern machinery today.
- The cams are widely used for operating the inlet and exhaust valves of internal combustion engines, automatic attachment of machineries, paper cutting machines, spinning and weaving textile machineries, feed mechanism of automatic lathes etc.

4.2 Classification of Followers

The followers may be classified as discussed below :



(a) Cam with knife edge follower. (b) Cam with roller follower. (c) Cam with flat faced follower.

(d) Cam with spherical faced follower. (e) Cam with spherical faced follower. (f) Cam with offset follower.

Fig. 4.1 classification of follower

According to surface in contact

a Knife edge follower

- When the contacting end of the follower has a sharp knife edge, it is called a knife edge follower, as shown in Fig. 7.1 (a).
- The sliding motion takes place between the contacting surfaces (i.e. the knife edge and the cam surface). It is seldom used in practice because the small area of contacting surface results in excessive wear. In knife edge followers, a considerable side thrust exists between the follower and the guide.

b Roller follower

- When the contacting end of the follower is a roller, it is called a roller follower, as shown in Fig. 7.1 (b). Since the rolling motion takes place between the contacting surfaces (i.e. the roller and the cam), therefore the rate of wear is greatly reduced.
- In roller followers also the side thrust exists between the follower and the guide. The roller followers are extensively used where more space is available such as in stationary gas and oil engines and aircraft engines.

c Flat faced or mushroom follower

- When the contacting end of the follower is a perfectly flat face, it is called a flat-faced follower, as shown in Fig. 7.1 (c). It may be noted that the side thrust between the follower and the guide is much reduced in case of flat faced followers.
- The only side thrust is due to friction between the contact surfaces of the follower and the cam. The relative motion between these surfaces is largely of sliding nature but wear may be reduced by off-setting the axis of the follower, as shown in Fig. 7.1 (f) so that when the cam rotates, the follower also rotates about its own axis.
- The flat faced followers are generally used where space is limited such as in cams which operate the valves of automobile engines.

d Spherical faced follower

- When the contacting end of the follower is of spherical shape, it is called a spherical faced follower, as shown in Fig. 7.1 (d). It may be noted that when a flat-faced follower is used in automobile engines, high surface stresses are produced. In order to minimize these stresses, the flat end of the follower is machined to a spherical shape.

According to the motion of follower

a Reciprocating or Translating Follower

- When the follower reciprocates in guides as the cam rotates uniformly, it is known as reciprocating or translating follower. The followers as shown in Fig. 7.1 (a) to (d) are all reciprocating or translating followers.

b Oscillating or Rotating Follower

- When the uniform rotary motion of the cam is converted into predetermined oscillatory motion of the follower, it is called oscillating or rotating follower. The follower, as shown in Fig 7.1 (e), is an oscillating or rotating follower.

According to the path of motion of the follower

a Radial Follower

- When the motion of the follower is along an axis passing through the centre of the cam, it is known as radial follower. The followers, as shown in Fig. 7.1 (a) to (e), are all radial followers.

b Off-set Follower

- When the motion of the follower is along an axis away from the axis of the cam centre, it is called off-set follower. The follower, as shown in Fig. 7.1 (f), is an off-set follower.

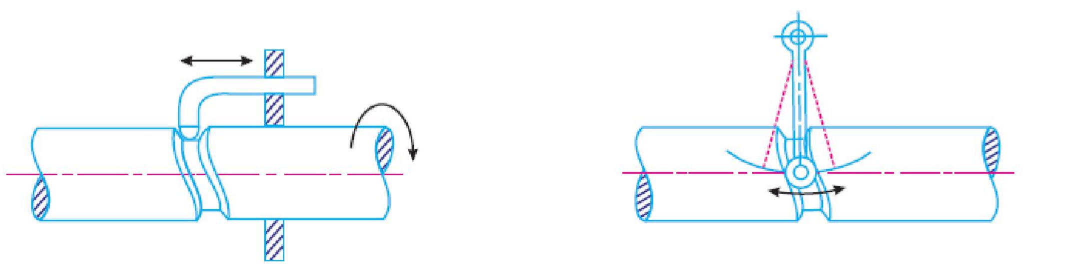
Classification of cams

a Radial or Disc cam

- In radial cams, the follower reciprocates or oscillates in a direction perpendicular to the cam axis. The cams as shown in Fig. 7.1 are all radial cams.

b Cylindrical cam

- In cylindrical cams, the follower reciprocates or oscillates in a direction parallel to the cam axis. The follower rides in a groove at its cylindrical surface. A cylindrical grooved cam with a reciprocating and an oscillating follower is shown in Fig. 7.2 (a) and (b) respectively.



(*a*) Cylindrical cam with reciprocating follower. (*b*) Cylindrical cam with oscillating follower.

Fig. 4.2 cylindrical cam

4.3 Terms used in radial cams

a Base circle

- It is the smallest circle that can be drawn to the cam profile.

b Trace point

- It is a reference point on the follower and is used to generate the pitch curve. In case of knife edge follower, the knife edge represents the trace point and the pitch curve corresponds to the cam profile. In a roller follower, the centre of the roller represents the trace point.

c Pressure angle

- It is the angle between the direction of the follower motion and a normal to the pitch curve. This angle is very important in designing a cam profile. If the pressure angle is too large, a reciprocating follower will jam in its bearings.

d **Pitch point**

- It is a point on the pitch curve having the maximum pressure angle.

e **Pitch circle**

- It is a circle drawn from the centre of the cam through the pitch points.

f **Pitch curve**

- It is the curve generated by the trace point as the follower moves relative to the cam. For a knife edge follower, the pitch curve and the cam profile are same whereas for a roller follower, they are separated by the radius of the roller.

g **Prime circle**

- It is the smallest circle that can be drawn from the centre of the cam and tangent to the pitch curve. For a knife edge and a flat face follower, the prime circle and the base circle are identical. For a roller follower, the prime circle is larger than the base circle by the radius of the roller.

h **Lift or Stroke**

- It is the maximum travel of the follower from its lowest position to the topmost position.

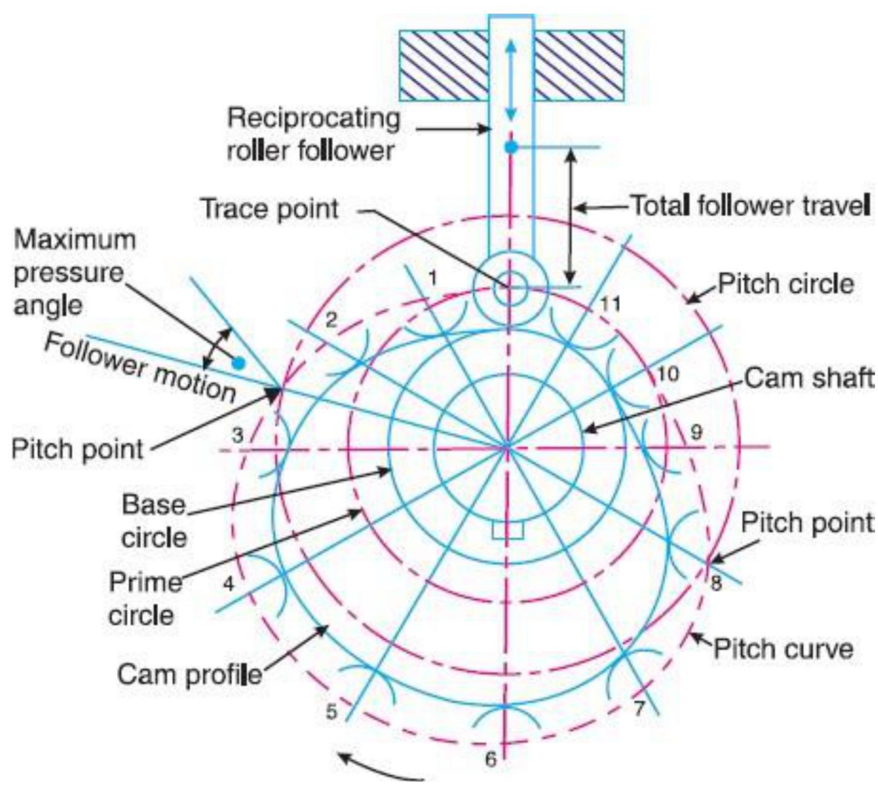


Fig. 4.3 terms used in radial cams

Motion of follower

The follower, during its travel, may have one of the following motions:

a Uniform velocity

b Simple harmonic motion

c Uniform acceleration and retardation

d Cycloidal motion

Displacement, Velocity and Acceleration Diagrams when the Follower Moves with Uniform Velocity

The displacement, velocity and acceleration diagrams when a knife-edged follower moves with uniform velocity are shown in Fig. 4.4 (a), (b) and (c) respectively.

The abscissa (base) represents the time (i.e. the number of seconds required for the cam to complete one revolution) or it may represent the angular displacement of the cam in degrees. The ordinate represents the displacement, or velocity or acceleration of the follower.

Since the follower moves with uniform velocity during its rise and return stroke, therefore the slope of the displacement curves must be constant. In other words, AB1 and C1D must be straight lines.

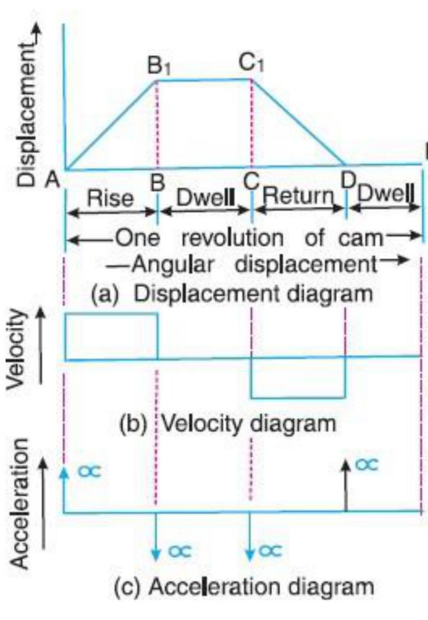


Fig. 4.4 displacement, velocity and acceleration diagrams

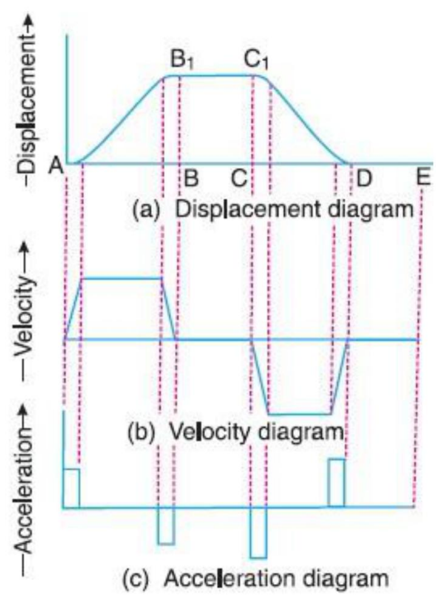


Fig. 4.5 modified displacement, velocity acceleration diagrams

A little consideration will show that the follower remains at rest during part of the cam rotation. The periods during which the follower remains at rest are known as dwell periods, as shown by lines B1C1 and DE in Fig. 4.4 (a). From Fig. 4.4 (c), we see that the acceleration or retardation of the follower at the beginning and at the end of each stroke is infinite. This is due to the fact that the follower is required to start from rest and has to gain a velocity within no time. This is only possible if the acceleration or retardation at the beginning and at the end of each stroke is infinite. These conditions are however, impracticable.

In order to have the acceleration and retardation within the finite limits, it is necessary to modify the conditions which govern the motion of the follower. This may be done by rounding off the sharp corners of the displacement diagram at the beginning and at the end of each stroke, as shown in Fig. 4.5 (a). By doing so, the velocity of the follower increases gradually to its maximum value at the beginning of each stroke and decreases gradually to zero at the end of each stroke as shown in Fig. 4.5 (b).

The modified displacement, velocity and acceleration diagrams are shown in Fig.4.5. The round corners of the displacement diagram are usually parabolic curves because the parabolic motion results in a very low acceleration of the follower for a given stroke and cam speed.

Displacement, Velocity and Acceleration Diagrams when the Follower Moves with Simple Harmonic Motion

The displacement, velocity and acceleration diagrams when the follower moves with simple harmonic motion are shown in Fig. 4.6 (a), (b) and (c) respectively. The displacement diagram is drawn as follows:

a Draw a semi-circle on the follower stroke as diameter.

b Divide the semi-circle into any number of even equal parts (say eight).

c Divide the angular displacements of the cam during out stroke and return stroke into the
same number of equal parts.

d The displacement diagram is obtained by projecting the points as shown in Fig. 7.6 (a).

The velocity and acceleration diagrams are shown in Fig. 4.6 (b) and (c) respectively. Since the follower moves with a simple harmonic motion, therefore velocity diagram consists of a sine curve and the acceleration diagram is a cosine curve.

We see from Fig. 4.6 (b) that the velocity of the follower is zero at the beginning and at the end of its stroke and increases gradually to a maximum at mid-stroke. On the other hand, the acceleration of the follower is maximum at the beginning and at the ends of the stroke and diminishes to zero at mid-stroke.

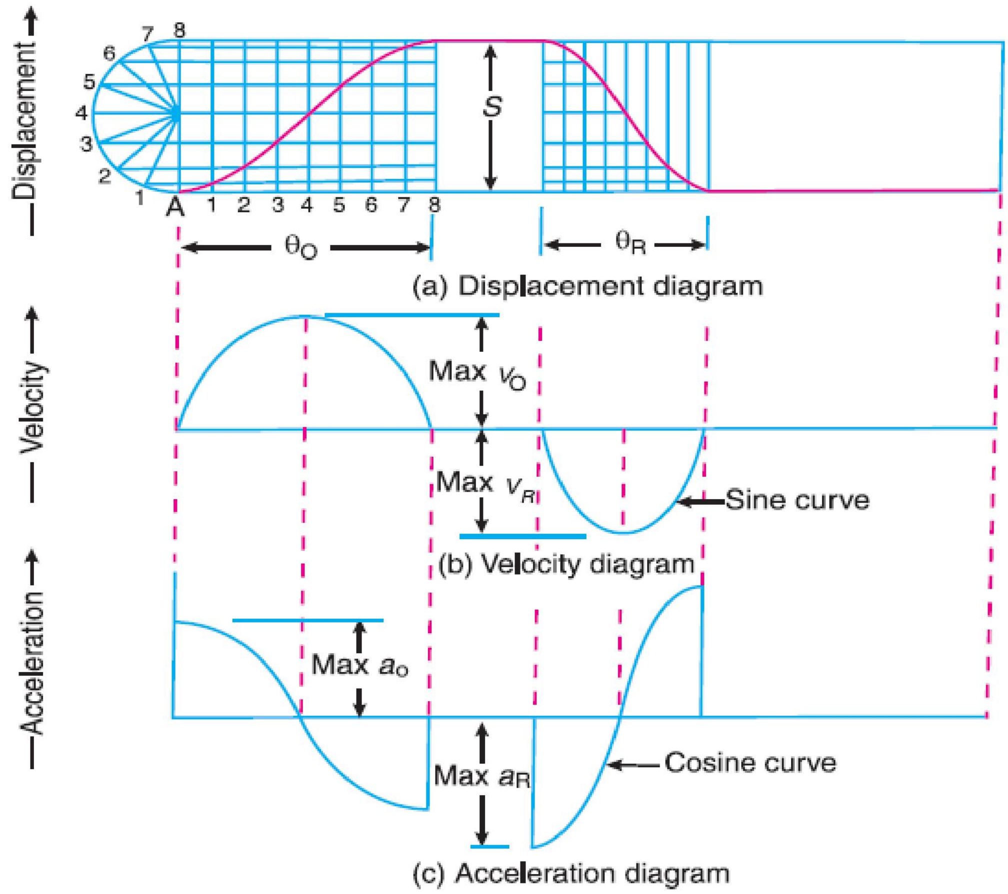


Fig. 7.6 acceleration diagram

4.3.1 L

S= Stroke of the follower

t

,

Θ_0 and Θ_R = Angular displacement of the cam during out stroke and return stroke of the follower respectively

ω = angular velocity of cam

Time required for the outstroke of the follower in second

$$t_0 = \frac{0}{\omega}$$

Consider a point P moving at uniform speed ω_P radians per sec round the circumference of a circle with the stroke S as diameter, as shown in Fig. 7.7 the point (which is the projection of a point P on the diameter) executes a simple harmonic motion as the point P rotates. The motion of the follower is similar to that of point P'.

Peripheral speed of the point P'

$$v_p = \frac{\pi \times s}{2} \times \frac{1}{t_0} = \frac{\pi \times s}{2} \times \frac{\omega}{\theta_0}$$

and maximum velocity of the follower on the outstroke,

$$v_0 = v_p = \frac{\pi \times s}{2} \times \frac{\omega}{\theta_0} = \frac{\pi \times \omega \times s}{2\,\theta_0}$$

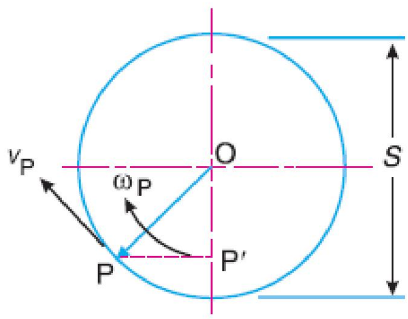


Fig. 7.7 motion of a point

We know that the centripetal acceleration of the point P

$$a_p = \frac{{v_p}^2}{op} = \left(\frac{\times\ \omega\ \times s}{2\ \theta_0}\right)^2 \times \frac{2}{s} = \frac{\pi^2 \times \omega^2 \times s}{2 \times (\theta_0)^2}$$

Maximum acceleration of the follower on the outstroke,

$$a_0 = a_p = \frac{\pi^2\ \times\ \omega^2\ \times s}{2 \times (\theta_0)^2}$$

Similarly, maximum velocity of the follower on the return stroke,

$$v_R = \frac{\pi \times\ \omega\ \times S}{2\ \theta_R}$$

and maximum acceleration of the follower on the return stroke

$$a_R = \frac{\pi^2 \omega^2\ S}{2\ (\theta_R)^2}$$

Displacement, Velocity and Acceleration Diagrams when the Follower Moves with Uniform Acceleration and Retardation

The displacement, velocity and acceleration diagrams when the follower moves with uniform acceleration and retardation are shown in Fig. 4.8 (a), (b) and (c) respectively. We see that the displacement diagram consists of a parabolic curve and may be drawn as discussed below:

Divide the angular displacement of the cam during outstroke (Θ) into any even number of equal parts and draw vertical lines through these points as shown in fig. 4.8 (a)

Divide the stroke of the follower (S) into the same number of equal even parts.

Join Aa to intersect the vertical line through point 1 at B. Similarly, obtain the other points C, D etc. as shown in Fig. 20.8 (a). Now join these points to obtain the parabolic curve for the out stroke of the follower.

In the similar way as discussed above, the displacement diagram for the follower during return stroke may be drawn.

We know that time required for the follower during outstroke,

$$t_0 = \frac{0}{\omega}$$

and time required for the follower during return stroke,

$$t_R = \frac{\theta_R}{\omega}$$

Mean velocity of the follower during outstroke

$$v_0 = \frac{S}{t_0}$$

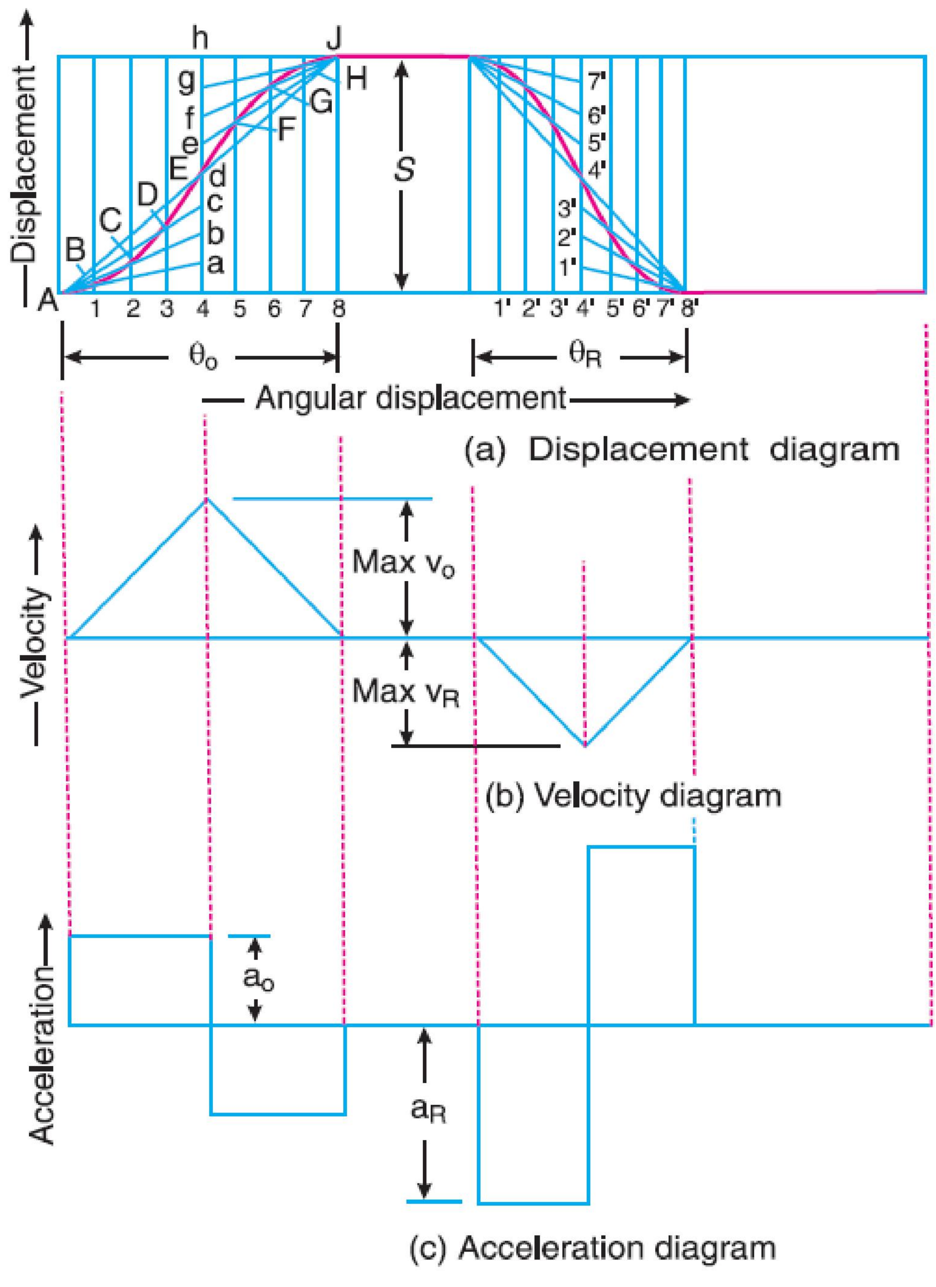


Fig. 4.8 Displacement, Velocity and Acceleration Diagrams when the Follower Moves with Uniform Acceleration and Retardation

Since the maximum velocity of follower is equal to twice the mean velocity, therefore maximum velocity of the follower during outstroke,

$$v_0 = \frac{2\,S}{t_0} = \frac{2\,\omega\,S}{\theta_0}$$

Similarly, maximum velocity of the follower during return stroke,

$$v_R = \frac{2\,\omega\,S}{\theta_R}$$

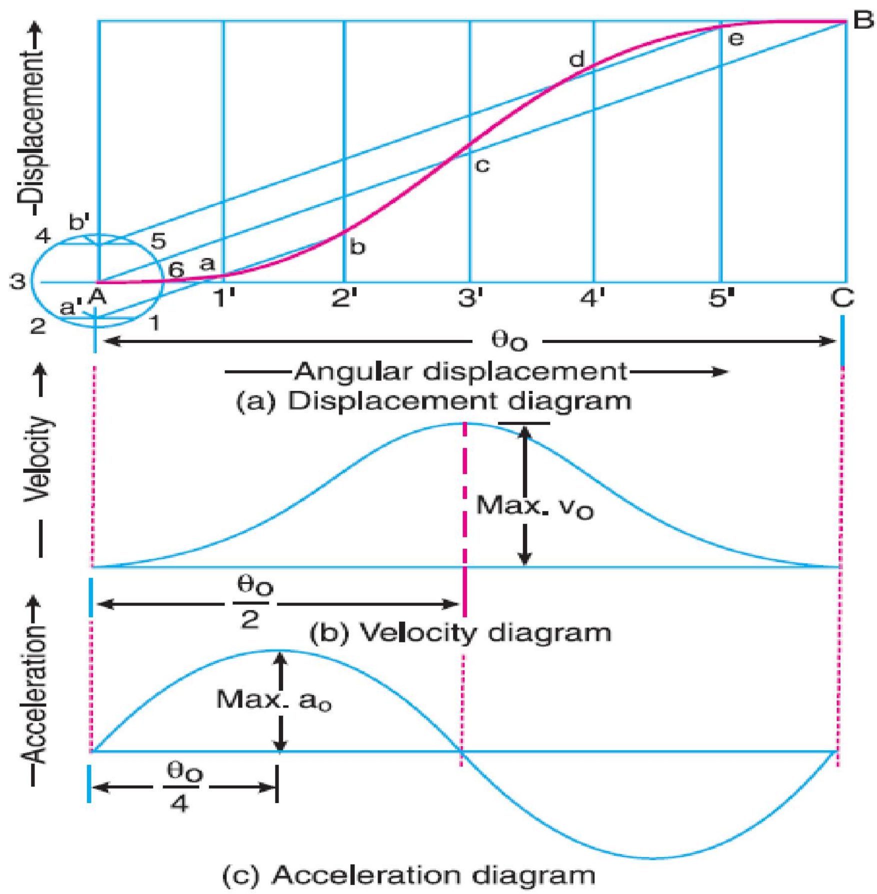
Maximum acceleration of the follower during outstroke,

$$a_0 = \frac{v_0}{t_0/2} = \frac{2 \times 2\,\omega\,s}{t_0\,\theta_0} = \frac{4\,\omega^2.\,S}{(\,)^2{}_0}$$

Similarly, maximum acceleration of the follower during return stroke,

$$a_R = \frac{4\,\omega^2\,S}{(\theta)^2}$$

Displacement, Velocity and Acceleration Diagrams when the Follower Moves with cycloidal Motion



(a) Displacement diagram

(b) Velocity diagram

(c) Acceleration diagram

- The displacement, velocity and acceleration diagrams when the follower moves with cycloidal motion are shown in Fig. (a), (b) and (c) respectively. We know that cycloid is a curve traced by a point on a circle when the circle rolls without slipping on a straight line.
- We know that displacement of the follower after time t seconds,

$$x = S\left[\frac{\theta}{\theta_0} - \frac{1}{2\pi}\sin\left(\frac{2\pi\theta}{\theta_0}\right)\right]$$

- Velocity of the follower after time t seconds,

$$\frac{dx}{dt} = S\left[\frac{1}{\theta_0} \times \frac{d\theta}{dt} - \frac{2\pi\theta}{\theta_0}\cos\left(\frac{2\pi\theta}{\theta_0}\right)\frac{d\theta}{dt}\right]$$

$$= \frac{S}{\theta_0} \times \frac{d\theta}{dt}\left[1 - \cos\left(\frac{2\pi\theta}{\theta_0}\right)\right]$$

$$= \frac{\omega S}{\theta_0}\left[1 - \cos\left(\frac{2\pi\theta}{\theta_0}\right)\right]$$

- The velocity is maximum, when

$$\cos\left(\frac{2\pi\theta}{\theta_0}\right) = -1$$

$$\frac{2\pi\theta}{\theta_0} = \pi$$

$$= \frac{\theta_0}{2}$$

- Similarly, maximum velocity of the follower during return stroke,

$$v_R = \frac{2\omega S}{\theta_R}$$

- Now, acceleration of the follower after time t sec,

$$\frac{d^2x}{dt^2} = \frac{\omega S}{\theta_0}\left[\frac{2\pi}{\theta_0}\sin\left(\frac{2\pi\theta}{\theta_0}\right)\frac{d\theta}{dt}\right]$$

$$= \frac{2\pi\omega^2 S}{(\theta_0)^2}\sin\left(\frac{2\pi\theta}{\theta_0}\right)$$

- The acceleration is maximum, when

$$\sin\left(\frac{2\pi\theta}{\theta_0}\right) = 1$$

$$= \frac{\theta_0}{4}$$

$$a_0 = \frac{2\pi\omega^2 S}{(\theta_0)^2}$$

$$a_R = \frac{2\,\pi\,\omega^2\,S\,(\theta}{)^2}$$

Construction of cam profile for a Radial cam

In order to draw the cam profile for a radial cam, first of all the displacement diagram for the given motion of the follower is drawn. Then by constructing the follower in its proper position at each angular position, the profile of the working surface of the cam is drawn.

In constructing the cam profile, the principle of kinematic inversion is used, i.e. the cam is imagined to be stationary and the follower is allowed to rotate in the opposite direction to the cam rotation.

Examples based on cam profile

Draw the profile of a cam operating a knife-edge follower having a lift of 30 mm. the cam raises the follower with SHM for 150⁰ of the rotation followed by a period of dwell for 60⁰. The follower descends for the next 100⁰ rotation of the cam with uniform velocity, again followed by a dwell period. The cam rotates at a uniform velocity of 120 rpm and has a least radius of 20 mm. what will be the maximum velocity and acceleration of the follower during the lift and the return?

- S = 30 mm : Øa = 150^0 ; N = 120 rpm ;
- $\delta_1 = 60°$; $r_c = 20$ mm : $\delta_2 = 50°$
- **During ascent:**

$$\omega = \frac{2\,\pi\,N}{60} = \frac{2\,\pi \times 120}{60} = 12.57\ rad/s$$

$$v_{max} = \frac{\pi \times \omega \times s}{2\,\theta_0} = \frac{\pi \times 12.57 \times 30}{2 \times 150 \times \frac{\pi}{180}} = 226.3$$

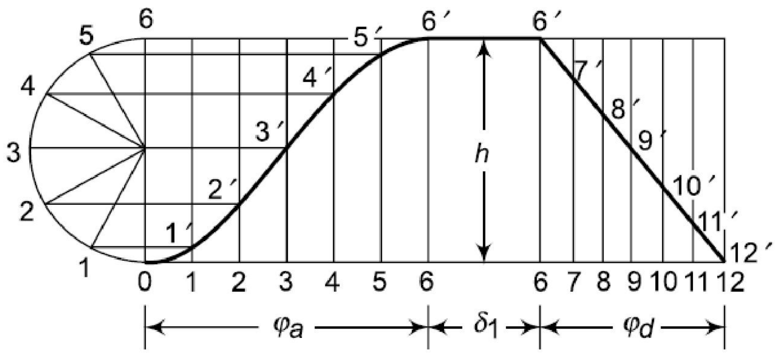
$$a_{max} = \frac{\pi^2 \times \omega^2 \times s}{2 \times (\theta^0)^2} = \frac{\pi^2 \times 12.57^2 \times 30}{2 \times (150 \times \frac{\pi}{180})^2} = 7.413\ {}^{m}/{}_{s^2}$$

- **During descent:**

$$v_{max} = \frac{\omega\,S}{\emptyset_d}$$

$$v_{max} = \frac{12.57 \times 30}{100 \times \frac{}{180}} = 216\ {}^{mm}/{}_{s}$$

$$\boldsymbol{f_{max} = 0}$$



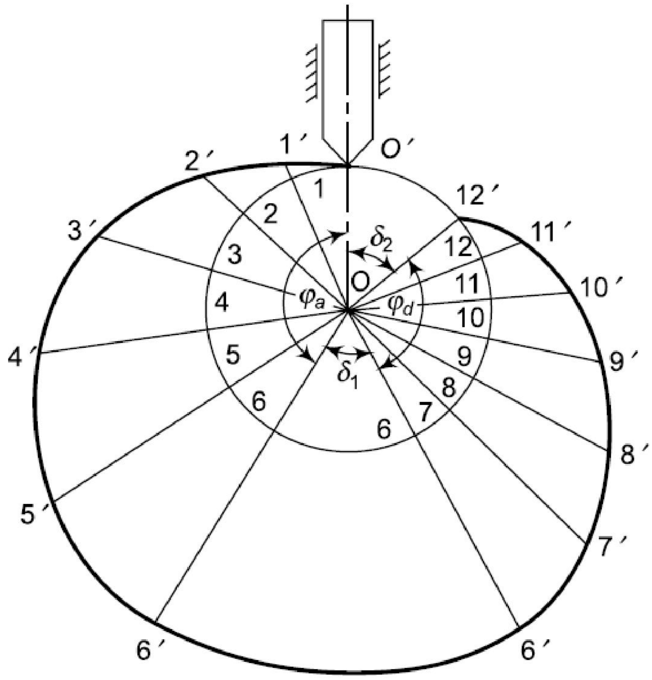


Fig. 4.10

A cam with a minimum radius of 25 mm is to be designed for a knife-edge follower with the following data:

To raise the follower through 35 mm during 60^0 rotation of the cam

Dwell for next 40^0 of the cam rotation

Descending of the follower during the next 90^0 of the cam rotation

Dwell during the rest of the cam rotation

Draw the profile of cam if the ascending and descending of the cam with simple harmonic motion and the line of stroke of the follower is offset 10 mm from the axis of the cam shaft.

What is the maximum velocity and acceleration of the follower during the ascent and the descent if the cam rotates at 150 rpm?

- S = 35 mm : $Ø_a = 60^0$; N = 150 rpm ;
- $\delta_1 = 40°$; $r_c = 25$ mm : $Ø_d = 90^0$; x = 10 mm

– **During ascent:**

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 150}{60} = 5\pi \ \frac{rad}{s}$$

$$v_{max} = \frac{\pi \times \omega \times s}{2\,\theta_0} = \frac{\pi \times 5\pi \times 35}{2 \times 150 \times \frac{\pi}{180}} = 827.7\ mm/s$$

$$a_{max} = \frac{\pi^2 \times \omega^2 \times s}{2 \times (\theta_0)^2} = \frac{\pi^2 \times 5\pi^2 \times 35}{2 \times (150 \times \frac{\pi}{180})^2} = 38.882\ m/s^2$$

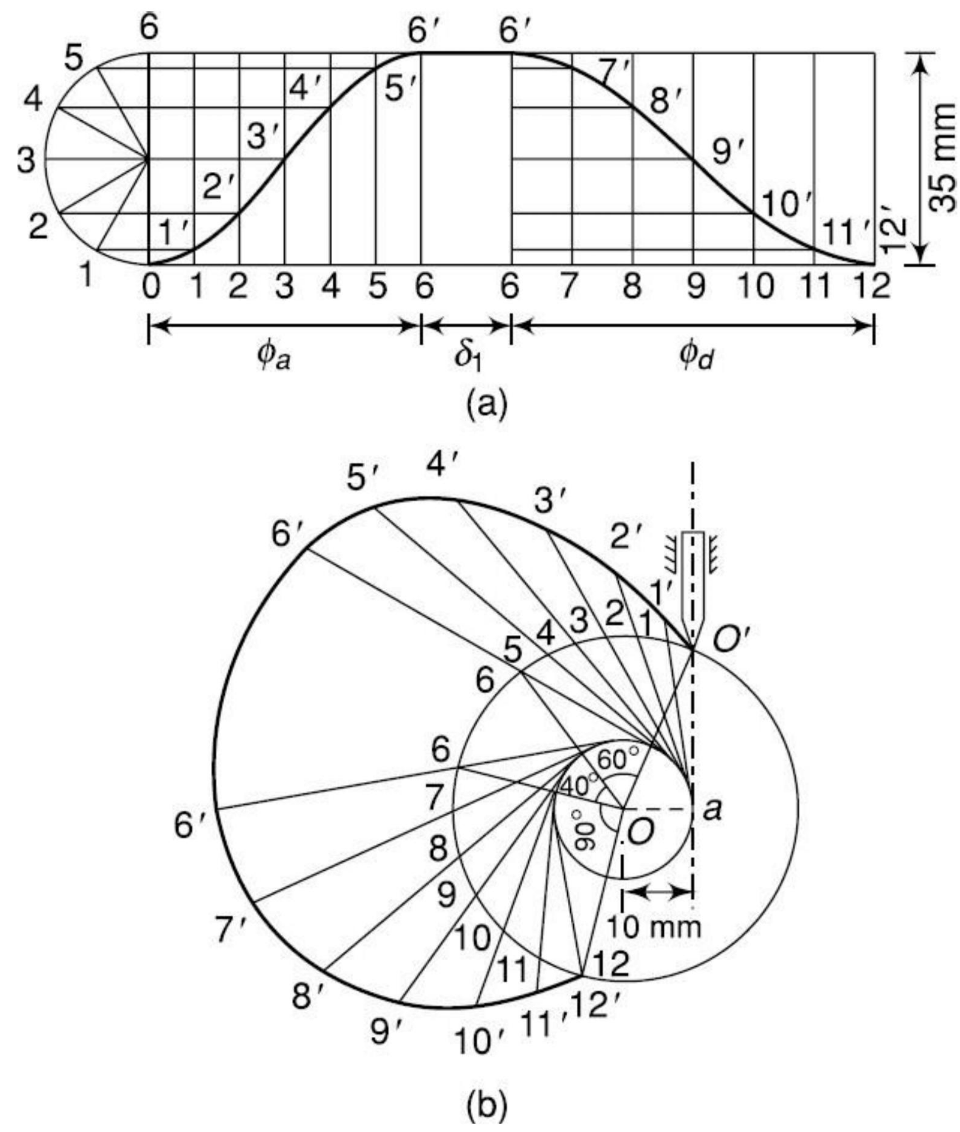


Fig. 7.11

– **During descent:**

$$v_{max} = \frac{\pi \times \omega \times s}{2\,\theta_0} = \frac{\pi \times 5\pi \times 35}{2 \times 90 \times \frac{\pi}{180}} = 549.80\ mm/s$$

$$a_{max} = \frac{\pi^2 \times \omega^2 \times s}{2 \times (\theta^0)^2} = \frac{\pi^2 \times 5\pi^2 \times 35}{2 \times (90 \times \frac{\pi}{180})^2} = 17.272\ m/s^2$$

A cam is to give the following motion to the knife-edged follower:

To raise the follower through 30 mm with uniform acceleration and deceleration during 120⁰ rotation of the cam

Dwell for the next 30⁰ of the cam rotation

To lower the follower with simple harmonic motion during the next 90⁰ rotation of the cam

Dwell for the rest of the cam rotation

The cam has minimum radius of 30 mm and rotates counter-clockwise at a uniform speed of 800 rpm. Draw the profile of the cam if the line of stroke of the follower passes through the axis of the cam shaft.

- S = 30 mm : Øa = 120⁰ ; N = 800 rpm ;
- $\delta_1 = 30°$; r_c = 30 mm : $Ø_d$ = 90⁰;
- **During ascent:**

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 840}{60} = 88\ \frac{rad}{s}$$

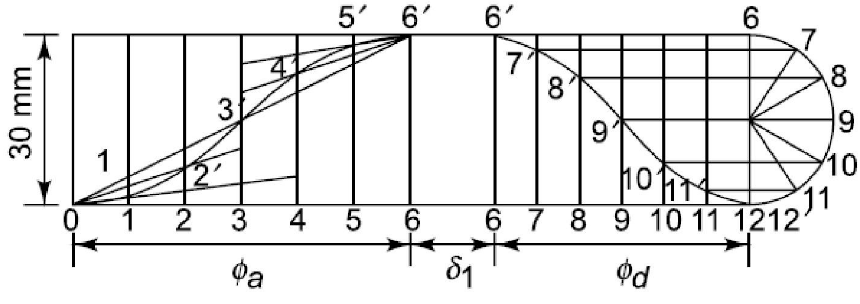
$$v_{max} = \frac{2 \times 88 \times 0.03}{120 \times \frac{\pi}{180}} = 2.52\ m/s$$

$$a_0 = \frac{4\ \omega^2 . S}{(\ )^2} = \frac{4\ 88^2 \times 0.03}{(120 \times \frac{\pi}{180})^2} = 211.9\ m/s^2$$

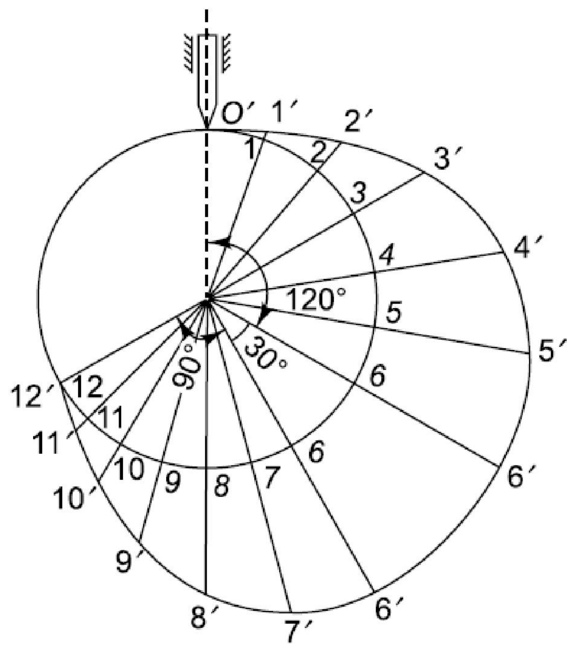
- **During descent:**

$$v_{max} = \frac{\pi \times \ \times S}{2\ \theta_0} = \frac{\pi \times 88 \times 0.03}{2 \times 90 \times \frac{\pi}{180}} = 2.64\ mm/s$$

$$a_{max} = \frac{\pi^2 \times \omega^2 \times s}{2 \times (\theta_0)^2} = \frac{\pi^2 \times 88^2 \times 0.03}{2 \times (90 \times \frac{\pi}{180})^2} = 467.6\ m/s^2$$



(a)



(b)

Fig. 7.12

Draw the profile of a cam operating a roller reciprocating follower and with the following data:

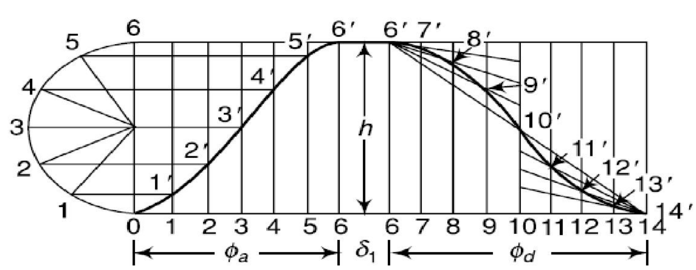
Minimum radius of cam = 25 mm

Lift = 30 mm

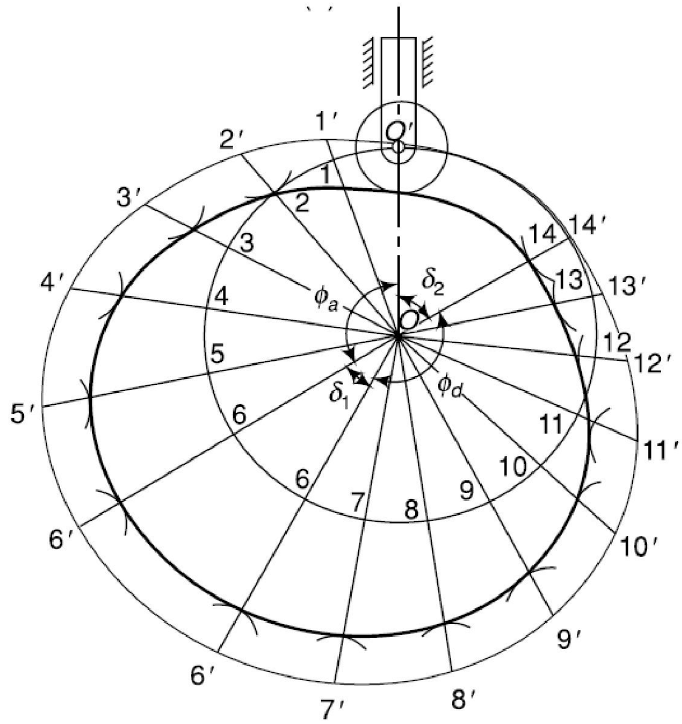
Roller diameter = 15 mm

The cam lifts the follower for 120º with SHM followed by a dwell period of 30º. Then the follower lowers down during 150º of the cam rotation with uniform acceleration and deceleration followed by dwell period. If the cam rotates at a uniform speed of 150 rpm. Calculate the maximum velocity and acceleration of the follower during the descent period.

- S = 30 mm : Øa = 120º ; N = 150 rpm ;$Ø_d$ = 150º
- $\delta_1 = 30°$; r_c = 25 mm : $\delta_2 = 60°$; r_r = 7.5 mm



(a)



(b)

Fig. 7.13

$$v_{max} = \frac{2 \times s \times \omega}{\varphi_d}$$

$$v_{max} = \frac{2 \times 30 \times \frac{2\times\pi\times150}{60}}{150 \times \frac{\pi}{180}} = 360\, m/s$$

$$f_{max} = \frac{4 \times S \times \omega^2}{(\varphi_d)^2}$$

$$f_{max} = \frac{4 \times 30 \times \left(\frac{2\times\pi\times150}{60}\right)^2}{\left(150 \times \frac{}{180}\right)^2} = 4320\, mm/s^2$$

The following data relate to a cam profile in which the follower moves with uniform acceleration and deceleration during ascent and descent.

Minimum radius of cam = 25 mm

Roller diameter = 7.5 mm

Lift = 28 mm

Offset of follower axis = 12 mm towards right

Angle of ascent = 60^0

Angle of descent = 90^0

Angle of dwell between ascent and descent = 45^0

Speed of cam = 200 rpm

Draw the profile of the cam and determine the maximum velocity and the uniform acceleration of the follower during the outstroke and the return stroke.

- S = 28 mm : Øa = 60º ; N = 200 rpm ;Ød = 90º
- $\delta_1 = 45°$; r_c= 25 mm : $\delta_2 = 165°$; r_r= 7.5 mm; x = 12 mm

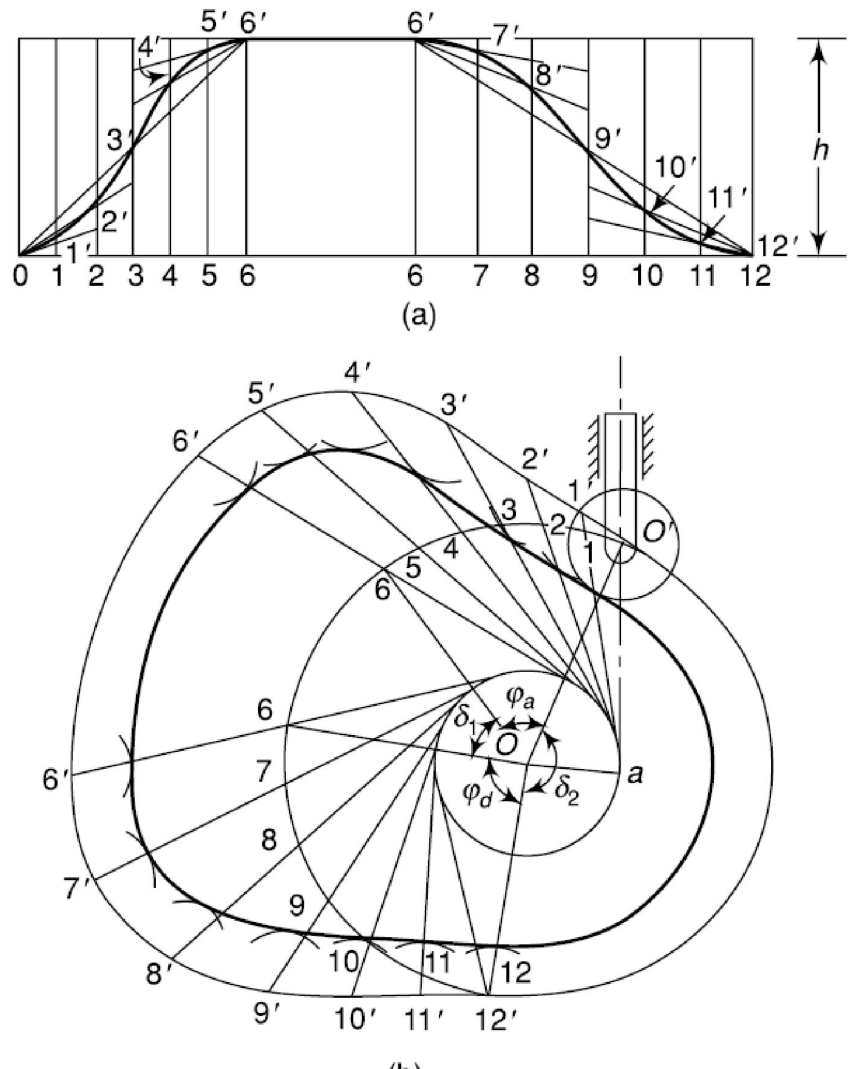


Fig. 7.14

- **During outstroke:**

$$v_{max} = \frac{2 \times s \times \omega}{\varphi_d}$$

$$v_{max} = \frac{2 \times 28 \times 20.94}{60 \times \frac{\pi}{180}} = 1.12\ m/s$$

$$f_{max} = \frac{4 \times S \times \omega^2}{(\varphi_d)^2}$$

$$f_{max} = \frac{4 \times 30 \times (20.94)^2}{(60 \times \frac{\pi}{180})^2} = 44800\ mm/s^2$$

– **During Return stroke:**

$$v_{max} = \frac{2 \times s \times \omega}{\varphi_d}$$

$$v_{max} = \frac{2 \times 28 \times 20.94}{90 \times \frac{\pi}{180}} = 0.747\ m/s$$

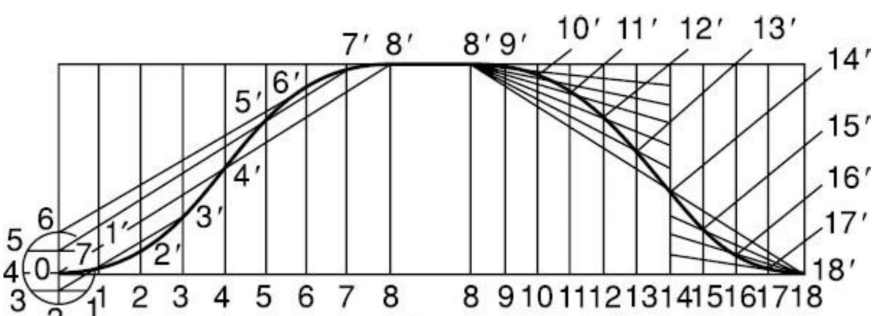
$$f_{max} = \frac{4 \times S \times \omega^2}{(\varphi_d)^2}$$

$$f_{max} = \frac{4 \times 30 \times (20.94)^2}{(90 \times \frac{\pi}{180})^2} = 19900\ mm/s^2$$

A flat-faced mushroom follower is operated by a uniform rotating cam. The follower is raised through a distance of 25 mm in 120° rotation of the cam, remains at rest for next 30° and is lowered during further 120° rotation of the cam. The raising of the follower takes place with cycloidal motion and the lowering with uniform acceleration and deceleration. However, the uniform acceleration is 2/3 of the uniform deceleration. The least radius of the cam is 25 mm which rotates at 300 rpm.

Draw the cam profile and determine the values of the maximum velocity and maximum acceleration during rising and maximum velocity and uniform acceleration and deceleration during lowering of the follower.

– S = 30 mm : $Ø_a = 60°$; N = 200 rpm ; $Ø_d = 90°$
– $\delta_1 = 45°$; $r_c = 25$ mm : $\delta_2 = 165°$; $r_r = 7.5$ mm; x = 12 mm
–



(a)

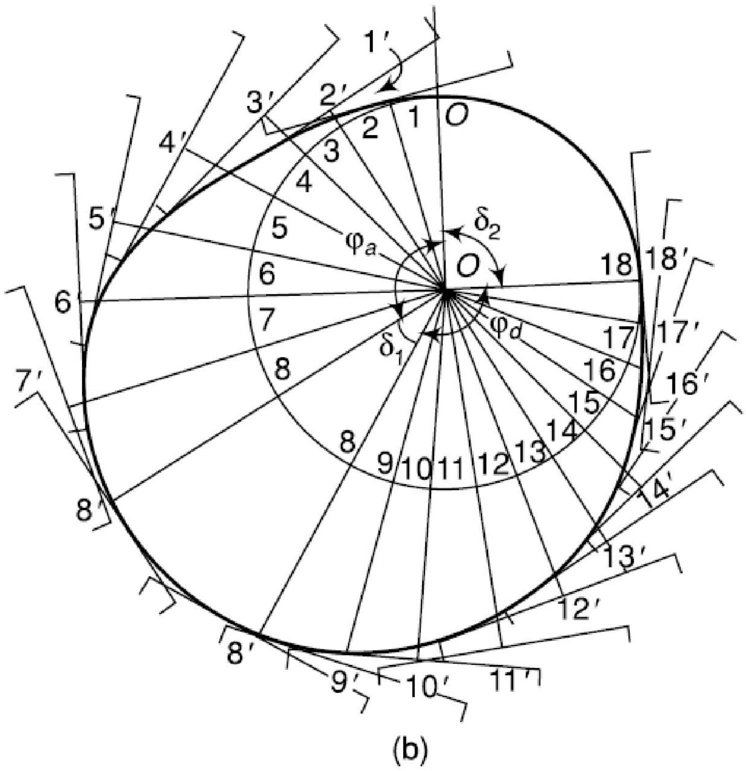


Fig. 7.15

– **During ascent:**

$$v_{max} = \frac{2 \times s \times \omega}{\varphi_a}$$

$$v_{max} = \frac{2 \times 25 \times 31.4}{120 \times \frac{\pi}{180}} = 0.75\,\frac{m}{s}$$

$$f_{max} = \frac{4 \times S \times \omega^2}{(\varphi_a)^2}$$

$$f_{max} = \frac{4 \times 30 \times (31.4)^2}{\left(120 \times \frac{\pi}{180}\right)^2} = 35310\,\frac{mm}{s^2}$$

The following data relate to a cam operating an oscillating an oscillating roller follower:

Minimum radius of cam = 44
mm Dia. Of roller = 14 mm
Length of the arm = 40
mm Distance from fulcrum
Centre from cam center = 50
mm Angle of ascent = 75°
Angle of descent = 105°
Angle of dwell in

Highest position = 60⁰
Angle of oscillation of
Follower = 28⁰
Draw the profile of the cam if the ascent and descent both take place with SHM.

– S = 19.5 mm : Øa = 75⁰ ;$Ø_d$ = 105⁰
– $\delta_1 = 60°$; r_c = 22 mm : $\delta_2 = 120°$; r_r = 7.5 mm;

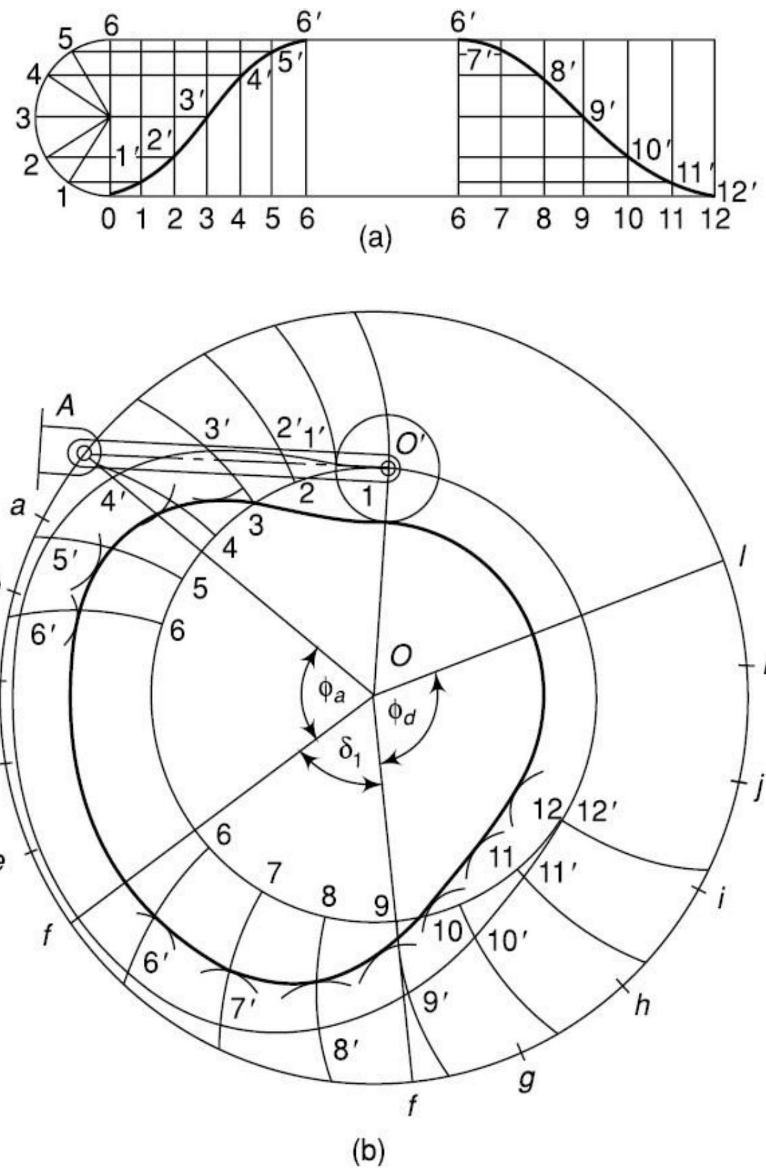


Fig. 4.16

References

1. Theory of Machines by S.S.Rattan, Tata McGraw Hill
2. Theory of Machines by R.S. Khurmi & J.K.Gupta,S.Chand