ME 114 – Engineering Drawing II

CAM DRAWING

- Timing belt
- Camshaft
- Valves
- Pistons
- Crankshaft

Samarins.com
Introduction

- A “cam” is a mechanical device with a surface or groove that controls the motion of a second part called a “follower” in order to **convert rotary motion to linear motion** (Fig. 1).

- The follower, held against the cam by a spring or by gravity, can be knife, roller, mushroom or flat-faced type (Fig. 2).

- **Type of follower, timing and manner of movement** to be created by the cam are the main elements in designing cams.
Cam Types

**Radial cam:** The follower is raised and lowered as the cam revolves (Fig. 3).

**Face cam:** The follower at the end of an arm oscillates as the cam revolves (Fig. 4).

**Toe (Follower) and Wiper:** The cam itself oscillates (Fig. 5).

**Positive-Motion Cam (Yoke):** The enclosed follower makes possible the application of force in both directions (Fig. 6).

**Cylindrical Groove and End Cams:** The follower moves parallel to the cam axis (Fig. 7). Force is applied to follower in both directions in groove cam (left) and in only one direction in end cam (right).
Types of Cam Motion

- Cams are designed to move the follower with a **constant velocity, constant acceleration / deceleration** or **harmonic motion** (from top to bottom in Fig. 8). In most cases, the combined motion of follower with **rise** or **fall**, or stationary (**dwell**) make up the complete cam surface.

- In studying the follower motion, a diagram showing the height of the follower for successive cam positions is frequently employed. These diagrams are usually **made to actual size**.

- The cam position is shown on the abscissa where **one complete rotation** (i.e. 360°) of the cam is divided into **equally-spaced intervals**, which are generally 30° although the intermediate points can also be used. The follower positions are shown on the ordinate divided into the same number of intervals as the abscissa.
Constant Velocity

- **Constant velocity** gives a uniform rise and fall as plotted in **Fig. 9**.

- The diagram is constructed by plotting the cam positions on the abscissa, measuring the total follower movement on the ordinate and dividing it into the same number of points as the abscissa.

- As the cam moves one unit of its rotation, the follower likewise moves one unit which produces **the straight line of motion**.

- The starting and end sections of the profile are rounded by fillets of radius which equals to ¼ of total displacement. This is done due to the reason that the cam surface should have smooth transition during the movement. This type of motion is called **modified constant velocity**.

![Figure 9](image-url)
With **constant acceleration or deceleration**, the distance travelled is proportional to the square of the time (i.e. 1, 4, 9, 16, 25, etc.) where the increments of follower distance are made proportional to 1, 3, 5, 7, etc. as shown in Fig. 10.

Using a scale, the rise of follower is divided into the same number of intervals as the abscissa, making the first part movement as one unit movement, the second part as three units, and so on.

The points at the intersection of the coordinate lines are then plotted to obtain the curve which accelerates and then decelerates when rising and falling.
Harmonic motion (sine curve) can be plotted as in Fig. 11 by measuring the rise, drawing a semicircle, dividing it into the same number of intervals as the abscissa, and projecting the points on the semicircle as ordinate lines.

Points are the plotted at the intersection of the coordinate lines.

The swinging action of a mass at the end of a pendulum is a good example of harmonic motion.
Drawing a Cam Profile with Combined Motions

Let's draw a complete drawing of a cam having the following specifications

(The cam is rotating in CCW direction and a roller follower is used)

<table>
<thead>
<tr>
<th>Base Circle Dia.</th>
<th>= 40 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hub Dia.</td>
<td>= 20 mm</td>
</tr>
<tr>
<td>Shaft Dia.</td>
<td>= 10 mm</td>
</tr>
<tr>
<td>Plate Thickness</td>
<td>= 12 mm</td>
</tr>
<tr>
<td>Hub Thickness</td>
<td>= 20 mm</td>
</tr>
<tr>
<td>Key Way</td>
<td>= 2 x 2 mm</td>
</tr>
<tr>
<td>Follower Dia.</td>
<td>= 6 mm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0° - 60°</th>
<th>Rise of 12 mm with uniform velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>60° - 90°</td>
<td>Dwell</td>
</tr>
<tr>
<td>90° - 180°</td>
<td>Rise of 24 mm with harmonic motion</td>
</tr>
<tr>
<td>180° - 210°</td>
<td>Dwell</td>
</tr>
<tr>
<td>210° - 240°</td>
<td>at 210° Sudden fall of 12 mm</td>
</tr>
<tr>
<td>240° - 360°</td>
<td>Fall of 24 mm with uniform acceleration</td>
</tr>
</tbody>
</table>
The Displacement Diagram

- The displacement diagram for given cam specifications is shown below.
- The circumference is divided into intervals of 30°, and the profile of each motion between specified intervals are plotted. Note that the intervals for harmonic motion are defined as 15°.
- Then, the intersection points between abscissa and ordinate (shown as A, B, C, etc.) are connected in order to obtain the complete cam profile.

![Figure 12](image_url)

- **Base Circle**
- **Cam Profile**
- **Uniform Velocity**
- **Dwell**
- **Harmonic Motion**
- **Dwell**
- **Dwell**
- **Uniform Acceleration**

Circumference = PI * (Base Circle Dia.)
The Cam Drawing

- The complete cam drawing is obtained based on the displacement diagram. The ordinate of each point on displacement diagram is measured and added onto the base circle with a radius of follower (see the distance of “M + follower radius”).
- Then, the follower circle is plotted having a center point as the end of each ordinate. Note that the order of placing the points A, B, C, etc. is in CW direction (i.e. the reverse of cam rotation).
- After that, the center of each follower circle is connected by smoothed curve to obtain follower path. This curve is shifted (i.e. offsetted) towards the base circle by the value of radius of follower in order to obtain the complete cam surface.
- The sectional side view is also required to show the plate and hub thickness.
A Case Study Sheet

Base Circle Dia. = 40 mm
Hub Dia. = 20 mm
Shaft Dia. = 10 mm
Plate Thickness = 12 mm
Hub Thickness = 20 mm
Key Way = 2 x 2 mm
Follower Type = Roller
Follower Dia. = 6 mm
Cam Rotation = CCW

0° - 60° Rise = 12 mm
(uniform velocity)
60° - 90° Dwell
90° - 180° Rise = 24 mm
(harmonic motion)
180° - 210° Dwell
at 210° Sudden fall = 12 mm
210° - 240° Dwell
240° - 360° Fall = 24 mm
(uniform acceleration)

Circumference = π * (Base Circle Dia.)
Timing Diagrams

- When two or more cams are used on the same machine and their functions are dependent on each other (as in Fig. 14), the 'timing' and relative motions of each cam can be studied by means of a diagram showing each follower curve.

- The curves can be superimposed, but it is better to place them as in Fig. 15.