ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY

KINEMATICS AND DYNAMICS OF MACHINES

UNIT II

Applications of Cams in Valve Timing Diagram of a 4-Stroke Engine

A **cam and follower mechanism** is widely used in internal combustion engines to control the opening and closing of inlet and exhaust valves. The cam is mounted on the camshaft and converts rotary motion into reciprocating motion of the valves through followers, push rods, and rocker arms.

Role of Cam in a 4-Stroke Engine

The cam ensures that the engine valves open and close at the correct time during the four strokes:

Suction (Intake) Stroke

- Inlet valve opens.
- Air-fuel mixture enters the cylinder.
- Exhaust valve remains closed.

Compression Stroke

- Both valves remain closed.
- Mixture is compressed.

Power (Expansion) Stroke

- Both valves remain closed.
- Combustion gases expand and produce power.

Exhaust Stroke

- Exhaust valve opens.
- Burnt gases leave the cylinder.
- Inlet valve remains closed except during valve overlap.

Typical Valve Timing Diagram

Event	Crank Angle
Inlet Valve Opens (IVO)	10°–20° before TDC
Inlet Valve Closes (IVC)	30°–50° after BDC
Exhaust Valve Opens (EVO)	30°–50° before BDC
Exhaust Valve Closes (EVC)	10°–20° after TDC

Where:

- **TDC** = Top Dead Centre
- **BDC** = Bottom Dead Centre

Functions of Cam in Valve Timing

1. Controls Valve Opening

The cam profile lifts the valve from its seat at the required crank angle.

2. Controls Valve Closing

The cam allows the valve to close smoothly through spring action.

3. Provides Correct Valve Lift

The cam shape determines the maximum valve opening, affecting engine breathing.

4. Maintains Valve Timing

Proper cam design ensures synchronization between piston movement and valve operation.

5. Produces Valve Overlap

Near the end of the exhaust stroke and beginning of the suction stroke, both valves remain slightly open, improving scavenging and volumetric efficiency.

Advantages of Using Cams in Engine Valve Mechanisms

- Accurate valve timing.

- Smooth valve operation.
- Improved engine efficiency.
- Better fuel economy.
- Increased power output.
- Reduced wear and noise.

Applications of Cam Mechanisms

- Automobile engines.
- Motorcycle engines.
- Diesel engines.
- Petrol engines.
- Textile machinery.
- Printing machines.
- Automatic machine tools.

The Camshaft's Role in the Valve Timing Diagram

A 4-stroke cycle operates over \(720^{\circ }\) of crankshaft rotation (two full revolutions). Because valves cannot open or close instantly without causing severe mechanical stress or airflow disruption, cam lobes are specifically designed to manipulate the valve sequence in four key ways:

Valve Lead (Advance): Cams are designed so the intake valve opens **before** Top Dead Center (TDC) and the exhaust valve opens **before** Bottom Dead Center (BDC). This maximizes the time available for gasses to flow, compensating for mechanical inertia.

Valve Lag (Delay): Cams keep the intake valve open well **after** BDC during the compression stroke and the exhaust valve open **after** TDC during the intake stroke. This takes advantage of the momentum and ram effect of the moving gasses to boost cylinder filling and exhaust scavenging. **Valve Overlap:** Because of the cam lobe profiles, there is a brief period at TDC where both the intake and exhaust valves are partially open simultaneously. This overlap creates a scavenging effect, where the exiting exhaust helps draw in the fresh air-fuel mixture.

Duration and Lift: The physical shape of the cam's nose (profile) determines how long the valve stays open (duration) and how high it opens off its seat (lift), defining the exact boundaries charted on a timing diagram.

Washing Machines: Automated Cam Timers

Older automatic washers utilized electromechanical **cam timers**—a motor turning a jagged plastic cylinder (cam) that pushed electrical contacts to open and close valves, drains, and motors at exact times.

Modern washers have upgraded this mechanical automation to digital precision.

- **Smart Controllers:** Microcontrollers and printed circuit board (PCB) assemblies now manage the timing profiles, motor speed, and water levels.
- **Load Sensing:** Instead of static cams, smart washers use sensors to weigh the laundry, calculate required water levels, and even dose liquid detergent automatically.
- **Smart Home Integration:** You can track and automate washing cycles using smart plugs and IoT applications, monitoring when a wash completes based on power consumption thresholds

Cam-driven mechanical toys and novelty item

Cam mechanisms are widely used in mechanical toys and novelty items to convert rotary motion into reciprocating, oscillating, or irregular motion, creating interesting and realistic movements.

Applications in Mechanical Toys

1. Moving Animal Toys

- Cams create motions such as walking, jumping, pecking, or wagging tails.
- Example: Toy birds pecking at food or toy animals moving their legs.

2. Dancing Toys

- Cam mechanisms produce rhythmic up-and-down or side-to-side movements.
- Used in dancing dolls and animated figures.

3. Wind-Up Toys

- Rotating cams control the sequence of movements after the spring is wound.
- Example: Wind-up jumping frogs and walking robots.

4. Mechanical Puppets

- Cams operate arms, legs, heads, or facial features to imitate human actions.

Applications in Novelty Items

1. Animated Display Models

- Used in moving displays, decorative models, and exhibition pieces.

2. Musical and Decorative Toys

- Cams synchronize movement with music in music boxes and decorative figurines.

3. Mechanical Greeting Cards

- Cam arrangements create pop-up and moving actions when activated.

4. Amusement Devices

- Small novelty gadgets use cams to generate entertaining repetitive motions.

Advantages

- Simple and compact mechanism.
- Produces complex motions from simple rotary input.
- Reliable and economical.
- Suitable for repetitive and automatic movements.