Module 8: Camshafts, Trains, and Timing Module

Terms and Definitions

- Backlash is the clearance between meshed gears.
- Cam follower is a device that drives the push rod to operate the valve.
- Cam lobe is an oval-shaped, machined part of the camshaft that opens the valve.
  
  **Note:** The cam lobe profile determines the engine operating characteristics.
- Duration is the amount of time (in crankshaft degrees) that the valve is open.
- Overlap is the amount of time (in crankshaft degrees) that both valves are open.
  
  **Note:** Overlap has a great effect on cylinder scavenging.

Types of Camshafts

- A diesel engine with injection nozzles has two cam lobes per cylinder.
  - One cam lobe to actuate the intake valve(s)
  - One cam lobe to actuate the exhaust valve(s)

- A diesel engine with mechanical or electronic fuel injectors has three cam lobes per cylinder.
  - One lobe to actuate the intake valve(s)
  - One lobe to actuate the exhaust valve(s)
  - One lobe to actuate the fuel injector
  
  **Note:** The size of the cam affects the speed.

Operation of a Camshaft

- Valve train
  - Components that open and close the valves (intake and exhaust)
  - Driven by the camshaft

- Gear train
  - Series of gears that transfer motion from the crankshaft to the camshaft
  - Driven by the crankshaft

Primary Parts of a Camshaft

- Cam lobes
  
  **Note:** The cam lobe profile determines the engine operating characteristics.

- Bearing journals
Parts of a Cam Lobe

**Valve lift**
- Projection on the cam that determines how far the valve will open
  - **Note:** Rocker arms use offset fulcrums to increase this by approximately 1.5:1.

**Base circle**
- Camshaft diameter at the lobe
- The inner base circle is the camshaft diameter at the beginning of the opening ramp.
- The outer base circle is the camshaft diameter at the lobe tip.
  - **Note:** The difference between the inner base circle and the outer base circle determines the lift.

**Ramp flank**
- Contour on each side of the nose that determines how quickly the valve opens and closes
  - **Note:** The quicker the valve is opened, the sooner the cylinder can begin to fill or empty.
- The nose is the contour that determines how long the valve remains open at maximum lift.

Parts of a Valve Train

**Valve**
**Rocker arm**
**Push rod**

Cam follower (valve lifter)
Cam on camshaft

Valve Actuation

**Cam in block**
- The camshaft is mounted in the cylinder block.
- Reciprocating motion is transmitted up through the block by push rods.

**Cam in head**
- The camshaft is mounted in the cylinder head.
- Motion is transmitted directly from the camshaft to the cam follower or rocker arm, and push rods are not used.

Valve Timing

**Two-stroke**
- The camshaft turns at the same speed as the crankshaft.
- The exhaust valve is opened and closed once during one revolution of the crankshaft.

**Four-stroke**
- The camshaft turns at one-half the speed of the crankshaft.
- Each intake and exhaust valve is opened and closed once during two revolutions of the crankshaft.

Types of Camshaft Bushings

**One-piece camshaft bushings have a press fit design.**

**Two-piece camshaft bushings snap fit in the bearing saddles.**
Cam Followers and Lifters

**Solid lifter**
- The lifter base is ground slightly convex, causing the lifter to rotate in its bore during the valve opening, and this evenly distributes wear across the cam and lifter contact surface.
- Requires periodic adjustment
- May be mushroom-shaped or cylindrical-shaped, with or without rollers

**Hydraulic lifter**
- Uses engine oil pressure to pump up an internal plunger, maintaining zero valve clearance
- Self-adjusting and requires no periodic maintenance
- Typically used in light- or medium-duty applications

Methods of Driving the Camshaft

**Belt**
- Little noise or vibration, and the belt acts as a damper
- Spring-loaded or hydraulic tensioners eliminate maintenance or inspections.
- Recommended replacement is every 60,000 to 75,000 miles.

**Chain**
- More noise generated than a belt-drive system
- Very little power is lost due to friction and is the most efficient means of power transmission available.
- Very long operational life
- Chains tend to stretch and must be adjusted or replaced.

**Gear**
- More accurate than either a belt or chain, and no timing variations due to stretch
- Very long service life, far outlasting belt and chain drives
- Higher friction loss than belt or chain drives
- Higher noise levels than belt or chain drives

Gear Timing

**Gear teeth are marked with dots, lines, or arrows, and the marks are matched up during assembly.**

**The timing mark alignment synchronizes the camshaft and crankshaft.**

**Because of the different reduction ratios between the gears, some engines take many revolutions to line up all the timing marks again.**

**Typical gears that are marked to ensure correct valve timing include crankshaft gears, camshaft gears, and idler gears.**