



## Automotive Vehicles AEL ZC441

BITS Pilani
Pilani Campus

Pooja Lakshmi D, BTech Mechanical Engg, MTech Design Engg Adjunct Faculty – Automotive Vehicles (Sem I)



### Lecture 1 - Recap

- Introduction to Automobile
- Development of Automobile (1769 to 2005)
- General Classification (Type I & II)
- Basic Structure &
- Components of Automobile (Basic Structure, Power Plant, Transmission System, Auxiliaries, Controls, Superstructure)

### Lecture 2 - Recap

- Chassis & Body
- Classification
- Conventional Construction
- Sub frames
- Frameless Constructions
- Classifications of Body
- Numerical problems on Chassis member bending

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#### Chassis!!!

- Chassis Frame supports the various components and the body, keep them in correct positions.
- Light and Sufficiently strong to withstand weight
- Less distortion



### **Types of Frame**

#### **Conventional**

 Separate Frame to attach all components

Eg. Trucks, Heavy vehicles

## Non Conventional (Frameless)

 No separate frame is used

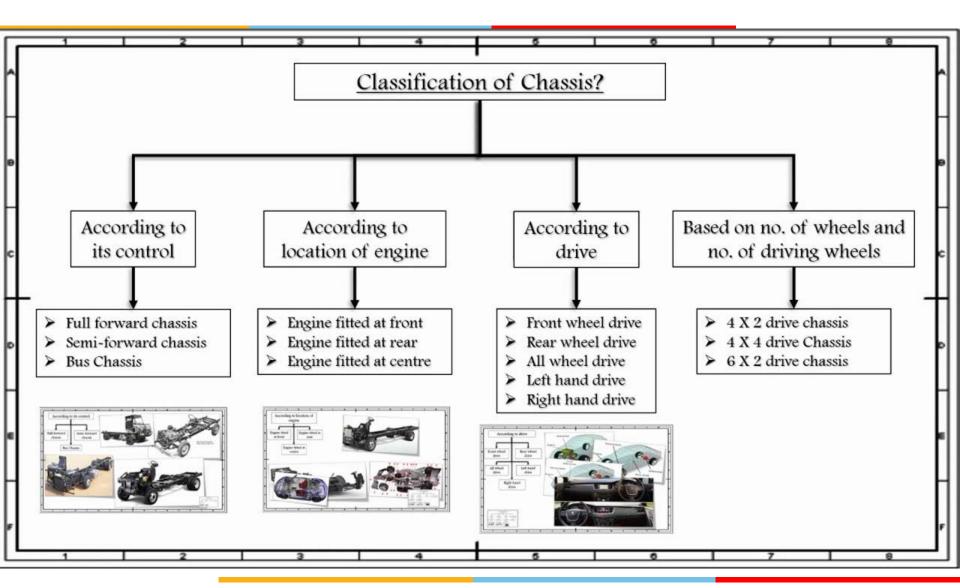
Eg. Cars





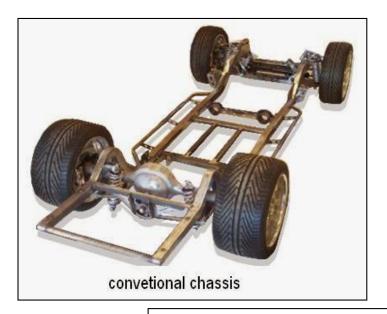
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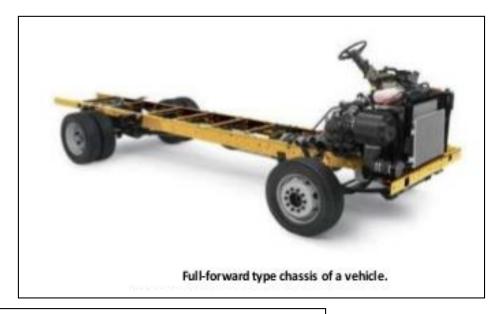
### **Classification: Chassis**





### **Classification: Chassis**

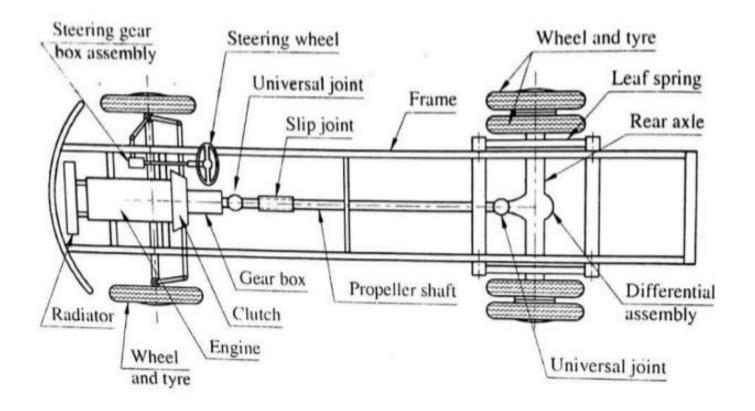






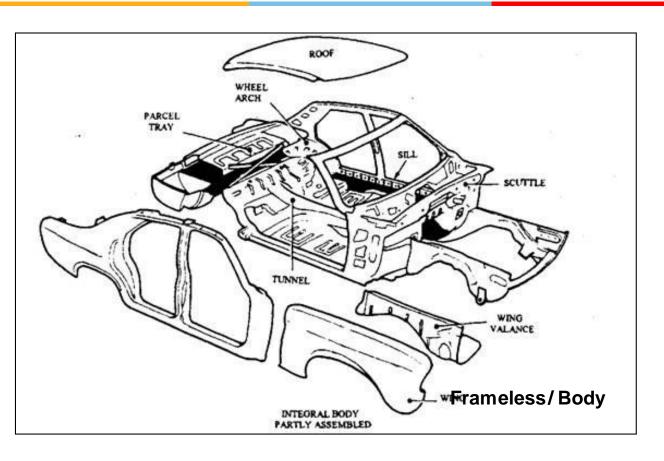
### **Conventional Construction**

#### SIMPLE CONSTRUCTION OF TRUCK CHASSIS





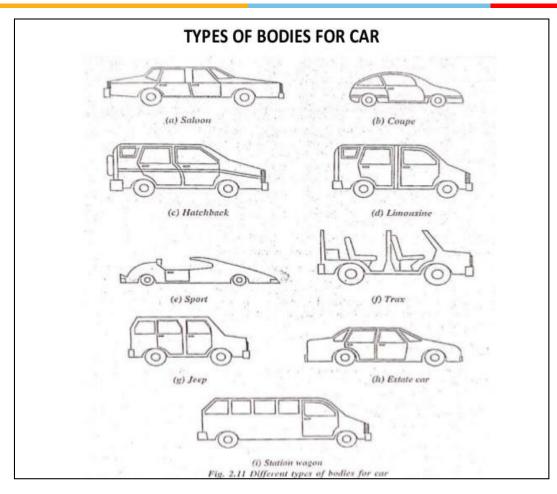
### **Frameless Construction**

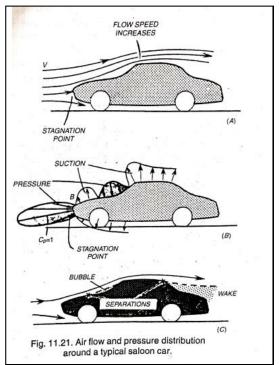


- 1. Body Safety
- 2. Bonnet
- 3. Side Pillars
- 4. Rearhood
- 5. Front side Panel
- 6. Rear side Panel
- 7. Door Pillars
- 8. Windshield Pillar
- 9. Rear Quarter Pillar
- 10. Body Sill
- 11.Roof
- 12. Door Panels
- 13. Front Bumper
- 14. Rear Bumper

## Frameless construction – Body shape & Types







The air resistance is given by the expression,  $R_a = (1/2) C_d \rho A V^2$ ,

where  $C_d$  = aerodynamic resistance coefficient that represents the combined effects of the above three components,

 $\rho$  = density of air,

A = projected area of the vehicle in the direction of travel,

and V = velocity of the vehicle relative to the wind.



## **Today's Topic**

Lect No.	Learning Objectives	Topics to be covered	Reference to Text
1	An introduction to automobiles	Overview of the course and evaluation scheme Development of automobiles, General classification, Basic structure and components of automobile	1TB1,1TB2
2	The chassis Construction and Body	Classification, Conventional construction, Sub frames, Frame less constructions, Classification of body, Numerical problems on chassis member bending.	11TB1, 1 TB2
3	Reciprocating Engine Construction and basics	Constructional details, Calculation of displacement velocity and acceleration of piston and connecting rod, Working of 2and 4 stroke engines.  Numerical problems on the above topics	3TB1
4	Cooling systems	Need. Variation of gas temperature. Piston temperature distribution. Theory of engine heat transfer and correlation. Parameters affecting engine heat transfer. Air-cooled systems.	8TB1, 12RBa
5	Cooling systems	Types of water-cooling systems. Radiators. Fans. Correlation for the power required for engine cooling. Numerical problems on the above topics	8TB1, 12RBa
6	Lubrication systems	Causes of engine friction. Function of lubrication. Mechanism of lubrication. Journal bearing lubrication.	7TB1, 11RBa
	Lubrication systems	Types of lubrication systems. Lubrication of engine components.	7TB1, 11RBa
7	Clutch	Definition of clutch, requirements, classification, principle of working of friction clutches, Driving system and Plate clutch (uniform pressure and uniform wear).	14TB1, 3TB2



# **Automotive Vehicles Lecture 3**

## Reciprocating Engine Construction and Basics



- Cylinder Block and crank case
- Cylinder Head
- Sump or oil pan
- Intake and Exhaust Manifolds
- Gaskets
- Cylinder Liners
- Piston

- Piston Rings
- Connecting Rods
- Piston Pins
- Crankshaft
- Main bearings
- Valves and Valve actuating mechanisms
- Mufflers

# Engine Construction – Cylinder Block



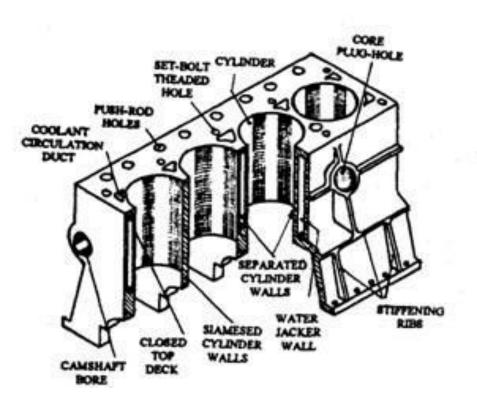


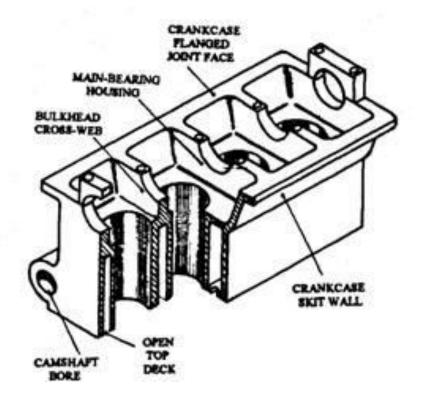
- Supporting structure of Engine
- Mounts and holds all parts in alignment
- Large diameter holes are Cylinder bores to guide Piston
- Bulk head to support crankshaft
- Bulkhead distribute loads
- Cylinders are surrounded by Cooling passages
- Drilled passages for coolant and lubricating oil
- Gaskets are used in joints to absorb variations / machining irregularities and temperature extremities



# Engine Construction – Cylinder Block

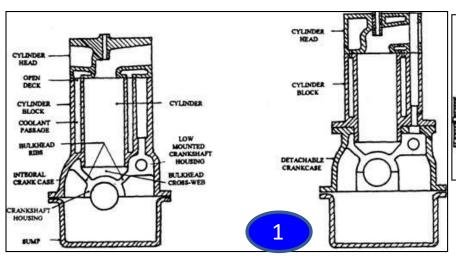


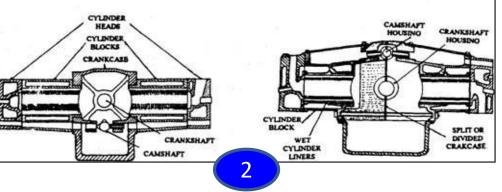




# Engine Construction – Cylinder Block (Types)

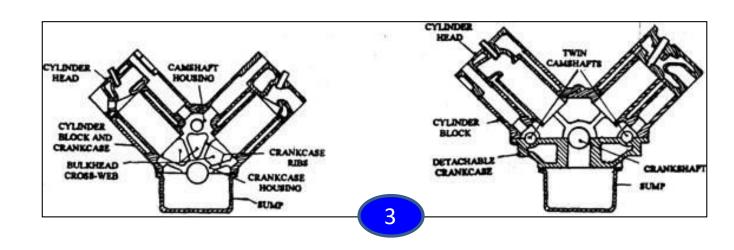






#### **3 Types CBs:**

- 1. In-line
- Horizontally Opposed
- 3. V-banked (60°)



# Engine Construction – Cylinder Block

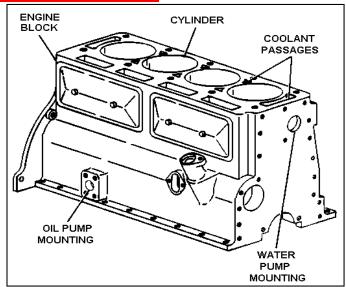


#### **Coolant Passages:**

- Cast to full depth
- Terminate near the Bottom of cylinders
- Open deck & Close deck

#### Crankcase:

- Supports alignment of Crankshaft / Rotation of journal bearings
- Semi-circular construction provides stiff and lightweight structure
- Integral or Detached





# Engine Construction – Cylinder Block



#### Cylinder Block Materials:

- Grey cast Iron
  - Good foundry Material
  - High Machinability
  - Does not wear too much'
  - Good damping properties
  - Low value of Co-efficient of thermal expansion
  - Relatively cheap

#### Aluminum alloys

- Corrosion resistant
- Retain strength
- Lightness
- High Thermal conductivity

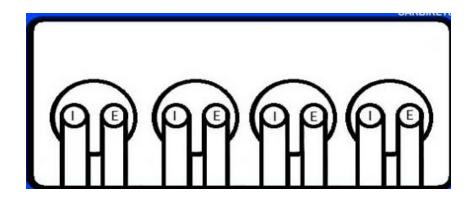
# Engine Construction – Cylinder Head

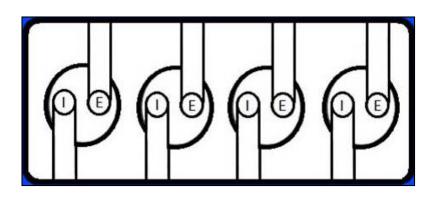


- Top surface of Cylinder Block
- Gaskets provide leak proof joint
- Based on Valve and port layout, Cylinder head classified to three types
  - 1. Loop flow type Cylinder head
  - 2. Offset cross flow type Cylinder head
  - 3.In-line cross flow type Cylinder head
- Cylinder Head Materials
  - Grey cast Iron
  - Aluminum Alloy

## Engine Construction – Cylinder Head

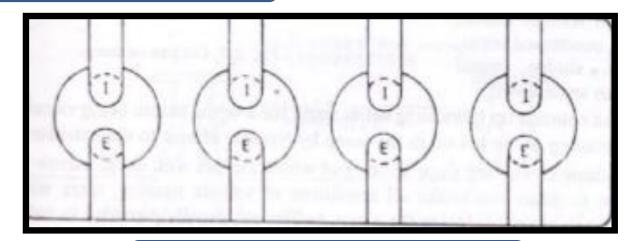






Loop Flow type Cylinder Head

Offset flow type Cylinder Head

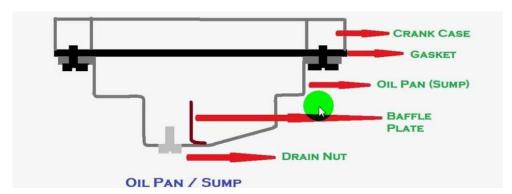


In-line cross flow type Cylinder Head

## Engine ConstructionOil Pan / Sump



- Bottom half of crankcase
- Functions of Sump:
  - Store the oil for Engine lubricating System
  - Collect the return oil from walls and bearings
  - 3. Serve as container (Sludge, condensed water, Metal particles etc..,) can settle down
  - 4. Enable hot lubricating oil to settle before being circulated
  - 5. Provide cooling for hot oil in the sump by transfer of heat to outside Air stream
- Sump made of Pressed
   Steel, Aluminum alloy casting





## **Engine Construction - Manifolds**



- Manifold : Pipes to carry Air-fuel mixture and the exhaust gases
- Inlet Manifold (Carries AF Mixture from Carburetor to Cylinders)
  - ❖ Inlet Manifold for 4-cylinder In-line Engine with single Carburetor
  - ❖ Inlet Manifold for 4-Cylinder In-line Engine with two Carburetor
- Mounted on same side of Exhaust Manifold to effect transfer of heat from exhaust gases
- Alternate method of heating the inlet manifold by hot water from Engine cooling system is adopted
- Length of intake track is varied by VLIM (Variable Length Intake Manifold Technology) / Variable Resonance Induction System (VRIS) : Engine power and Torque are optimized and Fuel efficiency is increased

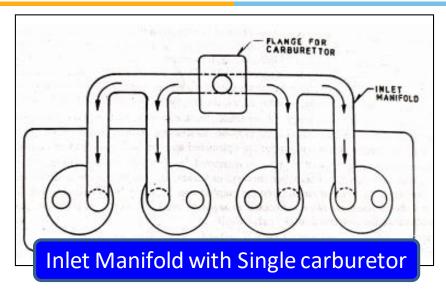
## **Engine Construction - Manifolds**

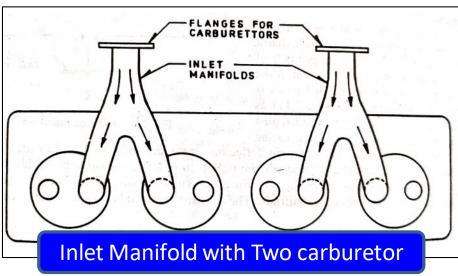


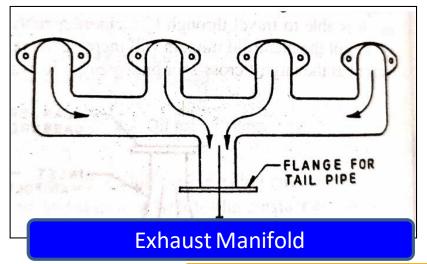
- Exhaust Manifold (Carrying Exhaust gases from Cylinder head to Exhaust system)
- Made of Cast Iron to withstand the heat of Exhaust gases
- Smoother flow of exhaust gases is provided for two-inone manifold than compared to simple one
- Designed to minimize restriction to the flow of exhaust gases
- Cast rib-deflectors / dividers are used to guide exhaust gases smoothly

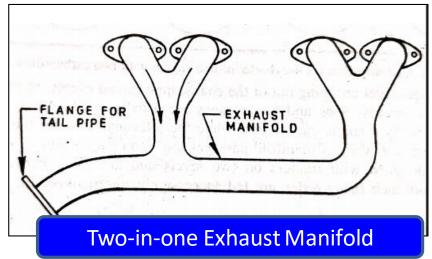
## **Engine Construction - Manifolds**











### **Engine Construction - Gaskets**

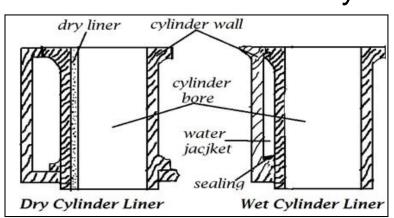
- Tight fitting joint between two surfaces
- Requirements of Gaskets:
  - Conformity (Conform the mating surfaces)
  - Resistance (Retain Sealing force at temperature change)
  - Impermeability
  - Resistance to chemical attack
  - Resistance to operating conditions
  - Provision to Apertures
- Materials used Gaskets : Cork, Asbestos, Rubber

- Types of Gaskets:
- 1. Cylinder Head Gaskets
  - Embossed Steel or Shim type
  - Metal Sandwich (Cu or Asbestos or Steel and Asbestos)
  - Shimbestos (Thin steel heat shield and reinforced asbestos)
  - Felbestos (Two treated asbestos)
- 2. Oil Pan Gaskets
- 3. Manifold Gaskets
- 4. Pump Gaskets

# Engine Construction – Cylinder Liners



- Cylinder Liners to protect Cylinder block from getting worn out
- Used to restore Cylinder block to original size
- Materials Used : Special alloy Iron containing Si, Mg, Ni, Cr and Cast centrifugally
- Aluminum Alloy liners are used with Al Cylinder blocks
- Al Alloy liners used to increate thermal efficiency
- 2 Types of Liners
  - Dry Liners
  - Wet Liners



# Engine Construction – Cylinder Liners



#### **Dry Liners**

- Flexible in design
- No Leak Proof required
- Cylinder Block is more robust due to Dry Liners
- Casing of Cylinder block is nor simplified
- Less cooling
- Dry type cannot be finished finally due to shrinkage Stresses
- Accurate machining is required for perfect contact

#### **Wet Liners**

- Should be a part of design
- Leak proof joint required
- Cylinder Block is less robust due to Wet Liners
- Casing of Cylinder Block is simplified
- Better Cylinder cooling as coolant is in contact with Liner
- Wet Type can be finished before fitting
- No accurate machining is required



### **Engine Construction - Pistons**

#### **Function:**

- To Transmit force of explosion to crankshaft
- To Form a seal so that high pressure gases in the Combustion chamber do not escape in the crankcase
- To serve as a Guide and a bearing for small end of the connecting rod

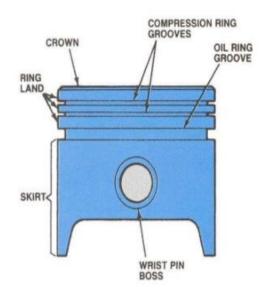
#### **Characteristics:**

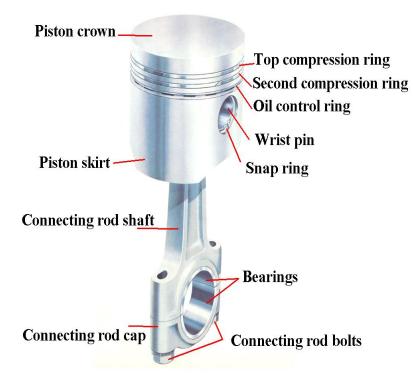
- Should be silent in operation
- Should not end in Seizure
- Should offer resistance to corrosion
- Should have shortest length to decrease Engine size
- Should be lighter in weight
- Should have material with high thermal conductivity for efficient Heat transfer
- Should have Long life

### **Engine Construction - Piston**

#### PARTS OF PISTON

- The Crown: is the top surface (closest to the cylinder head) of the piston which is subjected to tremendous forces and heat during normal engine operation.
- The Ring lands: Are the reliefs cut into the side profile of the piston where the piston rings sit.
- Ring Groove: is a recessed area located around the perimeter of the piston that is used to retain a piston ring.
- Skirt: of a piston is the portion of the piston closest to the crankshaft that helps align the piston as it moves in the cylinder bore.
- Wrist pin boss: is a bore that connects the small end of the connecting rod to the piston by a wrist pin.





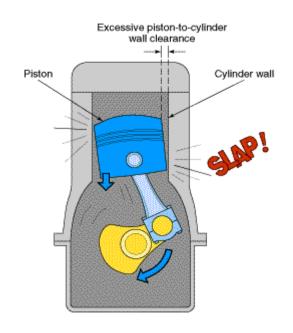


### **Engine Construction – Piston**

#### Material used – Al alloy, Si-Al alloy

#### **Cold Slapping:**

- The piston to wall clearance can be large enough so that the piston rocks from one side to another to cause the piston slap.
- The major cause of piston slap is the clearance,
- The gap between the piston and the cylinder bore becomes wider due to wear and tear.





### **Engine Construction - Piston**

#### To avoid Cold Slapping, Below Pistons are used

- Piston with Horizontal slot (Heat Barriers)
- 2. Inclined slot with Oil ring groove (Heat Barriers)
- 3. Heat Dam (Grove reduces Heat from crown to Skirt)
- 4. Use of Vertical or T Slots (skirt to expand w/o increase)
- 5. Taper Pistons (Crown side expands at heat)
- 6. Cam ground positions (Heat absorbed ovality)
- 7. Use of special alloys with low co-efficient of Expansion
- 8. Wire wound Pistons (Restricting the expansion)
- 9. Autothermic Pistons (Low expansion steel insert)
- 10. Bi-Metal Piston (Steel and AI, as Low co-efficient of thermal Expansion)
- 11. Offset Piston (Offset from distance causes the connecting rod, piston smoothly wipes into full wall contact)

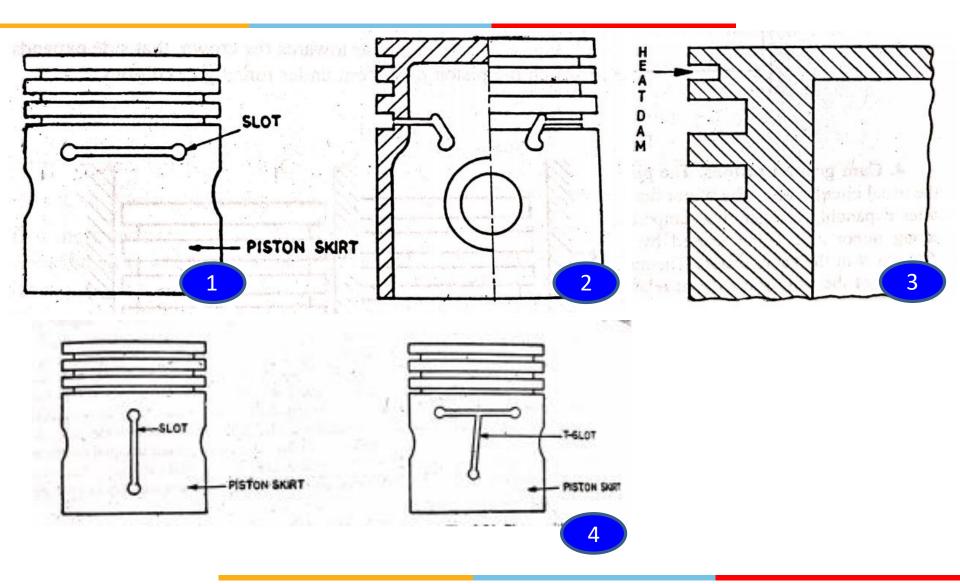


### **Engine Construction - Pistons**

- 12. Pistons with inserted Ring carrier (Resistance to corrosion)
- 13. Cast Steel Pistons (Steel Alloy with Si, Cu, Cd Wear and Heat resistant)
- 14. Anodized Pistons (Protects from Scoring)
- 15. Tinned Pistons (Avoids Wearing off)
- 16. Oil cooled Pistons (Reduces Piston temperature)
- 17. Two Piece Pistons (Different Materials for Crown & Skirt)
- 18. Composite insulated (heat shielded) piston
- 19- Squeeze Cast Piston (Eliminates Micro porosity)
- 20. AEconoguide Piston (Raised pads assist Lubrication)

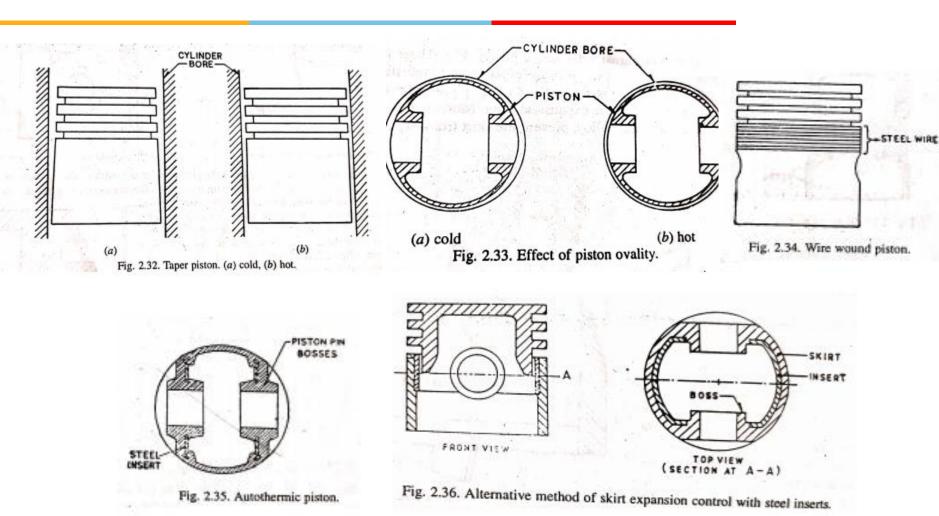


## **Engine Construction - Pistons**



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### **Engine Construction - Piston**



## **Engine Construction - Piston**



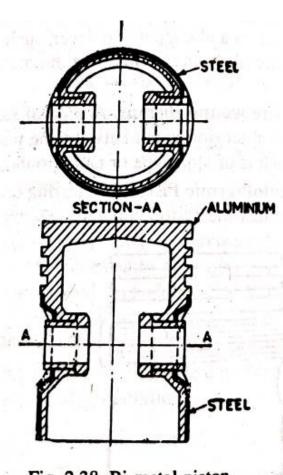


Fig. 2.38. Bi-metal piston.

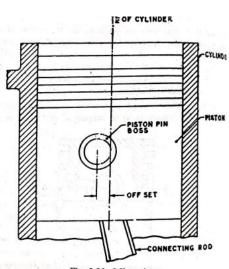


Fig. 2.39. Offset piston.

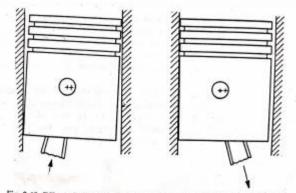


Fig. 2.40. Effect of piston pin offset. (a) Piston moving up (just before T.D.C.), (b) Piston moving down in power stroke (after T.D.C.)

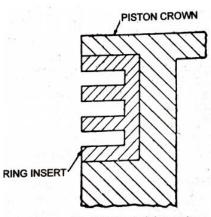


Fig. 2.42. Inserted ring carrier.

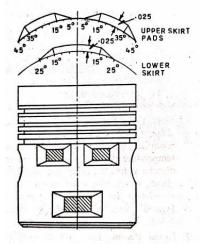


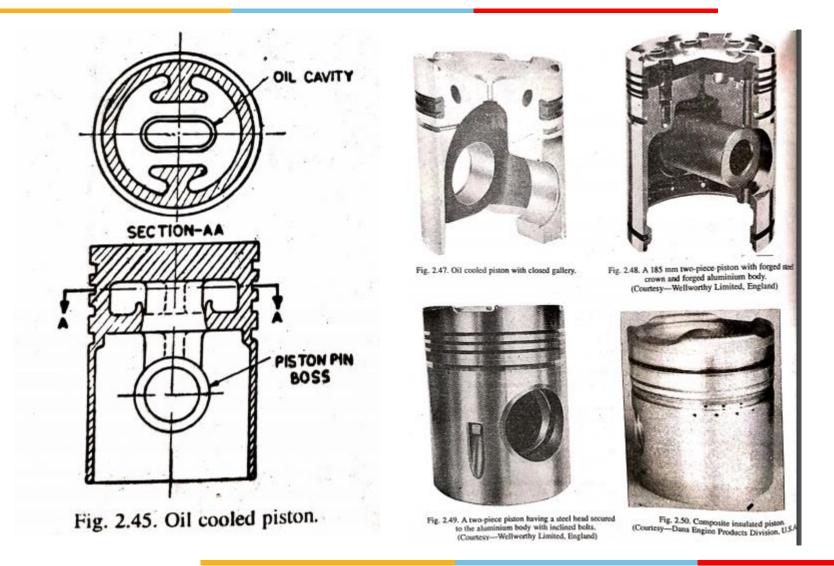
Fig. 2.52. AEconoguide piston. (Courtesy—Wellworthy Limited, England)

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### **Engine Construction - Piston**



### Reciprocating Engine Construction and Basics



- Cylinder Block and crank case
- Cylinder Head
- Sump or oil pan
- Intake and Exhaust
  Manifolds
- Gaskets
- Cylinder Liners
- Piston

- Piston Rings
- Connecting Rods
- Piston Pins
- Crankshaft
- Main bearings
- Valves and Valve actuating mechanisms
- Mufflers

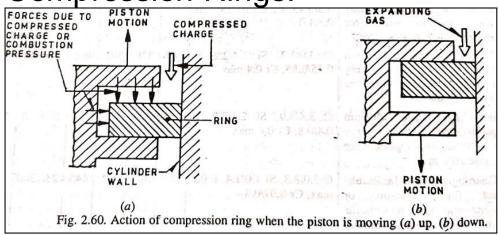
To be continued in L4



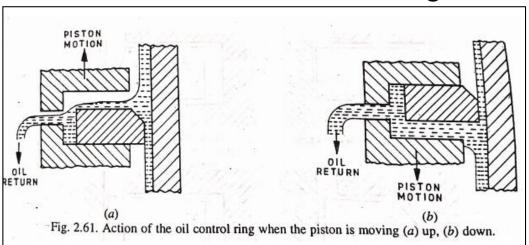
### Types of Rings:



Compression Rings:



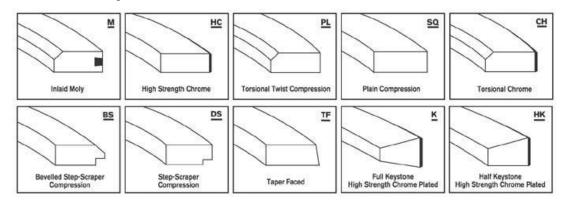
### Oil Control Rings:





### **Design Consideration:**

- Ring Width (1.5mm approx.)
- Shapes



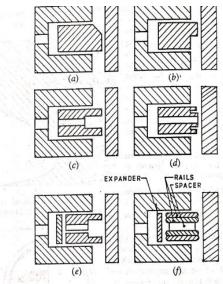
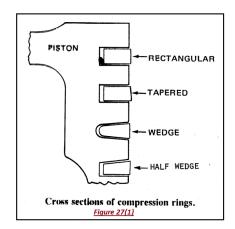


Fig. 2.68. Oil control rings. (a) bevelled ring, (b) stepped scraper, (c) slotted scraper, (d) delayed action scraper, (e) double action scraper, (f) composite rail scraper.





#### Factors affecting Ring selection:

- 1. Dimensions of Engine block
- 2. Piston Design
- 3. Piston Displacement
- 4. Piston Speed
- 5. Cylinder bore material
- 6. Carburation
- Bore to Stoke ratio
- 8. Compression ratio
- 9. Cooling capacity
- 10. Crankcase pressure
- 11. Engine Performance expected
- 12. Horse power requirement
- 13. Type of Cylinder bore lubrication
- 14. Peak manifold vacuum

#### Causes of Ring Failure:

- Rapid Wear
- 2. Scuffing/scoring
  - Overheated engine
  - Deficient Lubrication
  - Insufficient Clearance
- 3. Ring Breakage
  - Use of Ring of incorrect
     Size
  - Ring sticking
  - Insufficient end gap of rings
  - Uneven wear of ring grooves

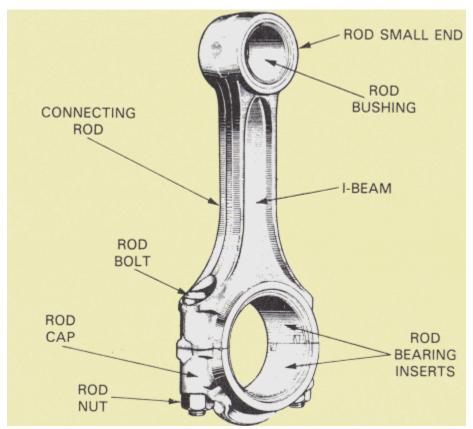
### Reciprocating Engines – Connecting Rod



<u>Function</u>: Convert Motion of Piston to rotary motion of the crankshaft

#### **Material:**

- Steel
- Duralumin
- Cast Iron



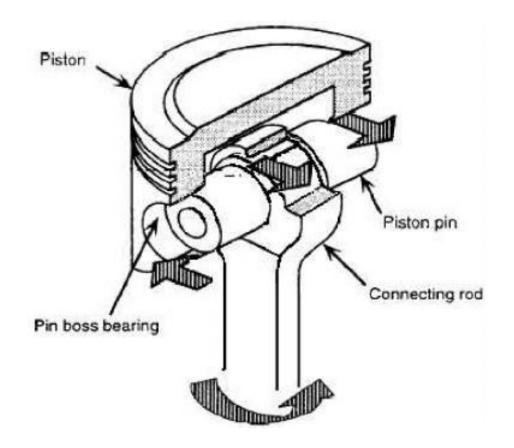


Function: Connects Piston & Connecting Rod

**Material**: Low carbon steel

#### **Method of Attachment:**

- 1. Set screws
- 2. Bolts
- 3. Floating Pins



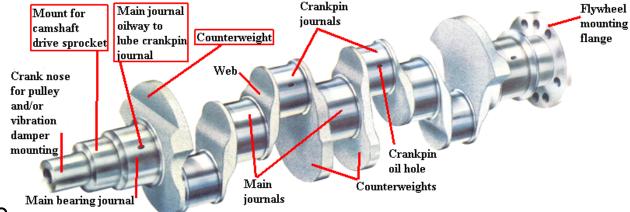
### Reciprocating Engines – Crank shaft



<u>Function</u>: Receives power from Connecting rod and transmits to clutch and wheels

#### **Major Parts:**

- Main journals
- Crank pins
- Crank webs
- Counter weights
- Oil holes



Materials: Cast Stee

**Manufacture:** Forging & Machining

#### **Vibration Dampers:**

- Attached to front end of the Crankshaft
- Reduces torsional vibrations of Crankshaft
- Maintain the speed as uniform

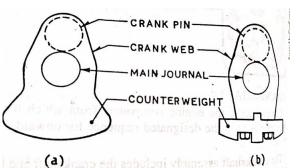


Fig. 3.2. Counter weights.
(a) integral, (b) attached separately.

## Reciprocating Engines – Engine Bearings



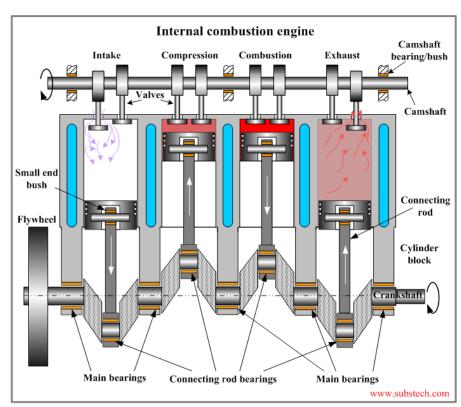
#### **Requirements:**

- 1. Support operating loads
- 2. Less friction with lubricant
- 3. Long life and fatigue life
- 4. Adequate comfortability
- Score resistance & prevent from Seizing
- Corrosion Resistance

Bearing Materials: Cu, Antimony, Al

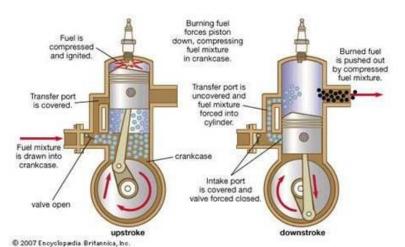
#### Types:

- Precision insert type
- Cast type



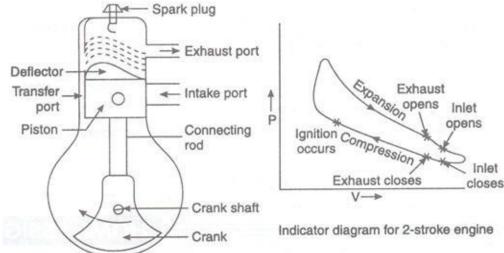
## Working of 2 Stroke Engine (Petrol & Diesel)





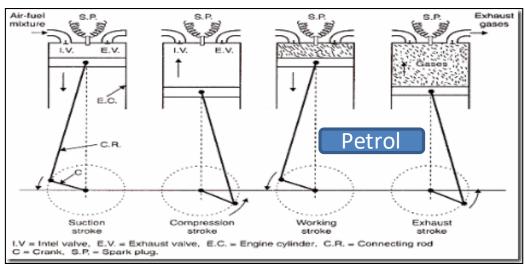
https://www.youtube.com/watch?v=Z6YC3I 54so4

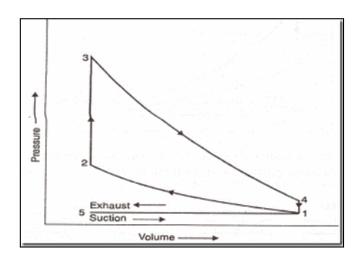
**Two Stroke** 

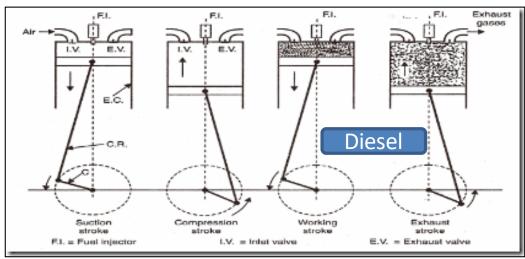


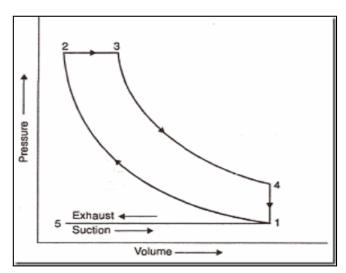
# Working of 4 Stroke Engine (Petrol & Diesel)





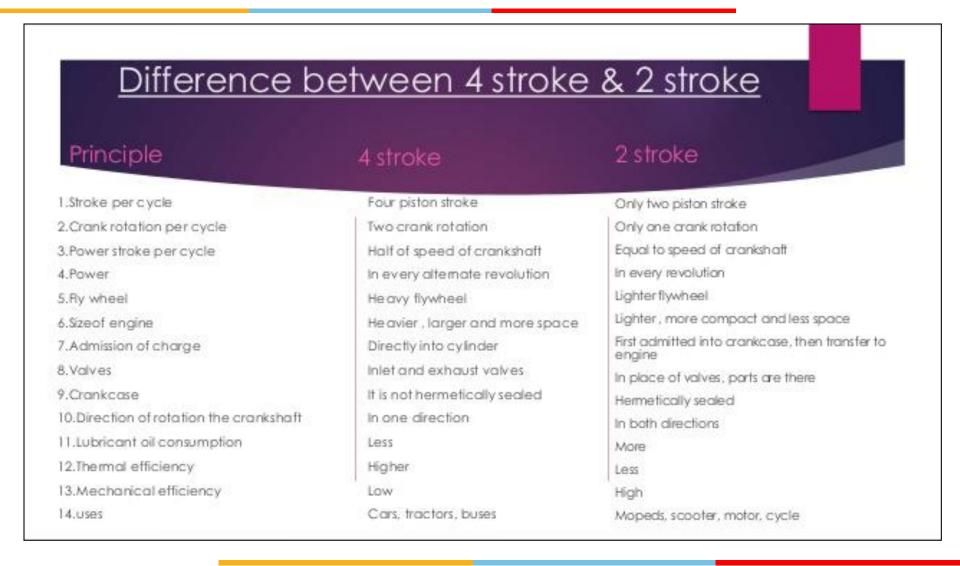






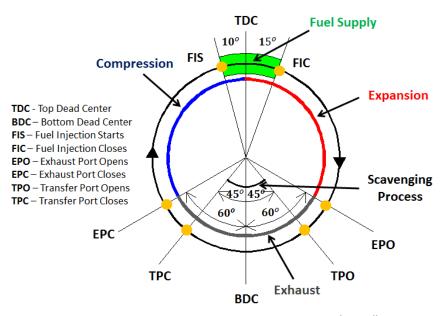


### 2 Stroke Vs 4 Stroke



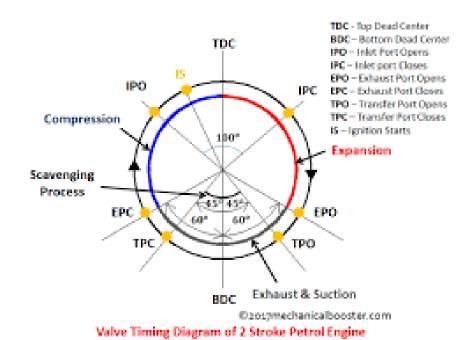
## Reciprocating Engines – Port Timing of 2 Stroke Engine





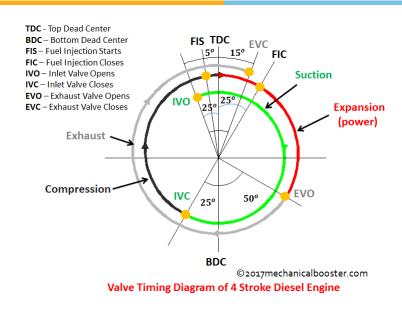
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Valve Timing Diagram of 2 Stroke diesel Engine



## Reciprocating Engines – Valve Timing of 4 Stroke Engine





Two Stoke Engines:

https://www.youtube.com/watch?v=Z6YC3I5

<u>4so4</u>

Four Stoke Engines:

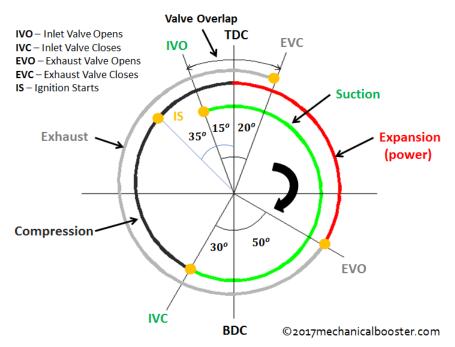
https://www.youtube.com/watch?v=fTAUq6G

9apg

https://www.youtube.com/watch?v=DKF5dKo

https://www.youtube.com/watch?v=mF5Ns 8 9MeE https://www.youtube.com/watch?v=DBDG

Ovsxpq8



Valve Timing Diagram of 4 Stroke Petrol Engine

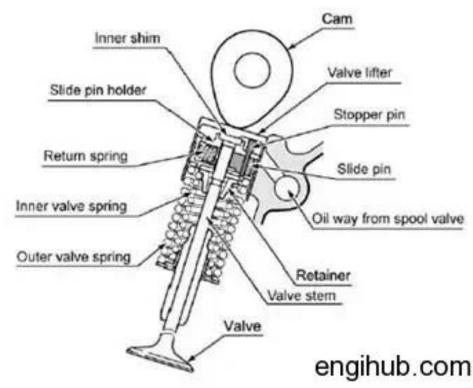


#### Valves:

- Controls in and out movements of charges / exhaust gases
- Located in Cylinder Head

#### Types:

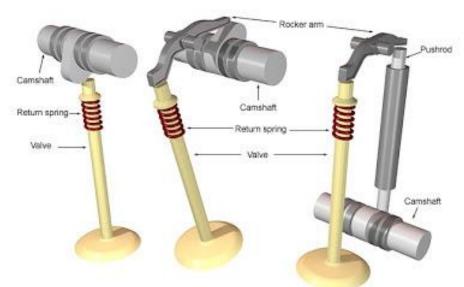
- Poppet Valve
- Sleeve Valve
- Rotary Valve





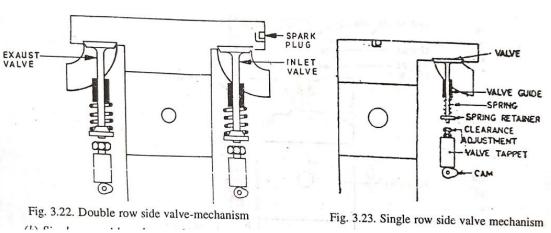
### Valve actuating Mechanisms:

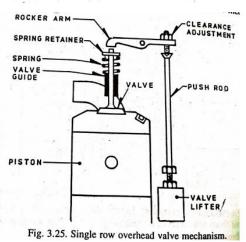
- Side camshaft with Push rod and Rockers
  - Double row Side valve Mechanism
  - Single row Side valve Mechanism
  - Overhead inlet and Side exhaust valve Mechanism
  - -Single row Overhead valve Mechanism
- Overhead camshaft with a sliding Inverted bucket followers
- Overhead camshaft with Pivoted Rocker arm

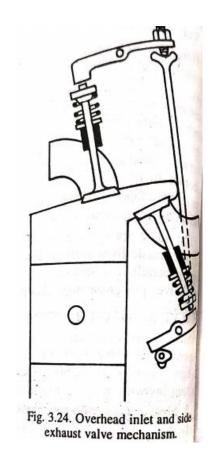




#### Side camshaft with Push rod and Rockers

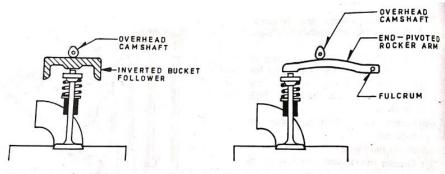






lead

#### Overhead camshaft



inverted bucket type follower (Single row valves).

ig. 3.28. Overhead camshaft-operated mechanism with Fig. 3.29. Overhead camshaft-operated mechanism with end-pivoted rocker arm (Single row valves).

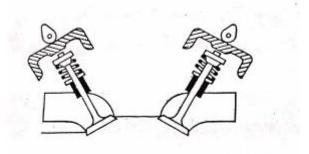


Fig. 3.31. Double overhead camshaft-operated mechanism with inverted bucket type followers

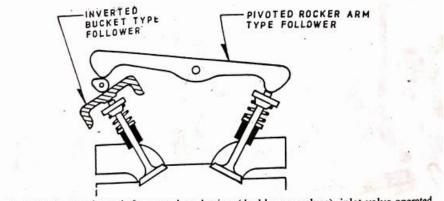


Fig. 3.30. Overhead camshaft-operated mechanism (double row valves), inlet valve operated by inverted bucket type follower and exhaust valve by pivoted rocker arm.

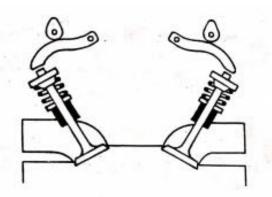


Fig. 3.32. Double overhead camshaft-operated mechanism with separate rocker arms.



Advantages of Side Camshaft over Overhead Camshaft

- Higher Volumetric efficiency
- Higher Compression ratios
- Leaner air-fuel mixture will be burnt

Disadvantages of Side Camshaft over Overhead Camshaft

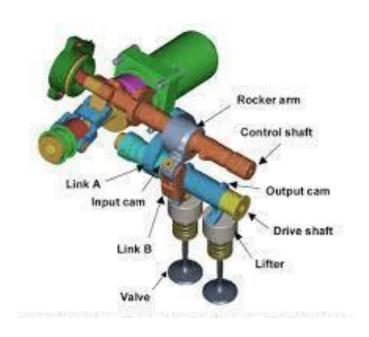
- Noisy Operation
- Greater Maintenance is required

## Reciprocating Engine – Valve Train components

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- 1. Cam shaft
  - With cam for intake and exhaust valve
- 2. Cam shaft Drive
- 3. Rocker Arm & Rocker shaft

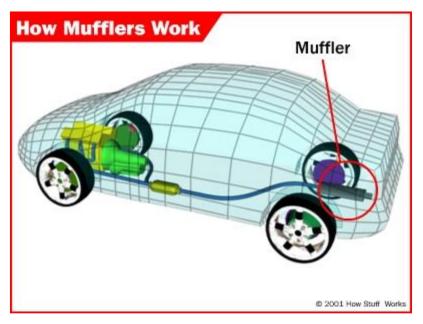




### Reciprocating Engine - Mufflers



- To reduce noise
- Engine exhaust connected via Exhaust pipe to the silencer
   -> Muffler
- Tail pipe carries Exhaust gases from Muffler to the rear side of vehicle Near Wheel



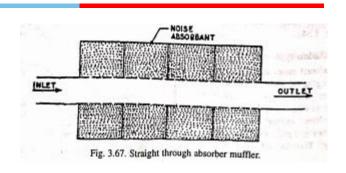


### Reciprocating Engine - Mufflers



### **Mufflers Types:**

- Baffle (Cylinders with Baffle)
- Wave Cancellation (Waves of Gases)
- Resonance Type (Resonators reduces Engine Noise)
- Absorber Type (Fiber glass absorbing noise)
- Combined Resonance & Absorber



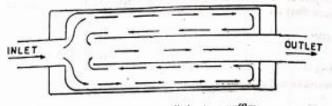
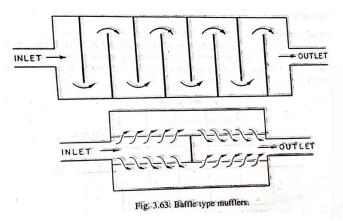
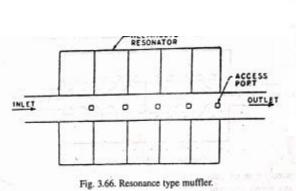


Fig. 3.65. Wave cancellation type muffler.





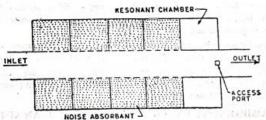


Fig. 3.69. Combined resonance and absorber type muffler.

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### **Reciprocating Engine**

- Cylinder Block and crank case
- Cylinder Head
- Sump or oil pan
- Intake and Exhaust Manifolds
- Gaskets
- Cylinder Liners
- Piston

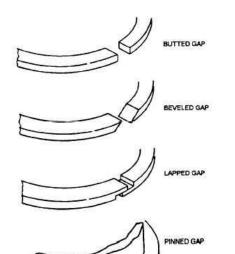
- Piston Rings
- Connecting Rods
- Piston Pins
- Crankshaft
- Main bearings
- Valves and Valve actuating mechanisms
- Mufflers

To be continued with Cooling System



#### **Functions:**

- To form a seal for high pressure gases from combustion chamber against leak into the crank case
- To provide passage for heat flow from the cylinder crown to walls
- To maintain efficient lubricating oil on cylinder walls



RING GROOVE PREVENTS RING FROM MOVING

#### Materials:

- Cast Iron with Si,
   Mg
- Chromium
- Alloy steel
- Stainless steel

#### Types of Rings:

- Compression
- Oil Control

