MVMWC501: Automobile Engineering







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Course Content (L-T-P: 3-0-2)

UNIT-1 Introduction to Vehicle Structure and Engine Components: Introduction to Automobiles: Classification and requirements of automobile body, vehicle frames, unitised body, car body styles, bus body & commercial vehicle body types, front engine rear drive & front engine front drive vehicles, four-wheel drive vehicles, safety considerations, engine cooling and lubrication.

UNIT-2 Ignition, Fuel Supply and Emission Control System: Ignition system-coil and magneto, electronic ignition system, fuel injection systems: mono-point and multipoint, electronic fuel injection system (EFI), GDI, MPFI, DTSI,

Automobile Emissions: Source of formation, effects on human health and environment, control techniques, exhaust gas recirculation (EGR), catalytic converter, emission tests and standards (Indian and European).

UNIT-3 Transmission System: Clutches-function and types, gearbox-manual, sliding, constant, synchromesh, automatic transmission, continuously variable transmission, overdrive, universal joint, propeller shaft, Hotchkiss drive, final drive, differential-need and construction, non-slip differential, differential locks, rear axle assembly.

Course Content (L-T-P: 3-0-2)

UNIT-4 Steering, Suspension and Braking System: Principle of steering, steering geometry and wheel alignment, steering linkages and gearboxes, power steering, front axle suspension system, independent and solid axle, coil and leaf spring, air suspensions, torsion bar, shock absorbers, wheels and tires-construction, type and specification, tire wear and causes, brakes-need and classification, anti-lock braking system (ABS).

UNIT-5 Automobile Electrical Systems and Instrumentation: General electrical circuits, automotive electronics, dashboard instrumentation. Passenger comfort and safety- HVAC, seat belts, air bags.

Advances in Automobile Engineering: Electronic Control Unit (ECU), Active Suspension System (ASS), Electronic Brake Distribution (EBD), Electronic Stability Program (ESP), Traction Control System (TCS), Global Positioning System (GPS).

SUGGESTED READINGS:

1. Automotive Mechanics - William. H. Crouse, Tata McGraw-Hill.
2. Automotive Engineering: Power train, Chassis System and Vehicle Body - David A. Corolla,, Butterworth Heinemann Publishing Ltd.
3. Automotive. Mechanics Principles & Practices. - Joseph Heitner, Affiliated East-west Press Private Limited.
4. Automotive Engineering Fundamentals - Richard Stone, Jeffrey K. Ball, SAE International.
5. Automobile Engineering - Kirpal Singh, Standard Publications.

List of Experiments

1. To study the chassis, frame and body in automobile vehicles.
2. To study the constructional details, working principles and operation of the engine cooling & lubricating systems.
3. To study the constructional details, working principles and operation of fuel supply systems.
4. To study the constructional details, working principles and operation of the automotive clutches.
5. To study the constructional details, working principles and operation of the automotive transmission systems.
6. To study the constructional details, working principles and operation of the automotive drivelines & differentials.
7. To study the constructional details, working principles and operation of the automotive tires and wheels.
8. To study the constructional details, working principles and operation of the automotive suspension systems.
9. To study the constructional details, working principles and operation of the automotive brake systems.
10. To study the constructional details, working principles and operation of the automotive steering systems.
11. To study the constructional details, working principles and operation of automotive emission / pollution control systems.

Course Outcomes (COs)

1. To understand the vehicle structure and engine components.
2. To explore the concepts of ignition, fuel supply and emission control systems.
3. To acquire the knowledge of the transmission systems used in automobiles.
4. To learn about the mechanisms of steering, suspension and braking systems.
5. To explore the advances in automobile engineering.

UNIT I: Introduction to Automobiles

S. No./ Topic No.	Topic Name	No. of Lectures
1.1	Introduction to Automobile & type of Automobile	1
1.2	Classification and requirements of automobile body, vehicle frames,	1
1.3	Unitised body, car body styles, bus body & commercial vehicle body types,	1
1.4	Front engine rear drive & front engine front drive vehicles, four-wheel drive vehicles,	1
1.5	Engine: Types and Construction,	1
1.6	Safety considerations	1
1.7	Engine lubrication system	1
1.8	Engine cooling system	1

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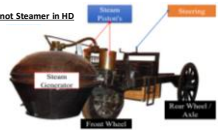
Introduction to Automobile

- Automobile is a **"Self Propelled vehicle"** generally driven by IC Engine and it is used for **transportation of passengers & goods on ground** – *W. H. Crouse*.

History

https://www.loc.gov/everyday-mysteries/motor-vehicles-aeronautics-astronautics/item/who-invented-the-automobile/

1769 Cugnot Steamer in HD



1769 - STEAM / Built the first self propelled road vehicle (military tractor) by Nicolas-Joseph Cugnot

- In 1769, the very first self-propelled road vehicle was a military tractor invented by French engineer and mechanic, Nicolas Joseph Cugnot.
- He used a steam engine to power his vehicle, which was built under his instructions at the Paris Arsenal.
- The steam engine and boiler were separate from the rest of the vehicle and placed in the front.
- It was used by the French Army to haul artillery at a whopping speed of 2 and 1/2 mph on only three wheels.
- The vehicle even had to stop every ten to fifteen minutes to build up steam power.
- The following year, Cugnot built a steam-powered tricycle that carried four passengers.

https://youtu.be/KP_oQHYmdRs

1885 – First Vehicle propelled with IC Engine, developed by Benz Motors in Germany

This photograph shows Karl Benz's (1844-1929) Patent-Motorwagen, or Patent Motorcar, the first automobile powered by a gasoline-fueled internal combustion engine. Introduced to the German public in July 1886 in Mannheim, it featured a single-cylinder, four-stroke, rear-mounted engine; a comfortable, three-wheeled chassis; wooden paneling; rack and pinion steering; and solid rubber tires of Benz's own design. Later models traveled up to ten miles per hour. Benz began selling the car in 1888, making it the first commercially available automobile in history.

https://germanhistory-intersections.org/en/knowledge-and-education/ghis:image-62

https://www.youtube.com/watch?v=qVkvH0nm8pU&ab_channel=SquirrelAndRope

Automobile Highlights

Inventor	Date	Type/Description	Country
Nicolas-Joseph Cugnot (1725-1804)	1769	STEAM / Built the first self propelled road vehicle (military tractor) for the French army: three wheeled, 2.5 mph.	France
Robert Anderson	1832-1839	ELECTRIC / Electric carriage.	Scotland
Karl Friedrich Benz (1844-1929)	1885/86	GASOLINE / Automobile powered by an internal combustion engine: three wheeled, four cycle, engine and chassis form a single unit.	Germany Patent DRP No. 37435
Gottlieb Wilhelm Daimler (1834-1900) and Wilhelm Maybach (1846-1929)	1886	GASOLINE / First four wheeled, four-stroke engine- known as the "Cannstatt-Daimler."	Germany
George Baldwin Selden (1846-1922)	1876/95	GASOLINE / Combined internal combustion engine with a carriage: patent no: 549,160 (1895). Never manufactured — Selden collected royalties.	United States
Charles Edgar Duryea (1862-1938) and his brother Frank (1870-1967)	1893	GASOLINE / First successful gas-powered car: 4hp, two-stroke motor. The Duryea brother s set up first American car manufacturing company.	United States

https://www.loc.gov/everyday-mysteries/motor-vehicles-aeronautics-astronautics/item/who-invented-the-automobile/

Types of Automobile

1. Purpose

- Passenger vehicle — Car, Station wagon, Jeep, Bus
- Goods vehicle — Truck, Pick-up
- Special purpose — Ambulance, Fire engine, Army vehicles, Concrete m

2. Load Capacity

- Light duty vehicle — Car, Jeep, Scooter, Motor cycle, etc.
- Heavy duty vehicle — Bus, Truck, Tractor, Coach.

3. Suspension System Used

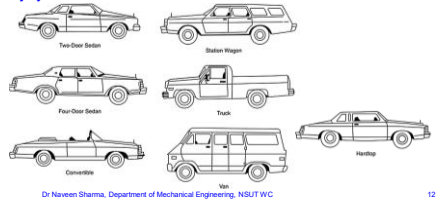
- Conventional — Leaf spring.
- Independent — Coil spring, Torsion bar, Pneumatic

4. Fuel Used

- Petrol vehicle — Car, Jeep, Motor-Cycle, Scooter, etc.
- Diesel vehicle — Car, Truck, Tractor, Bus, Bulldozer, etc.
- Electric vehicle — Which use battery to drive. (Fork lift, Battery truck)
- Steam vehicle — An engine which uses steam engine. (Steam road roller)
- Gas vehicle — LPG and CNG vehicles, where LPG is liquefied

5. Type of Automobile Body System

- Two door sedan
- Hard top
- Four door sedan
- Station wagon
- Convertible
- Van



6. On the basis of Transmission

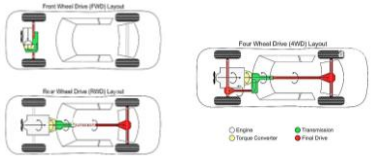
- Conventional vehicles with manual transmission, e.g. car with 5 gears.
- Semi-automatic
- Automatic: In automatic transmission, gears are not required to be changed manually.

7. On the basis of Drive

- Left hand drive
- Right hand drive

8. On the basis of Driving Axle

- Front wheel drive
- Rear wheel drive
- All wheel drive

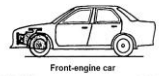


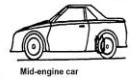
9. Position of Engine

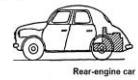
- Engine in Front - Most of the vehicles have engine in the front. Example: most of the cars,
- Engine in the Rear Side Very few vehicles have engine located in the rear. Example: Nano car.
- Engine in Middle (the engine is placed anywhere in the car such that the centre of gravity of the engine lies between front and rear axles) - These engine situations generally apply to sports cars because the engine sitting gives a load distribution that achieves both good handling & maximum traction from the driving wheels.

10. Number of Wheels and Axles

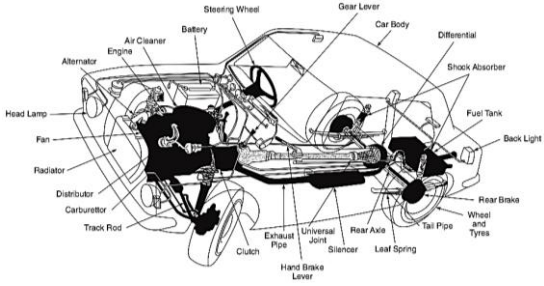
Two wheeler	Motor cycles, Scooters, Mopeds
Three wheeler	Tempo, Auto-rickshaws
Four wheeler	Car, Jeep, Bus, Truck, etc.
Six wheeler	Buses and Trucks
Six axle wheeler	Shaktiman, Dodge (10 tyres) vehicle


Front-engine car


Mid-engine car


Rear-engine car

Layout of an Automobile

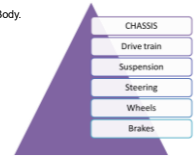


Major Components of Automobile

An automobile is made up of mainly two units, these are Chassis and Body.

"Frame" + "Base components" = "Chassis"

"Chassis" + "Body" = "Vehicle"



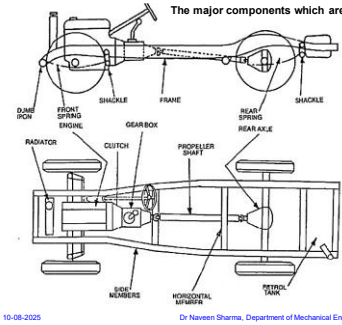

1. Power plant or Engine


2. Chassis


3. Power train or drive train


4. Car Body


5. Car body accessories



The major components which are used in an automobile are:

1. Engine or power plant (source of power) - converts explosive power of fuel and air mixture into rotating power to drive the automobile.
2. Frame - made of steel members known as a "chassis-frame". It supports the engine, wheels, car body and other component parts.
3. Power train which carries power from the engine to the car wheels. The power train includes the clutch, transmission, drive shaft (propeller shaft), differential, axles and wheels.
4. Steering system - used for changing the direction of the automobile.
5. Brake system is used to stop the automobile.
6. The car body.
7. The car body accessories, which include lights, heater, radio, windshield, wipers, convertible top, raiser and so on.

Chassis Frame or Frame

Chassis: If the frame contains the base components it called as chassis. The components are like Engine, radiator, clutch, gearbox, silencer, road wheels, fuel tank, wirings, differential units, etc..,

Chassis is a French term which is now denotes the whole vehicle except body in case of heavy vehicles. **In case of light vehicles of mono construction, it denotes the whole vehicle except additional fittings in the body.**

Frame

- ✓ High strength structure
- ✓ Support all the parts of vehicle
- ✓ Holds Engine, Transmission, suspension & other parts in position
- ✓ Normally separable from the body
- ✓ Integrated in case of unitized body design

Types of Frame

1. Conventional frame,
2. Semi integral frame;
3. Integral or untidiest frame.

Purpose of frame

- ✓ To Support engine, body, road wheels and transmission assemblies.
- ✓ To withstand the accelerating and braking torque.
- ✓ To accommodate suspension system.
- ✓ To resist Centrifugal force while taking a turn.
- ✓ To withstand bending and twisting stresses due to the fluctuation of rear and front axle.

Constructional Details

Constructed from

- ✓ Usually constructed from steel pressings
- ✓ May be Welded, Riveted or Bolted and Reinforced where necessary

Constructional Details

Frame (is the basic unit)

next

Various components are attached

later

Body is bolted on the frame

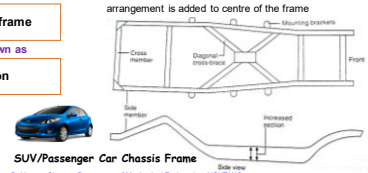
Known as

Frame Construction

Conventional Construction for passenger cars

Two longitudinal members referred as side members:

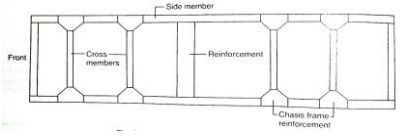
- Must taper in at the front to provide shorter turning radius of front wheel
- Widening out to provide a bigger space for body
- Braced by cross members (horizontal members) at front and rear of the frame.
- To improve Torsional stiffness Diagonal Cross – brace arrangement is added to centre of the frame



SUV/Passenger Car Chassis Frame

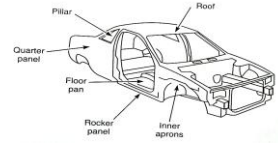
Conventional Construction for Commercial Vehicles

- Capable of carrying heavier and more varied loads.
- Parts of the chassis frame are manufacture from relatively heavy gauge steel plate than those in car's.
- Diagonal cross-bracing is rarely used, Instead
  - A series of channels or tubular sections are welded or riveted to the side members
- In most design the side members are not swept up at front and rear



Unitized or Frameless Construction

- Most of the cars have Frameless Construction
- All members are load carrying members
- Panels or members that share the load are called stressed panels
  - Bends increase strength
- Unstressed panels are those do not contribute significantly to strength
- Complex design that spreads collision forces through out the body to help protect the occupants
- Strength and rigidity achieved by body design rather than having a heavy steel frame
- Low weight and able to style the outer body panels



Types of Chassis

Conventional Chassis

- Engine is fitted in front of the driver cabin or driver seat such as in cars.
- Chassis portion can not be utilized for carrying passengers and goods
- Heavy Engine can be fitted, which can used to give more power

Semi Forward Chassis

- Half portion of the engine is in the driver cabin & and remaining half is outside the cabin such as in Tata trucks / Tempos
- In this arrangement a part of the chassis is utilized for carrying extra passengers

Forward Chassis

- Complete engine is mounted inside the driver cabin; Driver seat is just above the front wheel.
- More boot space available as full utilization of chassis.

Monocoque

The Monocoque chassis frame is a structural design in which the vehicle's body itself serves as the main load-bearing framework. Unlike traditional body-on-frame construction, the monocoque integrates the chassis and body into a single cohesive unit, distributing stress across the entire shell. This design significantly reduces weight while enhancing rigidity, safety, and fuel efficiency. It allows for better crash absorption and improved handling due to its lower center of gravity. Monocoque frames are widely used in passenger cars, crossovers, and modern SUVs, offering a balance of performance, comfort, and structural integrity. Their popularity continues to grow as manufacturers seek lighter, safer, and more efficient vehicle designs.

https://www.carblogindia.com/types-of-chassis-frames-monocoque-vs-ladder/

Disadvantages:

- Limited off-road capability due to stiff, non-flexible structure.
- Reduced agility—components lack independent movement as seen in ladder frames.
- Economical only when produced in large volumes (mass production).
- Less adaptable for rugged terrain or heavy-duty applications.

Ladder Frame Chassis

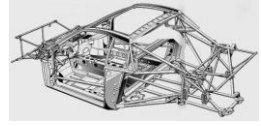
The Ladder Frame Chassis is the second-most popular type of vehicle frame and is especially renowned for its use in off-road-capable SUVs. Its name comes from its resemblance to a ladder, with two longitudinal rails connected by several cross members. This design separates the vehicle's body from the chassis, allowing the body to be mounted on top of the frame. Such separation provides added durability and resistance to torsional stress, making it ideal for rugged terrain. In India, SUVs like the Toyota Fortuner, Ford Endeavour, Mahindra Thar, and Force Gurkha are prime examples of vehicles that utilize ladder frame construction to deliver impressive off-roading performance. These vehicles often feature All-Wheel Drive (AWD) or Four-Wheel Drive (4WD) systems, further enhancing their capability. The ladder frame's robust build and modularity make it a preferred choice for heavy-duty applications, though it comes with its own set of trade-offs.

Advantages and Disadvantage:

- **Multiple body types can be mounted on a single frame.**
- **Independent chassis movement improves suspension travel.**
- **Incredibly agile and flexible.**
- Poor handling due to increased height and separation from the ground.
- Not suitable for lightweight or performance cars.
- Generally a bit expensive.

Tabular Chassis

- Tabular chassis, commonly seen in racing cars, are designed with a cage-like framework made from interconnected tubular pipes.
- These chassis prioritize performance and safety, which is why racing vehicles often have stripped-down interiors to reduce weight and enhance speed.
- The dense network of pipes forms a rigid structure that provides excellent torsional stiffness, improving handling and crash protection.
- This design allows for high customization and is ideal for motorsport applications where strength, agility, and minimal weight are crucial.
- The term "tabular chassis" comes from the prominent use of tubular elements throughout the vehicle's frame.



Advantages and Disadvantage:

- **Due to the dense pipes, the construction is lightweight and more rigid.**
- **Since these are 3 dimensional in nature, the overall safety is higher in comparison to regular monocoque construction.**
- One of the major disadvantages is the lack of practicality.
- One can't use this type of structure for day-to-day cars.

Backbone Chassis

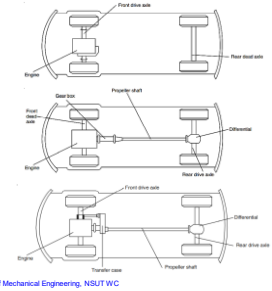
- The Backbone Chassis is a unique and less commonly known type of vehicle frame, characterized by its central spine-like structure.
- It consists of a strong, rectangular cross-sectional tube that connects the front and rear axles, resembling a human backbone. This central tube houses and protects the driveshaft, offering a neat and compact layout.
- The engine and drivetrain are mounted at either end of the backbone, making the design both functional and space-efficient.
- Though it was more prevalent in older vehicles, some modern cars still utilize this chassis for its simplicity and structural integrity. Its design is particularly suited for lightweight vehicles and offers decent protection for mechanical components.

Advantages and Disadvantage:

- **Allows for a better connection of the axles to the ground. This enhances the stability of the car.**
- **In the case of off-roading, the drive shaft is quite safe even if the car hits the ground often.**
- **Rigidity is also higher & can withstand a lot of pressure.**
- *Difficulty in repairing the drive train as the entire backbone has to be opened up.*
- *Manufacturing cost for the backbone chassis is high which makes the car more expensive.*

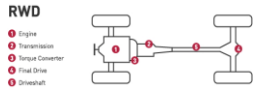
Types of Vehicle Layout Or Chassis Layout

- Front Engine Rear Wheel Drive
- Front Engine Front Wheel Drive
- Rear Engine Rear Wheel Drive
- All Wheel Drive



Front Engine Rear Wheel Drive

A rear-wheel drive system relies on the rear wheels to deliver the power. Commonly found on trucks and performance vehicles, RWD gives needed traction with heavy loads and optimal handling on performance cars. One drawback of rear-wheel drive is reduced traction on slippery roads; this might not be ideal for snowy climates.



Advantages:

- Superior handling.
- Exceptional braking.
- Quick initial acceleration.
- Excellent for performance driving.

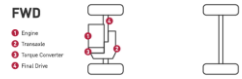
Disadvantages:

- Not ideal for winter weather – poor traction in snow and ice.
- Traction on wet roads not as good as FWD.

https://www.drivparts.com/parts-matter/learning-center/driver-education-and-vehicle-safety/drivetrain-guide.html

Front Engine Front Wheel Drive

The majority of vehicles on the road today are powered by front-wheel drive systems. In this system, the front wheels provide the power. All of the drivetrain components are located in the front of the vehicle which increases traction in the front wheels. Vehicles with front-wheel drive are typically lighter, helping to improve gas mileage.



Advantages:

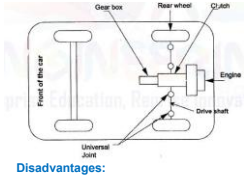
- Fewer parts mean lower purchase price and repair bills.
- Lighter weight helps vehicle achieve better gas mileage.
- Better traction than rear-wheel drive.
- With most of weight over front wheels, it's balanced for traction.
- Less aggressive handling is good for new and cautious drivers.

Disadvantages:

- Not as effective in low-traction situations like gravel and ice
- Nose heavy makes it harder to handle in high speeds or with heavy loads.
- Can cause understeer where front wheels lose traction and car drifts outside of the turn.

Rear Engine Rear Wheel Drive

This arrangement eliminates the necessity for a propeller shaft when the engine is mounted adjacent to driven wheels. The engine-clutch-gearbox-final drive forms a single unit in this layout. In order to reduce the 'overhang' distance between wheel centers and the front side of the engine, the final drive is generally placed between clutch and gear box.



Advantages:

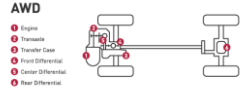
- Short driveline with integrated engine, gearbox, & final drive
- Better traction during hill climbs and acceleration.
- No propeller shaft means a flatter floor and simpler drive shaft design.
- Engine heat, noise, and fumes are kept away from the cabin.
- Front design allows better visibility and aerodynamics

Disadvantages:

- Rear-heavy setup makes the car sensitive to side winds and sharp turns.
- Liquid cooling is harder to manage in rear engine placement.
- Reduced front traction affects control in low-grip conditions.
- Long linkages are needed for engine, clutch, and gearbox operation.

All Wheel Drive

AWD delivers power to all four wheels. Most all-wheel drive systems are always on, using sensors to determine which wheel needs power. However, be aware that systems vary and some all-wheel drive setups stay in two-wheel drive most of the time and only go into all-wheel drive mode when the sensors detect the vehicle is losing traction.



Advantages:

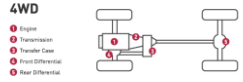
- Better acceleration.
- Improved traction in snow and on wet roads.
- Always on – don't have to think about engaging the system.

Disadvantages:

- More expensive with more parts than FWD and RWD.
- Worse gas mileage due to vehicle being heavier.
- Can cost more to repair than a FWD or RWD vehicle.

Four-wheel drive

A four-wheel drive system features two driveshafts and a transfer case to deliver power to all four wheels. Today's 4WD systems are either full-time or part-time. In a full-time system, the vehicle automatically switches between two-wheel and four-wheel drive while a part-time system requires the driver to manually engage the four-wheel drive system. 4WD shines in heavy snow and off-road situations.



Advantages:

- Excellent for towing trailers or big loads.
- Ideal for serious off-roading, crawling over rocks and moving through mud.
- Powers through deep snow.
- Delivers the traction needed for climbing hills.

Disadvantages:

- More expensive than FWD and RWD due to extra parts.
- Lower gas mileage due to heavier drivetrain system.
- Have to remember to engage it in a part-time system.

Difference Between 4WD (4-Wheel Drive) and AWD (All-Wheel Drive)

Parameters	All-Wheel Drive (AWD)	Four-Wheel Drive (4WD)
Working Principle	Sends power to the front and rear wheels all the time	The driver engages the system to power all four wheels
Power Transmission	Uses a centre differential	Uses a transfer case
Power Delivery	Varies power to each axle as needed without driver input	Sends equal power to the front and rear wheels
Application	Best for SUVs, crossovers, and high-performance vehicles	Ideal for trucks and off-road SUVs
Flexibility	The driver cannot switch between AWD and 2WD	The driver can switch between 4WD and 2WD
Fuel Efficiency	Generally lower	Better than AWD due to manual engagement

When to Choose Front Wheel Drive vs Rear Wheel Drive?

When to opt for 2WD or 4WD?

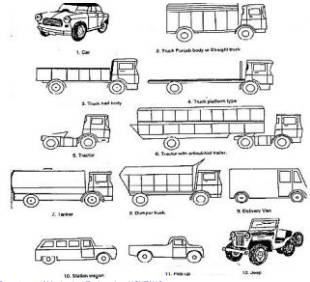
2WD vs 4WD: Key Comparisons

Factor	Two-Wheel Drive (2WD)	Four-Wheel Drive (4WD)
Traction	Powers two wheels only (front or rear). Less traction in poor conditions.	Power all four wheels. Superior traction in off-road and slippery conditions.
Fuel Efficiency	Generally better fuel economy due to lighter weight and less drivetrain loss.	Lower fuel efficiency because of a heavier drivetrain and increased mechanical drag.
Complexity & Cost	Simpler drivetrain, cheaper to manufacture and maintain.	More complex and expensive due to extra drivetrain components.
Driving Conditions	Best suited for city driving, highways, and light off-road use.	Best for off-road, rugged terrains, snow, and poor road conditions.
Weight	Lighter vehicles overall, improving performance and fuel consumption.	Heavier due to additional drivetrain parts.
Handling	FWD offers better traction in wet conditions; RWD provides better handling dynamics.	Enhanced stability and control on slippery and uneven surfaces.
Use Case	Every day commuting, light cargo, urban environments.	Off-roading, towing, heavy-duty applications, and adverse weather.

Body Body is the superstructure of the vehicle and it is bolted to the chassis.

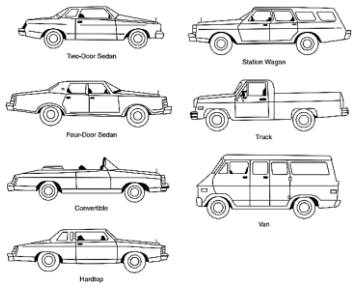
Types

- Car
- Truck
- Tractor
- Delivery van
- Jeep
- Bus, etc..



The main **purpose** of the bodywork is to provide accommodation for the driver and passengers, with suitable protection against wind and weather. The degree of comfort provided depends upon the type of car and its cost.

The body on the first automobiles was little more than a platform with seats attached. It gradually developed into a closed compartment complete with roof and windows. The modern automobile body is constructed of sheet steel formed to the required shape in giant punch presses. Most of the body components are welded together to form a light rattle-free unit.



🚗 Car Type	📄 Description	📌 Examples
Hatchback	Small cars with a rear hatch that opens into a trunk connected to the rear seats. Seats often fold to increase cargo space.	Maruti Suzuki WagonR
Sedan	Also called saloons. Feature a three-box design: engine, passenger cabin, and cargo space. Offer more headroom and a sharper look.	Toyota Corolla Altis
Compact Sedan	Smaller version of a sedan, ideal for tight urban spaces.	Maruti Suzuki Dzire
Sports Car	High-performance, stylish two-seaters with powerful engines and low ground clearance.	Lamborghini Huracan EVO
SUV (Sport Utility Vehicle)	Large passenger vehicles suitable for off-roading. Hatchback-like rear but bigger and more comfortable for long-distance travel.	Toyota Fortuner
Compact SUV	Smaller version of an SUV. Popular for daily use due to balanced size and power.	Maruti Brezza
Crossover	SUV-like vehicles built on a unibody platform. Offer better comfort and fuel economy but less off-road capability.	Maruti Suzuki S-Cross
Convertible/ Cabriolet	Cars with retractable roofs. Stylish but structurally weaker. Often resemble sports cars.	Mercedes-Benz C-Class Cabriolet
Minivan	Personal-use vans, often used by families. Spacious and practical for transporting kids and cargo.	Maruti Suzuki Eeco
Station Wagon	Two-box design with extended cargo space. Less popular today due to SUVs and minivans offering better features.	Baleno Altura
Pickup Truck	Small trucks with a closed cabin and open cargo bed. Common in America for both personal and commercial use.	Tesla Cybertru

Specifications

Technical Details of Various Indian Vehicles

Name of vehicle	Engine: No. of cylinder and arrangement	Engine: Capacity (cc)	Engine: Maximum output	Engine: Maximum torque	Engine: Bore x stroke (mm)	Engine: Compression ratio	Weight (kg)	Fuel tank capacity (litre)
Ambassador (Petrol)	4 in-line	1817	75 HP @ 5000 rpm	13.8 kgm @ 3000 rpm	84 x 82	8.5 : 1	1104	42
Ambassador (Diesel)	4 in-line	1489	36 HP @ 4000 rpm	8.5 kgm @ 2250 rpm	73 x 88.9	23 : 1	1200	54
Fiat (Padmini Premier)	4 in-line	1089	47.5 BHP @ 5000 rpm	8.0 kgm @ 3000 rpm	68 x 75	7.3 : 1	1050	38.25
Maruti 800	3 in-line	796	39.5 BHP @ 5500 rpm	6 kgm @ 3000 rpm	68.5 x 72	8.7 : 1	910	27.165
Maruti Gypsy	4 in-line	970	68 BHP @ 5500 rpm	7.5 kgm @ 3000 rpm	65.5 x 72	8.8 : 1	1450	40
Mahindra Jeep (CJ3B)	4 in-line	2199	72 BHP @ 4000 rpm	15.7 kgm @ 2000 rpm	79.37 x 111.12	7.4 : 1	1043	40
Maruti Zen	4 in-line	993	50 BHP @ 6500 rpm	7.2 kgm @ 4500 rpm	72 x 61	8.8 : 1	910	35

Contd.

Name of vehicle	Transmission: Type	Transmission: Gear box	Steering: Type	Steering: Turning radius (M)	Brakes	Tyre size
Ambassador (Petrol)	Manual	Five speed all synchromesh	Rack & pinion	5.4	Drum on all four wheels	5.90 x 15-6PR
Ambassador (Diesel)	Manual	Four speed synchromesh on 2nd , 3rd and 4th	Rack & pinion	5.4	Drum on all four wheels	5.90 x 15-6 PR
Fiat (Padmini Premier)	Manual	Four speed synchromesh on 2nd , 3rd and 4th	Worm and roller	5.25	Drum on all four wheels	5.20-14
Maruti 800	Manual	Four speed all synchromesh	Rack & pinion	4.4	Disc in front wheels and drum on rear wheels	4.50-12-4 PR 4.50-12-6 PR
Maruti Gypsy	Manual	Four speed all synchromesh	Rack & pinion	5.7	Disc in front wheels and drum on rear wheels	F78 - 15
Mahindra Jeep (CJ3B)	Manual	Three speed synchromesh on 2nd, and top	Worm and roller	5.3	Drum on all four wheels	6.00-16

Contd.

Maruti Esteem	Manual	5 speed all synchromesh, 1 reverse	Rack and Pinion	4.8	Booster assisted ventilated disc in front wheels and booster assisted drum on rear wheels	155/80 R13
	Automatic	3 speed automatic, 1 reverse				
Maruti Wagon R	Manual	5 speed all synchromesh	Electronic power steering	4.6	Booster assisted disc in front	145/70 R13
		with two overdrive gears			wheels and booster assisted drum on rear wheels.	
	Automatic	3 speed				
Maruti Alto (LX, VX 1.1)	Manual	5 speed all synchromesh	Power steering	4.6	Booster assisted disc in front wheels and booster assisted drum on rear wheels.	145/80 R12
Maruti Baleno	Manual	5 speed all synchromesh 1 reverse	Rack and pinion with hydraulic power assisted	4.9	Ventilated disc in front wheels and drum on rear wheels	165/80 R13

Contd.

MANUFACTURERS OF MOTOR VEHICLES IN INDIA

In India we have the following vehicles and engines being manufactured at present.

1. Passenger Cars

1. Premier Automobiles Ltd., Bombay	Fiat, NE 118, Peugeot 309
2. Hindustan Motors Ltd., Calcutta	Ambassador, Contessa
3. Maruti Udog Ltd., Gurgaon	Maruti 800, Omni 800, Gypsy, Maruti 1000 cc, Maruti Zen, Maruti Esteem
4. Standards Motor Products of India Ltd., Madras	Standard 1000, Standard 2000
5. Mahindra & Mahindra Ltd., Bombay	Jeep Universal (Petrol & Diesel)
6. Telco, Poona	Indica (Petrol & Diesel)
7. Hyundai Motor India Ltd.	Santro (Petrol & Diesel)

2. Commercial Vehicles (Light Duty Vehicles)

1. Allwyn Nissan	Cabstar
2. Hindustan Motors Ltd., Calcutta	Trekkar Petrol and Diesel and 1 ton portor
3. Bajaj Tempo Ltd., Poona	Tempo Janseat-3 wheels & Tempo Viking & Matador- 4wheels.
4. DCM Toyota	DCM Toyota Dyna
5. Swaraj Mazda	T-3500
6. Standard Motors, Madras	Standard-20 Commercial vehicle
7. Premier Automobiles Ltd., Bombay	LD-170 N
8. Mahindra &Mahindra Ltd., Bombay	FC-160 P(Petrol), FJ 460 D (Diesel)& NC 665 DP(Diesel)

3. Heavy Duty Vehicles

1. Tata, Engg. Locomotive Jamshedpur	Tata Trucks & Buses in the range of 5 to 9 tonnes and Co., 3- axle 10 tonnes Dumpers.
2. Ashok Leyland Ltd., Madras	Comet Bus & Trucks and Beaver Hipod Jump Trucks in the range of 5 to 16-tonnes.
3. Hindustan Motors Ltd., Calcutta	Hindustan Truck and Buses in the range of 5, 7 ½ and 12 tonnes.
4. Premier Automobiles Ltd., Bombay	Dodge and Fargo Trucks and buses

4. Motor Cycles and Scooters

1. Enfield India Ltd., Madras	Bullet 350 cc Mini Bullet 198 cc
2. Ideal Jawa (India) Pvt. Ltd., Mysore	Yezdi 250 cc and colt 60 cc.
3. Escorts Ltd., Faridabad	Rajdoot 350 cc, 175 cc and Yamaha Rx 100.
4. Hero-Honda	Hero-Honda (CD-100)
5. TVS-Suzuki, Madras	TVS-Suzuki AX 100
6. Bajaj Auto Ltd., Bombay	Bajaj 150 cc., Bajaj Chetak, Bajaj Super, KB-700

5. Tractors and Three Wheelers

1. Eicher Tractors Ltd., Faridabad	Eicher Tractors
2. Escorts Ltd., Faridabad	Escorts 3036,3350 and Junior Escorts
3. Escorts Tractors Ltd., New Delhi	Ford Tractors 3600

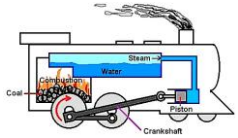
Engine: Types and Construction

An internal combustion engine is the source of 'power' in an automobile (engine is the heart of an automobile). The engines used in automobiles must be light in weight and their fuel consumption must be minimum. These are the two main considerations which have led engineers to develop various types of automobile engines.

An engine is a machine designed to convert one form of energy into mechanical energy. Heat engines burn a fuel to create heat which is then used to do work. The engine has two types one is the internal combustion engine and another one is external combustion engine.

- The internal combustion engine is those heat engines that burn their fuel inside the engine cylinder.
- External combustion engines are those heat engine that burns their fuel outside the cylinder engine.

Internal Combustion Engine



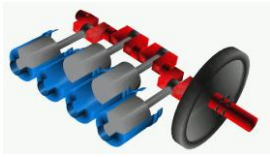
External Combustion Engines

Classification of Automobile Engines

1. Number of Cylinders

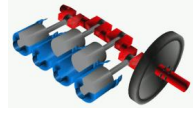
An engine may be a single-cylinder engine or a multi-cylinder engine. In a single-cylinder engine there is only one cylinder, whereas in a multi-cylinder engine there are more than one cylinders. The pistons of all the cylinders are connected to the common crankshaft. Therefore engines may be:

- Single-cylinder Cylinder may be vertical or horizontal
- Multi-cylinder Cylinders may be vertical or inclined to vertical plane.



2. Cylinder Arrangement

(i) In-line Cylinder Engine: The in-Line cylinder engine is a multi-cylinder engine, with all the cylinders arranged in one straight line. Each cylinder has an independent crank.

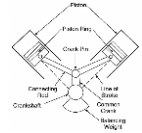


Advantages inline engine

- ✓ Design of engine block simple, cheaper.
- ✓ Running of four-cylinder inline engine is smoother than the one or two cylinder engines.
- ✓ Inline engine design does not need heavy counterweights.

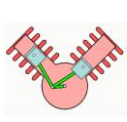
Why inline engine arrangement not popular for high power cars?

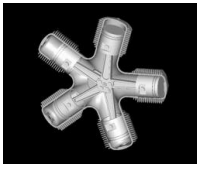
Because of simplicity, inline engine is popular in economy cars. However, it suffers secondary imbalance and causes minor vibration in the smaller engine. This vibration also increases as the size and power increases. For this reason, the powerful engine does not adopt inline arrangement



(ii) V Cylinder Engine or V Engine: The V cylinder engine has two cylinders inclined at 90° to each other. The connecting rods are connected to a common crank pin. There is a common crank for both cylinders. This arrangement reduces the overall engine length, height and weight compared to the equivalent inline arrangement. The angle between two cylinder banks is known as bank angle.

In narrow bank angle V engines, cylinders are combined into a single cylinder block. Engine with more than six cylinder usually adopts this cylinder arrangement. Most high powered automobile use eight cylinder v engine (four engine is in inline on each side of V).

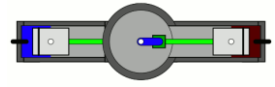




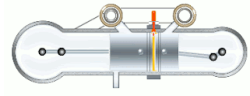
(iii) Radial Engine: In a radial engine, the cylinders arranged in equally spaced around the one crankshaft (i.e. the cylinders are arranged radially in a circle).

- Pistons of these cylinders are coupled to the same crankshaft.
- The radial arrangement is widely used in large air crafts until gas turbine engines became predominant.
- In air cooled aircraft engine with 3, 5, 7 or 9 cylinders are used radial arrangement.
- For the higher capacity of engine multi-row radial engine is used.

(iv) Opposed cylinder engine/ Flat engine/ Boxer engine: In this type of arrangement two cylinder banks (or two inline-engines) in the same plane but opposite side of the crankshaft. One of the advantages of an opposed cylinder engine is that it inherently well balanced. The type of engine arrangement found application in small aircraft.

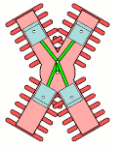


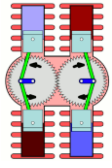
(v) Opposed piston engine: In this type of arrangement, single engine cylinder houses two piston and has no cylinder head. Each piston drives two separate crankshafts. The movement of piston made synchronised by coupling this two crankshaft. The type engine usually working on the principle of two-stroke engine. The advantages opposed piston includes, it get rid heavy cylinder head, and it is a well balanced arrangement. The opposed piston engine is used in large diesel plants.



(vi) Delta type engine/ Napier Deltic engine: It is a combination of three opposed piston engine. The piston of this engine is coupled to three interlinked crankshafts.

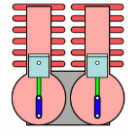
(vii) X engine: This is a variation of V type with four banks of cylinder attached to the single crankshaft. This twinned V block engine has four banks and appeared as X shape. X type arrangement is extremely uncommon because of its complexity and weight.



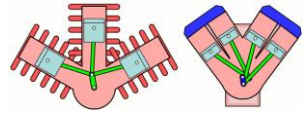


(viii) H engine: In this type two opposed cylinder type is connected to two separate but interconnected crankshaft. It shows excellent mechanical balance.

(ix) U type engine: In u type engine, two separate straight engine joined by using gears or chains. It appears in the shape of U. This cylinder arrangement is uncommon as it is heavier than the similar V engine.



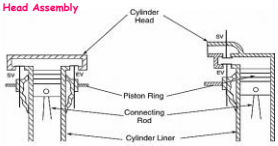
(x) W engine: It is similar to V engine but it has three or four cylinder bank engine banks.



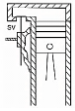
3. Valve Arrangement in Cylinder Head Assembly

(i) T-head Engine: the suction valve (SV) and the exhaust valve (EV) are on the cylinder block in opposite directions.

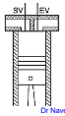
(iii) L-head Engine: the suction and exhaust valves are arranged side by side in the cylinder block.

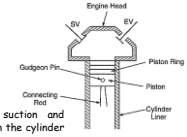


(ii) F-head Engine: one valve is in the cylinder block and the other valve is in the cylinder head.



(iv) I-head Engine: the suction and exhaust valves are arranged in the cylinder head as shown in Figure.



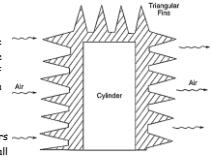


(v) Overhead Engine: the suction and exhaust valves are arranged in the cylinder head having a hemispherical shape.

4. Cooling Method

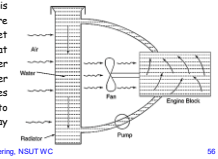
(i) Air-cooled Engines:

Air-cooled engines have fins to radiate heat into the surrounding air. The fins are made triangular in shape as they increase the cooling surface area. These fins are made of aluminium, which is a good conductor of heat. Air-cooled engines run at higher temperatures because air is not a good conductor of heat.



(ii) Water-cooled Engines

require circulation of water and fitted with radiators. Radiator offers resistance to the flow of air through the passages in between the small diameter tubes carrying hot water. Therefore, an induced draught fan is provided at the back of the radiator. This fan creates the pressure difference required to get an increased flow of air. Similarly, to get pressure difference and to overcome the resistance in the water flow at the jackets of the engine, a water pump is provided which draws water from the radiator and forces it into the water jacket of the engine. Water is not allowed to rise to a higher temperature, as at higher temperatures scale formation takes place. Scale formation causes local heating due to poor cooling as scales are bad conductor of heat. Such local heating may lead to detonation, which may damage engine parts.



5. Fuel Used

(i) Gasoline Engine: In the gasoline engine, gasoline (petrol) is used as fuel. A mixture of gasoline and air is prepared outside the cylinder and an electric spark plug is used to initiate combustion of the compressed charge.

(ii) Diesel Engine: The diesel engine utilizes a compressed mixture of air and diesel prepared inside the cylinder as fuel. The heat of compression is utilized to initiate combustion of the mixture.

(iii) Gas Engine: Combustible gases are used as fuel. These engines are not commonly used in automobiles.

6. Thermodynamic Cycles

Engines may be classified as following based on the thermodynamic cycle used:

(i) Constant volume combustion cycle engine, which is also called Otto cycle engine.

(ii) Constant pressure combustion cycle engine, which is also called Diesel cycle engine.

(iii) Mixed cycle engine which has partial combustion at constant volume and partial combustion at constant pressure.

7. Mechanical Cycles

(i) Two-stroke Cycle Engine: The two-stroke engine its completes thermodynamic cycle in two strokes of the piston (one revolution of the crank).

(ii) Four-stroke Cycle Engine: The engine which completes its thermodynamic cycle in four strokes of the piston (two revolutions of the crank) is a four-stroke cycle engine.

8. Ignition System

(i) Spark Ignition Engine: A spark ignition engine is either a gasoline engine or a gas engine. The electrical energy required to produce spark in the spark plug is obtained either from a battery or a magneto.

(ii) Compression Ignition Engine: Compression ignition engines are diesel engines in which air is highly compressed to raise its temperature and initiate combustion when diesel fuel is injected.

9. Lubrication Systems

Three systems for lubricating the moving engine parts are used:

(i) Petrol lubrication system

(ii) Wet sump lubrication system

(iii) Dry sump lubrication system

Petrol lubrication system is also known as mist lubrication system. This system is used in two-stroke cycle gasoline engines. The wet sump lubrication system is of two types: splash lubrication and pressure lubrication system. These systems are used in four-stroke cycle automobile engines. Dry sump lubrication system is used in heavy-duty engines.

Use of Engines

1. Two-stroke cycle gasoline engines with petrol lubrication are used in light duty automobiles like mopeds, scooters etc.

2. Two-stroke cycle diesel engines with pressure lubrication are used in medium duty automobiles like tempos etc.

3. Four-stroke cycle gasoline and diesel engines with splash and pressure lubrication are used in heavy duty automobiles like trucks, buses, delivery vans etc.

4. Cars are provided with four-stroke gasoline engines with splash and pressure lubrication systems.

5. The inline engine is vertical, i.e. the stroke of the pistons is vertical. Such inline vertical engines are used in cars, buses, trucks etc.

6. V-engines have cylinders at 90° and are used in heavy duty motor cycles, which are designed for long run.

7. Single-cylinder horizontal engines are used in scooters and mopeds. This engine is so located that the cylinder head is towards the front of the scooter or moped.

Advantages of a Multi-cylinder Engine for the Same Power

If a single cylinder and a multi-cylinder engine develop the same power, then it indicates that their stroke volumes (swept volumes) are also the same. For the same crank speed and the same piston stroke, the single cylinder engine has a larger cylinder bore. A larger cylinder bore leads to two disadvantages:

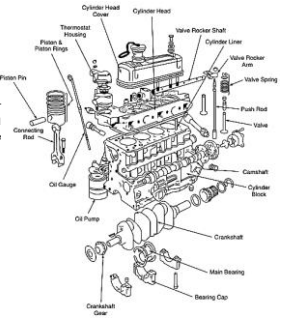
- Poor cooling of the cylinder walls.
- Increased vibrations and stresses. The weight of the piston in the single cylinder engine increases primary and secondary forces on the engine bearings. These forces are not balanced and cause vibrations.

Therefore, the advantages of a multi-cylinder engine are:

- Reduced Temperature stresses, as the multi-cylinder engine has more cooling surface area due to smaller cylinder bore.
- Significantly reduced intensity of vibration, as the primary and secondary forces are balanced.

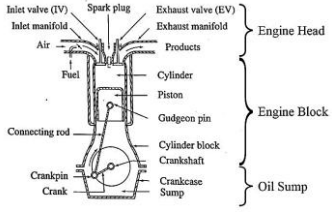
Engine Construction

The reliability of an automobile engine depends on the proper construction of the engine components. The constructional details depend on the stresses and the function of the components.



The main car engine parts are as follows:

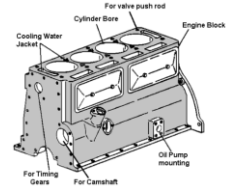
1. Cylinder lock
2. Cylinder Head
3. Crank Case
4. Oil Pan
5. Manifolds
6. Gasket
7. Cylinder Liner
8. Piston
9. A Piston Ring
10. Connecting Rod
11. Piston Pin
12. Crank Shaft
13. CamShaft
14. Flywheels
15. Engine Valves
    1. Poppet valve, 2. Sleeve valve, 3. Rotary valve



1. Cylinder Block

A cylinder block consists of three parts:

1. The cylinder in which the piston slid up and down.
2. The port or opening for the valves.
3. The passages for the flow of cooling water.

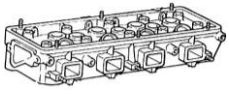


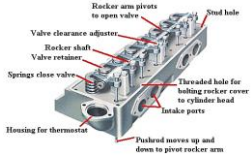
Construction and Working:

- The cylinder block is usually made of grey cast iron or aluminium and its alloys.
- Forms the middle portion of the engine, on its lower end crank case is located and on its upper end the cylinder head is located.
- Passages are provided in the cylinder walls for the circulation of cooling water.
- Mating surfaces of the block are carefully machined to provide a perfect sealing surface.
- Cylinder block also carries lubrication oil to various components through drilled passages called oil galleries.

2. Cylinder Head

- It is usually made up of cast iron and aluminium alloy.
- The top of the cylinder is covered by a separate cast piece know as the cylinder head.
- The cylinder head is attached to the cylinder block by means of studs fixed to the block gaskets are used to provide a tight, leak-proof joint between the head and block.
- Cylinder head contains a combustion chamber above each cylinder. It also contains valve guides, valve seats, ports, coolant jackets and threaded holes for spark plugs. It incorporates passages for the flow of cooling water.





Applications

- The cylinder head casts integrally with cylinder blocks also be done in a few cases usually in racing cars to obtain a gas-tight joint.
- The detachable head types are more advantages than integral construction.
- However, for certain heavy-duty engine requires high cooling rates such as in racing cars copper alloys may be used.

Types of Cylinder Head

Depending upon the valve and port layout, the cylinder head may be classified into three types as follows:

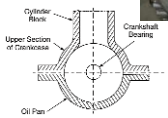
o **Loop flow type:** In the loop, flow types the inlet and the exhaust manifolds are on the same side, which facilitates preheating of the intake air.

o **Offset cross flow type:** Offset cross flow types the inlet and the exhaust manifolds are placed on different sides of the cylinder head.

o **In line cross flow type:** In line cross-flow type, the valve is positioned transversely and usually inclined to each other, while the inlet and the exhaust manifolds are on different sides of the cylinder head. This arrangement gives better performance, but it is costlier.

3. Crankcase

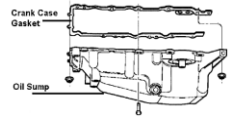
- supports the cylinders and the crankshaft and is an important structure in the IC engine.
- functions like a housing and protects the engine parts against dust, water and splashing mud.
- stores lubricating oil required for lubricating the engine parts.
- Size of a crankcase is sufficiently large as it accommodates the revolving crankshaft with the connecting rod. Various accessories like carburettor, fuel pump, generator, water pump, air cleaner, starting motor, fan, oil filter, oil body of cooler, etc. are also mounted on the crankcase. It not only gives support to engine parts & engine mountings, but also withstands the loads caused by piston thrust, gas pressure, primary and secondary forces and couples, etc.



- Therefore the crankcase must be strong to withstand these loads and pressures.
- When the cylinder block and the crankcase are cast together in one unit, grey cast iron is used because it has rigidity, low cost and high wear resistance.
- Aluminium alloy is the most suitable material for crankcase due to its light weight & has good thermal conductivity.
- A crankcase is usually divided into an upper and a lower section. The lower section is known as the 'oil pan' and acts as a reservoir for the storage of lubricating oil. For cooling the lubricating oil, fins or ribs are provided on the outside of the oil pan. These fins also increase the strength of the oil pan.

4. Oil Pan

The bottom half of the crankcase is called the oil pan or sump. It is attached to the crankcase through set screws and with a gasket to make the joint leak proof. The oil pan serves as a reservoir for the storage, cooling and ventilation of engine lubricating oil.



At the bottom of the oil sump, a drain plug is provided to drain out the dirty oil at the time of oil replacement. Generally, the sump is made of pressed steel sheet or aluminium alloy casting is used.

The various functions of the oil pan as follows

- To store the oil for the engine lubrication system.
- Oil pan used to collect the return oil draining
- To serve as a container for impurities or foreign matters
- Oil pan provides for cooling of the hot oil in the sump.

5. Manifolds

- There are separate sets of pipes attached to the cylinder head which carry the air-fuel mixture and the exhaust gases, these are called manifolds.
- It is generally made of cast iron so that it is able to withstand the high temperature of the exhaust gases.

Construction

- It consists of the air intake, throttle body, intake manifold flange for tail-pipe and flange for a carburettor.

Working

- The air goes into the air intake travels through, throttle body into the intake manifold and from there it goes into the engine through the cylinder head.
- The inlet manifold carries the air-fuel mixture from the carburettor to the cylinders.
- The exhaust manifold is the set of pipes carrying exhaust gases from the cylinder head to the exhaust system.

6. Gaskets

Gasket is a piece of soft sheet or spongy sheet having similar holes and cuts as in the cylinder head and cylinder block so that the packing (gasket) placed between the cylinder block and cylinder head does not interfere with the flow of gases or water or bolts passed. The gasket prevents leakages and ensures tight fit joints. Sealing action is provided by the elastic deformation of the gasket material. The material of the gasket must be able to withstand high pressure and temperature.

Materials used for gaskets are: Cork, Asbestos, Rubber

Requirement/properties of the gasket as follows

- **Conformity:** gaskets should conform to the mating surfaces which may have roughness.
- **Resistance:** It should have resistance to high pressures, extreme temperature and vibrations.
- **Impermeability:** The gasket must be impermeable to the fluid.
- **Resistance to chemical attack:** the gasket should have resistant to the chemicals such as fuel, products of combustion, coolant and engine oil.
- **Provision of apertures:** The gasket must have apertures for any studs, bolts, opening etc.,

Types of Gaskets

The types of gaskets which are frequently used in automobile engines are:

1. Copper-asbestos Gasket: In the copper-asbestos gasket, asbestos sheet is covered by thin copper plates on both sides so that the asbestos remains in combined form.

2. Steel-asbestos Gasket: The steel-asbestos gasket has thin steel sheets on both sides covering the asbestos sheet.

3. Single Sheet Rigid or Corrugated Gasket: Only a single sheet or corrugated sheet of soft metal like copper or lead, etc. is used in the single sheet rigid or corrugated gasket.

4. Stainless Steel Gasket: In the stainless steel gasket a thin sheet of stainless steel is used. These gaskets are used as cylinder head gaskets between the cylinder block and the cylinder head. Usually, these gaskets are coated with a special varnish, which melts and seals the leakages when the cylinder head is hot.

5. Cork Gasket: The cork gasket is used for the oil pan in the crankcase and rocker cover where high pressure on the gasket is not needed.

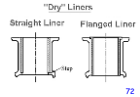
6. Rubber Gasket: The rubber gasket is also used in place of the cork gasket in the crankcase holes.

7. Cylinder Liners

- These are cylindrical shapes used in the cylinders to avoid the problem of cylinder wear. It is one of the most important functional parts to make up the interior of an engine.
- These can be replaced after they are worn out. These are made of special alloy iron containing silicon, manganese, nickel and chromium.
- Usually, these are cast centrifugally. These liners resistance to wear and corrosion. These liners are of the oil hardening type and offer considerably longer life for the engine.
- Cylinder liners are of two types: **Dry liners and wet liners.**

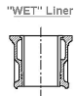
Dry liners:

✓ This liner is made in the shape of a barrel with a flange at the top which keeps it into position. The entire outer surface bears against the cylinder block casting and hence these can be machined accurately at both outer and inner faces.



✓ The liner should not be too loose, otherwise, the heat dissipation becomes poor because of the absence of good contact with the cylinder block.

Wet liners:



✓ These liners will be in direct contact with the cooling water at their outer face.

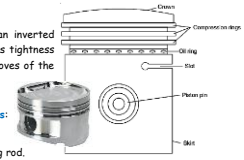
✓ These liners need not be machined very accurately at the outer surface. However, they have been machined accurately at the inner surface.

✓ They are resisting corrosion with continuous contact with cooling water, and they coated with aluminium at their outer surface.

Construction

- At the top, the liner is provided with a flange which fits into the groove in the cylinder block.
- At the bottom of the liner is provided with a groove, generally three in number.
- The middle groove is left empty for drainage for any water that may leak from the upper ring.
- And in the top and bottom ones are inserted packing ring, made of synthetic rubber.

8. Pistons



A piston of an internal combustion engine is in the form of an inverted bucket shape and it is free to slide in the cylinder barrel. The gas tightness is secured by means of flexible piston rings, which are in the grooves of the piston. These grooves are cut in the upper part of the piston.

A piston of an internal combustion engine serves three functions:

1. It forms a moveable wall of the combustion chamber.
2. It transmits turning force to the crankshaft via the connecting rod.
3. It functions like a crosshead and transmits side thrust, which is due to the angularity of the connecting rods, to the cylinder walls.

The piston must possess the following qualities:

1. It must be strong enough to withstand high pressure caused due to the combustion of fuel.
2. It must be very light in weight to have minimum primary and secondary forces, which are caused due to the inertia forces of the reciprocating masses. A light piston permits higher speed of the crank.
3. The piston material must be a good conductor of heat so that detonation is suppressed, and higher compression ratio is possible to get fuel economy.

Apart from the qualities mentioned previously, the piston must meet the following requirements:

1. The piston operation must not be noisy.
2. The piston must be of less coefficient of expansion.

Constructional Features

— The top of the piston is called the head or crown. Towards the top of the piston, a few grooves are cut to house the piston rings. The bands left between the grooves are known as lands.

— The part of the piston below the ring is called Skirt is provided with bosses on the inside to support the piston pin (Gudgeon pin).

— The distance between the axis of the piston pin and the top of the piston crown is called compression height.

Type of pistons: Various **types of pistons** are classified depending on the shape, design, operation.

1. Cast Iron Pistons
2. Forged pistons
3. Cast Steel Piston
4. BI-metal piston
5. Two-piece piston
6. Oil-cooled pistons
7. Anodized piston
8. Tinned pistons

Piston materials: Cast Iron, Aluminium, Lo-Ex Alloy, Invar, Steel alloy.
Protective coating: Cadmium plating, Anodized pistons, Tinned pistons, Chromium plating.

9. Piston Rings

— The piston rings are fitted into the grooves of the piston to maintain a good seal between the piston and the cylinder wall.

— The number of piston rings used is about 2 to 4 compression rings and 1 to 2 oil control ring was used but in modern design the number if rings usually three out of which one is the oil control ring.

The function of piston rings

- To form a seal for the high pressures gases from the combustion chamber entering into the crankcase.
- The piston ring provides easy passage for heat flow from the piston crown to the cylinder walls.
- To maintain sufficient lubrication oil on cylinder walls throughout the entire length the piston travel, hence it minimizes the cylinder wear.

Construction:

— The ring is generally cast individually and machined carefully so that when in the position it is able to exert uniform pressure against the cylinder walls.

— A gap has been cut at the end.

— In practice, the piston ring end gap when installed is kept about 0.30 to 0.35mm.

— The gap is almost closed when the piston is inside the cylinder, so that piston and cylinder.

Material for piston rings:

The material generally used for piston rings is

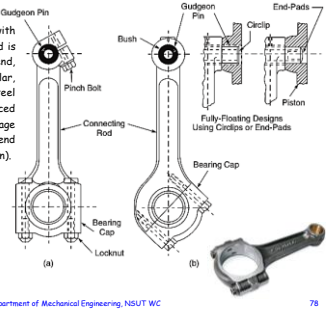
- Fine-grained alloy cast iron containing silicon and manganese. It has good heat and wears resisting qualities.

Chromium plated rings are also used for the top ring, which is subjected to the highest working temperatures and the corrosive action of the combustion products.

Types of Piston Rings:

- **Compression rings:**
  - Compression rings effectively seal the compression pressure and the leakage of the combustion gasses. these are fitted in the top grooves. They also transfer heat from the piston to the cylinder walls.
- **Oil control rings:**
  - The main purpose of the oil ring is to scrape the excess oil from the liner and return it back to the oil sump during the downward and upward movement of the piston.
  - It prevents the oil from reaching the combustion chamber. One of two oil control rings is used in a piston. If two rings are used one has fitted above and other is fitted below the gudgeon pin in the piston
  - These rings are provided with drain holes or slots. these slots allow the scraped oil to reach into the oil sump through the piston holes.

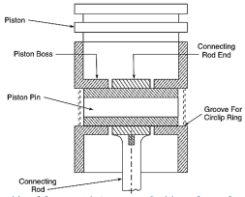
10. Connecting Rod



As the name indicates it connects the piston with crankshaft. Its one end holds the piston pin and is known as small end. Other end, known as big end, holds the crank pin. It may have circular, rectangular, I, T or even H section. It is a steel forging and is highly polished for enhanced endurance strength. It is provided with a passage for transferring lubricating oil from the big end bearing (crank pin) to small end bearing (piston pin).

- Main function of the connecting rod is to convert the reciprocating motion of the piston into the rotary motion of crankshaft.
- It must be light and strong enough to withstand stress and twisting forces.

11. Piston Pin



A piston pin is also known as a wrist pin because of its similc construction with human hand and arm joint. A piston pin is a l connecting the piston and the connecting rods. Since the pis reciprocates with the piston, its weight is minimized by making it so that inertia forces at piston TDC are decreased. The pistor fitted in the basses which are in the piston. The small end connecting rod is accommodated in between the piston bosses.

Piston pins are made of casehardening steel, either plain carbon steel, nickel steel or chrome-nickel steel. The pins are designed to work as bearing journals.

Assembly of Piston and Connecting Rod by a Piston Pin

In the figure the piston pin is in a floating state and its axial movement is restricted by fitting snap rings or circlip rings, which are inserted in the grooves made at the entrance of the piston boss. The ends of the circlip ring are pressed and inserted in the piston boss, and then released in the groove made for this ring.

Circlip Ring

Mainly there are three types of piston pins as follows.

a) Set screw types piston pin.
b) Semi-floating piston pin
c) Fully floating piston pin

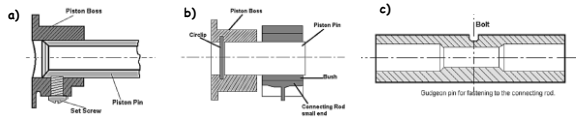


Fig (a) shown Set screw type piston pin, This pin is fastened to the piston to the piston by a SET SCREW such that the connecting rod end swivel has required by the combined reciprocating and rotary motion of the piston and crankshaft.

Fig (b) shown the Semi-floating piston pin, It is fastened to the connecting rod with a clamp screw.

Fig (c) shown Fully floating piston pin. The pin floats in both the piston bosses and the small end of connecting rod. It is prevented from coming in contact with the cylinder wall by two circlips.

12. Crankshaft

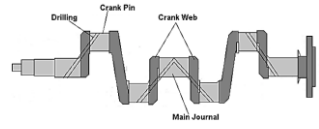
- The crankshaft is the engine component from which the power is taken. It is one of the main power transmission sources in all engine parts.
- The Crankshaft is the first part of the power transmission system in which the reciprocating motion of the piston is converted into the rotating motion with the help of connecting rod.

Construction

- **The crankshaft** is made of casting or forging of heat treated alloy steel and is machined.
- A crankshaft consists of crankpins, weds, balancing weight and main journals and oil holes.
- Big end of the connecting rod is connected to the crankpin of crankshaft.
- Centre to centre distance between the crankpin and crankshaft is hal of the piston displacement during the stroke.
- One complete revolution of crankshaft makes two strokes of piston.

- The parts of the crankshaft inside the main bearing are called main journals.
  - Balancing weights are provided on the opposite side wed for balancing. The crankshaft has drilled oil passages through which oil flow the main bearing to the connecting rod bearings.
- The front end of the crankshaft carries three devices that
  - **A gear** that drives the camshaft,
  - **The vibration damper** to control torsional vibration, and
  - **The fan belt pulley:** This pulley drives the engine fan, water pump, and generator with a V-belt.
- The rear end of the crankshaft carries flywheel. The flywheel tends to keep the crankshaft running at constant.

Next, to the rear end, the main journal and oil seal is fitted. In some engine, oil return threads are provided which return the lubricating oil to the sump.



The crankshafts are generally of two types,

- **In one piece type**, all the parts are integral and are formed by drop forging and then machining.
- **In build-up type**, the crankpins and journals are fastened to the crank webs.

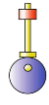
13. Cam Shaft

A camshaft is a shaft on which cams are mounted. A cam is a device that changes the rotary motion of the camshaft into the linear motion of the follower. A camshaft is responsible for the opening of the valves.

Construction:

- A camshaft has a number of cams along the length, two cams for each cylinder, one to operate the inlet valve and the other the exhaust valve.
- In addition, the camshaft has an eccentric to operate the fuel pump and gear to drive the ignition distributor and oil pump.
- The camshaft is driven by the crankshaft. The camshaft gear has twice as many teeth as the gear on the crankshaft.
- Camshaft made from forged alloy steel.

This gives 1:2 gear ratio, the camshaft turns at half the speed of the crankshaft.



Working

- Thus, every two revolutions of the crankshaft produce one revolution of the camshaft and one opening and closing of each valve, in the four-cylinder engine.
- Thus there is correct opening and closing of the valves takes in relation to the position of the piston in the cylinder.

There are three types of camshaft drive mechanism as follows,

- Gear drive.
- Chain drive.
- Belt drive.

The function of a camshaft is dependent on how a valve works and the function of the cam itself. A valve on a cylinder head consists of two basic parts, a stem and a head (see Figure). The head plugs the nozzle that allows fuel intake or exhaust flow and requires linear motion. A cam, in its simplest definition, is a mechanical link that converts rotational motion into linear motion, or vice versa. The cams on a camshaft achieve this displacement by the rotation of a radial pattern, and a follower which moves perpendicular to the rotational axis. The cam pattern on a camshaft is non-circular with a single lobe. The follower matches the displacement of the cam as it rotates. This displacement is then translated to the stem of the valve, allowing head to rise as the lobes of the cam pass through the follower

14. Flywheel

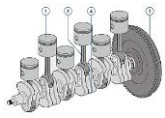
The flywheel used in a transmission system of a vehicle.

Construction:

- A flywheel is a heavy steel wheel attached to the rear end of the crankshaft.
- The size of the flywheel depends upon the number of cylinders and the construction of the engine.

Working

- During the power stroke, the engine tends to speed up and during the other strokes, it tends to slow down.
- The inertia of the flywheel tends to keep the running of the crankshaft at a constant speed. Hence the engine speed is maintained constant.



15. Engine Valves

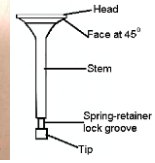
Engine valves are essential to control the timing of air-fuel mixture entry into the cylinder and combustion products out of the cylinders.

Construction:

- These are located at the inlet and outlet opening of the engine cylinder.
- The valves fit on the valve seats in their closed position.

There are three types of engine valves as follows,

1. Poppet valve
2. Sleeve valve
3. Rotary valve



Poppet Valve

This is the most widely used valve in automobile engines. The poppet valve is given the name because of its motion of popping up and down. Its construction is very simple. This is also called a mushroom valve, because of its shape.

Construction:

- It consists of a head and a stem. The valve face usually with an angle of 30° to 45° is ground perfectly, since it has to match with the valve seat for perfect sealing.
- The stem has a spring retainer lock groove and the stem end is in contact with cam for up and down movements of the valve.

Sleeve Valve

The sleeve valve as the name implies, that it is a tube or sleeve kept between the cylinder wall and the piston.

Construction

- The inner surface of the sleeve actually forms the inner cylinder barrel in which the piston slides.

The sleeve is in continuous motion and admits and drives out the gases by virtue of the periodic coincidence of port cut in the sleeve with ports formed through the main cylinder casting.

Advantages:

1. Simple in construction.
2. Sleeve valves are silent in operation.
3. There is noise because there is no noise-making parts like valve cams, racker arm, tappets valves etc.,
4. The tendency of detonation is less.
5. Cooling is very effective as the valve is in contact with water jackets.

Disadvantages:

1. High oil consumption for lubrication as a larger area of sleeve surface to be lubricated.
2. Cleaning of the ports and the valve is complicated.

Rotary Valve

There are many types of rotary valves. The figure shows the disc type rotary valve. It consists of a rotating disc which has a port. While rotating, it communicates s alternately with the inlet and exhaust manifolds.

Advantages:

1. Rotary valves are simple in construction.
2. These valves are manufactured at cheaper costs.
3. They are suitable for high-speed engines.
4. Stresses and vibrations are less compared to poppet and sleeve valves.
5. They are smooth in operation and are uniform and noise-free operation.

Disadvantages:

1. It is difficulties in pressure sealing between the rotary disc and cylinder.
2. Efficient valve lubrication is difficult.

Valve Material: Silico-Chrome steel for inlet valves. Molybdenum as added to Silico-Chrome for exhaust valves. The recent materials for exhaust valve are austenite steel and precipitation hardening steel is generally used.

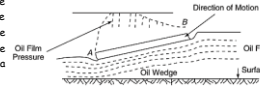
Lubrication System

Lubrication is the action of applying a substance such as oil or grease to an engine or component so as to minimize friction and allow smooth movement.

Mechanism of Lubrication

Figure shows an inclined surface AB and a stationary surface which is horizontal. Both these surfaces are separated by a lubricant. If the inclined surface AB is moved, then the layers of the lubricant are compressed at the corner A of the surface where the sectional area is less. Thus a wedge is built up and the molecules of the lubricant (fluid) cannot escape from this wedge in a short time. This results in developing a fluid pressure under the inclined surface AB. This fluid pressure sustains load on the inclined surface AB.

If the surfaces are not inclined to each other and are parallel, or the inclined surfaces do not have relative motion, the fluid pressure could not be developed and the load on the surface AB could not be supported by the lubricant. This indicates that it is essential to build up a wedge to sustain load on the moving surface.



The fluid pressure developed under the surface AB due to the wedge action of the fluid is known as hydrostatic pressure and it is influenced by the following factors:

1. **Relative velocity of the surfaces:** Higher relative velocity increases hydrostatic pressure.
2. **Viscosity of the lubricant:** Higher viscosity of the lubricant increases hydrostatic pressure.
3. **Geometric configuration of surfaces:** Plain surfaces develop a greater hydrostatic pressure.

Purpose of Lubricating Oil

A lubricating oil performs the following functions:

- Lubricating oil **reduce friction** between the moving parts. This saves energy, i.e. reduces losses.
- It **functions like a cooling medium**. The engine piston is cooled by the lubricant.
- It **reduces noise between the striking surfaces**. A highly viscous lubricant is more effective in reducing noise.
- Lubricating oil **seal a joint to make it gas-leak proof**. Gas leakage is stopped by the film of the lubricant in between the piston and cylinder.

Types of Lubrication System

In a lubrication system, the engine bearings are lubricated in two ways:

(i) Lubricating oil is delivered into the oil hole which is provided above the bearing and allowed to drain from there to the bearing surface. This is the **principle of the splash system**.

(ii) Lubricating oil is fed directly to the bearing surface under pressure. This is the **pressure lubrication system**.

The lubrication systems in engines may be classified as:

1. Petroil lubrication system (Mist lubrication system)
2. Wet sump lubrication system
3. Dry sump lubrication system.

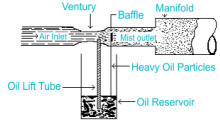
1. Petroil Lubrication System (Mist lubrication system)

This system is used in two-stroke cycle engines in which the crankcase is used to charge the cylinder. 2-3% of lubricating oil is added in the petrol tank where it mixes with the petrol. In the carburettor, the gasoline (petrol) is evaporated and the lubricating oil is left in the form of mist. The lubricant mist is carried into the cylinder by the stream of charge to lubricate the piston rings and the cylinder. Some droplets of the lubricant impinge (strike) on the engine parts and lubricate the main bearings and the connecting rod bearings which are in the crankcase.

The two-stroke engine is sensitive to the type of the lubricant mixed in petrol. The mixture of petrol and lubricating oil influences the exhaust smoke, corrosion, bearing life, ring and cylinder bore wear, and may cause ring sticking & spark plug fouling. Thus, only the recommended lubricating oil must be added for petrol lubrication. The advantage of the petroil lubrication system is that the system does not require extra units like pump, filters, etc. Therefore, the initial cost of the engine is reduced.

The disadvantages of this system are:

a) Droplets of the lubricating oil when partially burnt leave gum deposits over the piston head (crown), piston rings and the exhaust port. Such deposits reduce the engine efficiency.
b) The acidic vapours of the lubricant results in the corrosion of bearings.
c) When the throttle valve is a closed for idling, there is a shortage of the lubricating oil which may result in overheating and piston seizure if idling is continued for a long time.



d) The burning of the lubricating oil in the combustion chamber increases the oil consumption, which in turn increases the running cost of the automobile.
e) Since there is no control over the proper mixing of the lubricating oil and gasoline, the engine may be over-oiled or under-oiled for most of its running time.

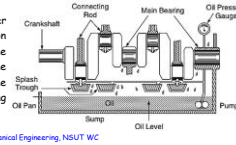
2. Wet Sump Lubrication System

The bottom portion of the crankcase where lubricating oil is stored is called the sump. In the wet sump lubrication system, lubricating oil is stored in the sump. The various types of the wet sump lubrication system are:

a) Splash system
b) Modified splash system
c) Full pressure system

Splash Lubrication System – Figure shows a splash lubrication system. There are splash troughs under all the connecting rod heads. An oil pump delivers the lubricant to these troughs. Thus, the oil pump takes the lubricating oil from the sump and maintains a constant level of lubricant in the troughs. In some installations, an oil pressure gauge is provided on the dash board.

Each connecting rod cap is provided with a splash or dipper which dips into the oil in the trough below it on each revolution of the crankshaft, and splashes the lubricating oil over the whole interior of the crankcase, into the pistons and the exposed portion of the cylinder walls. To lubricate the connecting rod bearing a hole is drilled through the connecting rod cap directly in front of the dipper.



To lubricate the main bearings and the crankshaft bearings, oil pockets are provided over the bearings to catch the splashed oil. Any oil caught in these pockets is drained into the bearings.

Advantage of the System: The only advantage of the splash lubrication system is that the system is simple. However, the system is costly. In some designs the pressure gauge is removed to reduce the engine cost.

Disadvantages of the System: The splash lubrication system has the following disadvantages:

(i) The energy required to splash the lubricating oil is not fully utilized to lubricate the engine parts. Most of the engine energy is lost in splashing the oil over the interior of the crankcase and the oil returns to the sump without lubricating the parts.

(ii) Perfect lubrication of a bearing is a matter of chance. Some bearings are over-oiled and some bearings are under-oiled.

(iii) The upper piston ring, and the overhead valves and valve guides are not lubricated by this system.

(iv) The mist of the lubricating oil in the crankcase comes in contact with air, water vapour and the gases of combustion that have blown by the piston rings. Lubricant readily deteriorates and clogs the holes of bearings.

(v) The unfiltered lubricating oil is splashed again and again. This reduces the life of the bearings.

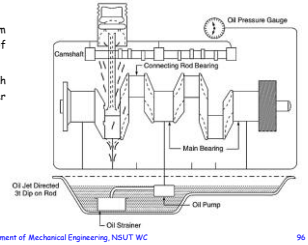
(vi) At high speed, small droplets of the lubricant which are suspended in air in the crankcase are carried away by air through the breather holes. This increases oil consumption.

Modified Splash Lubrication System

This modified form of the splash lubrication system is used in engines in which the bearing loads are higher. An oil pump supplies lubricating oil under pressure to the main and camshaft bearings. There are nozzles which direct the stream of the lubricating oil against the dippers on the connecting rod bearing cups.

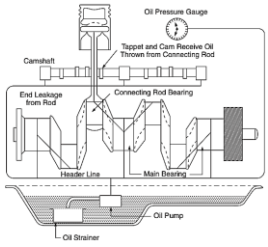
The crankpin bearings receive the lubricating oil from the dipper through the slots cut in the lower ends of the connecting rods.

The other engine parts are lubricated by the splash or spray of the lubricating oil thrown up by the dipper (see Figure).



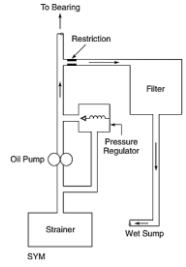
Full Pressure Lubrication System: The full pressure lubrication system is used in large engines and many automotive engines which are designed for heavy duty. This system keeps the bearings cool. The full pressure system supplies a continuous flow of oil that maintains the bearings at a relatively low temperature.

In this system (see Figure), there is an oil pump which supplies oil under pressure and forces oil through the drilled passages to all the bearings. The drilled holes in the connecting rods permit the lubricating oil to flow from the connecting rod bearings (big end bearings) to the piston pins. The cylinder walls, piston and piston rings are lubricated by the oil spray from around the piston pin bearings and the connecting rod bearings (big end bearings). In this design, holes are drilled in the upper part of the connecting rod bearings so that oil under pressure is sprayed on the cylinder walls and the underside of the pistons.



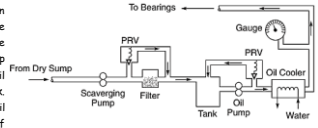
In Figure, a schematic diagram of the wet sump pressure lubrication system has been shown with the following basic components.

1. Oil pump (gear pump)
2. Strainer
3. Pressure regulator with a spring loaded valve
4. Oil filter



3. Dry Sump Lubrication System

The dry sump lubrication system is used in heavy duty engines. In this system, the sump is kept dry and the oil collected in the sump after lubrication is taken out for filtering and cooling, then again pumped onto the bearings. Figure shows the schematic diagram of a dry sump pressure lubrication system. There is a scavenging pump which extracts the sump oil and feeds it to an oil filter. The filtered oil is collected in a storage tank. The other pressure pump feeds this oil to an oil cooler which is a heat exchanger. Here, viscosity of the oil is increased.

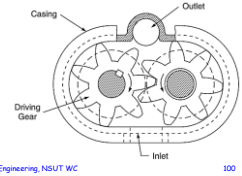


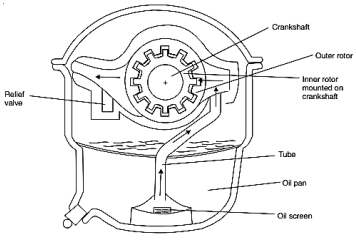
Pressure relief valve (PRV) is parallel to the oil filter and is essential for flow of the lubricant in case the oil filter is choked or clogged. Lifting of the relief valve gives a signal to the operator, but the flow of the lubricant continues. Another pressure relief valve (PRV) in parallel to the pressure oil pump which functions like a safety valve so that excess oil pressure is relieved by the leakage of oil through the relief valve.

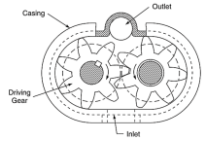
- It should be noted that the oil pressure (hydrostatic pressure) generated within the bearing has no relation to the oil pump pressure. The reason being that in film lubrication it does not matter how oil enters the bearing as long as there is a sufficient quantity of oil.
- This dry sump pressure system supplies a continuous flow of oil, which helps to maintain the bearing at a relatively low temperature.
- Excess flow of the lubricating oil increases power consumption for running the pumps. The scavenging pump has a greater capacity than the oil pump.

Parts of a Lubrication System

Gear Oil Pump: In automobile engines, gear pumps are commonly used for pressure lubrication. Figure illustrates the basic principle of a gear pump. The pump consists of a casing in which two spur gears or helical gears are fitted. One of the gears is keyed to the driving shaft and gets drive from the engine while the other gear meshes with the driving gear. The lubricating oil enters the pump casing from the side where the meshing teeth separate. The space between the adjacent teeth and the casing wall is filled with the lubricating oil.

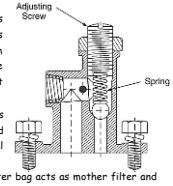






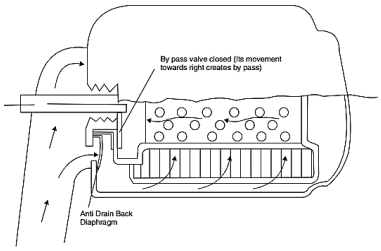
Thus the oil between the teeth is mechanically carried to the opposite side of the housing (casing) and leaves through the delivery (outlet) port. On the opposite side, the meshing teeth engage and push out the oil from the space between the teeth. Thus the volume of oil delivered depends on the tooth space and the face width of the gear. Actual delivery of the lubricant reduces due to the leakages from gaps.

Relief Valve: A relief valve in the force — feed system automatically maintains the constant pressure at which it is set. In Figure, the pressure relief valve has been shown. The unit consists of a spring-loaded valve in the bypass passage from the delivery side of the pump to the inlet side. When the oil pressure exceeds the set pressure then the valve opens and allows some of the oil to return to the inlet side of pump. This relieves delivery pressure in the system.



Oil Filter: An oil filter consists of a closed bag of filtering cloth. This filter bag is placed within a steel shell so that the dirty oil enters the shell at its one end and passes through the filter bag leaving the shell at the other end. Any dirt in the oil is filtered out and adheres to the outside of the filter bag.

It is also possible that the layer of sediment deposited on the surface of the filter bag acts as mother filter and the effectiveness of the filter increases with time. However, this also increases the resistance to the flow of oil. For this reason the old filter must be replaced by a new one as per recommendations of the manufacturer. The job of the filter is to remove the abrasive particles which cause wear of the surfaces. Filters also prevent sludge deposits from passing into the bearings.



The oil is made to pass through the filter as it comes out of the pump. This helps to retain any insoluble impurity. The oil that goes to engine must not have any impurity as that can damage the engine. Clogging of the filter may occur after continuous use. To avoid it, filter should be cleaned periodically. There is a valve provided in the filter. This valve prevents the drainage of oil when engine is not running. When the engine is started, the pressure builds up and the filter permits the supply of oil.

Cooling System

The cooling systems control the engine temperature by dissipating heat into the atmospheric. About 30% of heat is lost by the cooling system and only 10% of heat is lost by radiation. About 25% to 30% of heat is used to perform work. The rest of the heat is lost through the exhaust gases and the cooling medium.

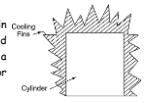
Lubricating oil is also affected by the heat of combustion. Its viscosity decreases with the rise in temperature which increases the friction losses. The heat of friction is carried away by the cooling medium and the exhaust gases.

There are two types of cooling systems:

1. Direct cooling, i.e. air cooling.
2. Indirect cooling, i.e. water cooling.

1. Air Cooling

In case of the air cooling system or the direct cooling system, air is brought in contact with the engine parts. However, the specific heat of air is low (0.24), and therefore a large amount of air is needed to cool the engine parts. Also air is not a good conductor of heat and it carries heat by the convection method only. It is for this reason that the air contact area is increased by providing fins.



As shown in the figure, fins are provided over the cylinder. In an automobile, such air-cooled engines are exposed to the atmosphere for cooling by the draughts obtained due the motion of the vehicle. In case of scooters in which engines are covered, air blowers are used to force the cool air over the fins. Fins are made of aluminium which is a good conductor of heat and the shape increases the surface area for cooling. Due to inertia a certain time elapses before the heat begins to flow from the cylinder to the cooling fins. Since the heat is not quickly dissipated due to the characteristics of air, the cylinder temperature is higher in air-cooled engines than in water-cooled engines.

Advantages of Air Cooling

1. The air cooling system is lighter in weight, i.e. less weight-power ratio.
2. It does not require a radiator and a water pump.
3. No antifreezes agents are required as in water-cooled engines.
4. No salt and mud deposits are formed in water-cooled engines.
5. Air-cooled engines are cheaper.

Disadvantages

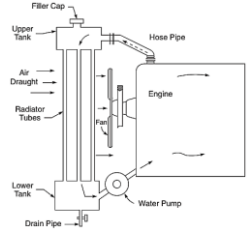
1. The engine is not cooled efficiently and so runs hot.
2. Due to non-uniform cooling, temperature stresses are developed in the engine parts.
3. Engines are noisier.
4. It needs an impeller to blow air over the fins. This impeller is noisy and it absorbs more power in case of scooters, in which engines are covered.

2. Water Cooling

The water cooling system is an indirect cooling system. Water is cheap and easily available. Its specific heat being greater than that of air, water can absorb more heat than air. Water absorbs heat and dissipates it into the atmospheric air. Therefore, the same water can be circulated by a pump and used again.

Figure shows a water cooling system. Water is forced by a water pump in the water jacket of the engine. Hot water comes out from the jacket of the engine and is passed into the radiator. The vertical radiator tubes are brought in contact with the atmospheric air. Water passing through these tubes gets cooled and is collected at the bottom of the radiator. The water pump recirculates water through the water jacket of the engine.

There is also a fan which is driven by the engine or electrically as in a modern car. The fan draws air and blows it over the engine parts. Thus the partial vacuum created behind the radiator, increases the pressure difference across the radiator and more air flows through the narrow gaps between the radiator tubes.



Thus the quantity of air passing through the radiator is increased. This air drawn by the fan is blown over the engine body and the engine temperature is reduced.

The forced circulation of water does not allow its temperature to rise to the boiling point. Scale formation takes place in boiling water. Scales are the deposits of salts and mud and are a bad conductor of heat. Therefore scale deposition leaves hot spots in the combustion chamber which may lead to detonation and pre-ignition in a petrol engine. Hence forced circulation of water is essential in the engines.

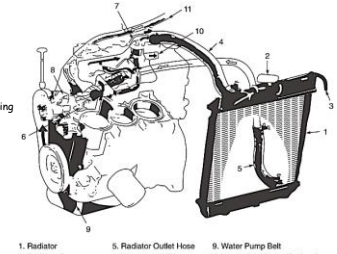
Advantages of Forced Cooling

1. Forced cooling reduces the size of the radiator. Therefore a smaller radiator is needed.
2. Water under pressure is forced into every corner of the water jacket. Therefore no hot spots are left in the combustion chamber.
3. This system gives a rapid cooling effect.
4. Scale formation does not take place.
5. Pressurised cooling has an advantage that its boiling temperature is increased and its heat absorption capacity is also increased.

PARTS OF COOLING SYSTEM

The cooling system consists of the following main parts:

- Water jacket
- Water pump
- Thermostat
- Fan and fanbelt
- Radiator and radiator cap



1. Radiator
2. Radiator Cap
3. To Reservoir Tank
4. Radiator Inlet Hose
5. Radiator Outlet Hose
6. Water Intake Pipe
7. Thermostat
8. Water Pump
9. Water Pump Belt
10. Heater Inlet Hose (Optional)
11. Heater Outlet Hose (Optional)

Cooling System (Courtesy: Maruti Udyog Ltd.)

Water Jacket

The water jacket is the space inside the engine through which water is circulated for cooling the hot parts of the engine. Therefore the water jacket is a hollow space in the engine.

Water Pump

The water pump (see Figure A) is a centrifugal pump driven by the crank through a belt. It takes water from the bottom of the radiator and forces it into the water jacket for circulating water in the engine. Figure B shows the exploded view of a Fiat water pump. The pump is made watertight by a special rubber seal encased in a metal shell, and provided with a spring which presses the seal against the front face of the impeller shaft bush. The seal is press fitted in the pump body so that no water can leak between the seal and the pump body even after a long period and without any adjustment being necessary.

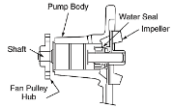


Figure A: Water Pump
(Courtesy: Maruti Udyog Ltd.)

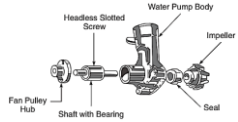


Figure B: Water Pump Components
(Courtesy: The Premier Automobiles Ltd.)

Thermostat

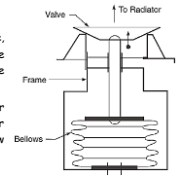
A thermostat valve is used in the water cooling system to regulate the circulation of water in the system. The continuous circulation of water is necessary for maintaining the normal working temperature of the engine parts during different operating conditions. Two types of thermostat are used in automobile vehicles:

1. Bellows type
2. Pellet type

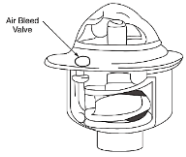
Figure shows the working of the **Bellows type thermostat**.

When water temperature is low, the thermostat having air inside, contracts and closes the valve. Thus cold water is not circulated and the heat lost by cooling is reduced. When the engine runs and the water in the jacket is sufficiently warmed then the hot water heats the thermostat.

The thermostat expands and pushes off the valve from its seat. The water which is under pressure in the jacket starts flowing through the radiator and the water pump. Thus the thermostat permits the hot water to flow and eventually cool. This saves heat loss through the cooling medium.



The most recent trend in the automotive industry is to use the **wax pellet type of thermostat** (see Figure of thermostat fitted in a Maruti engine). The temperature sensitive material in the thermostat is placed in a metal case and it expands when heated and contracts when cooled. When the pellet is heated and it expands, the metal case pushes down the valve and opens it. As the pellet is cooled, its contraction allows the spring to close the valve. Thus the valve remains closed while coolant is cold, preventing the circulation of coolant through the radiator. Maruti thermostat is designed to open at a temperature of 82°C.



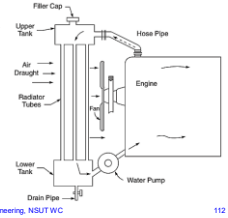
Fan and Fanbelt

A fanbelt of V-section gives drive to a fan from the crankshaft pulley. The fan is placed behind the radiator to force air over the engine body. This creates a pressure difference between the front and the rear of the radiator, and the rate of flow of air through the radiator is increased. Such increase in the air flow provides effective cooling for the water circulated through the radiator. In excessively cold weather, the water in the radiator and in the jacket must not freeze otherwise the radiator or other engine parts may be broken or damaged. To avoid such damages, an antifreeze mixture is added to water so that the water freezing point of water is lowered. The antifreeze mixtures commonly used are—wood alcohol, denatured alcohol, glycerine, ethylene glycol, propylene glycol, mixtures of alcohol and glycerine, etc.

Radiator

A radiator is a device which is used as a heat exchanger between the hot water and atmospheric air. Radiators are essentially used in heavy duty automobiles for cooling the automobile engines. Water, which is forced by a pump into the water jacket of the automobile engine, is sent to the radiator, from where water is passed through the tubes of the radiator which dispel the heat to the air which flows round the tubes. Thus a radiator is a device which permits the cooling of water through the transfer of heat to the atmospheric air.

1. Location of Radiator: Radiator is located in front of the automobile engine so that it gets the advantage of the air draught obtained by the motion of the vehicle (see Figure). The other advantage of having the radiator in front of the engine is that the pipes required to connect the radiator to the engine are of smaller length. This reduces the losses, and less power is needed to circulate the cooling water through the water jacket of the engine and the radiator. Since a greater mass of air is needed to cool the water which is passing through the tubes of the radiator, a fan is used to create the pressure difference across the radiator. This increases the flow of atmospheric air between the water tubes of the radiator. This air fan is driven by a belt and the power required for driving it is obtained from the engine crank.



Since air has poor specific heat (Cp = 0.24) and is a bad conductor of heat, effective cooling is obtained by providing an increased cooling surface area. This is obtained by providing metal fins between the radiator tubes.

2. Types of Radiators: Basically, radiators are of two types:

(i) Tubular type, and

(ii) Cellular type

In the **tubular type core**, the upper and lower tanks are connected by a number of tubes arranged in series. These vertical tubes carry hot water from the upper tank to the lower tank. While water passing through these tubes, heat is transferred to air which flows through the core.

Between the water tubes or water channels there are spacers which provide additional indirect radiation which helps in the rapid cooling of hot water. Different designs of the tubular type core have been shown in Figure.

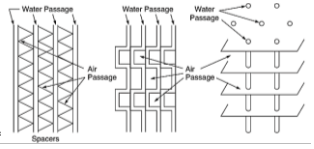


Figure: Types of Tubular Core

The tubular type core increases resistance to air flow through the core. Therefore a stronger fan is needed to overcome this resistance caused by the water tubes. An advantage of this type of core is that it has fewer soldered joints and hence is more robust than the cellular type core. For this reason, the tubular type core is preferred for use in heavy vehicles in which the radiator is subjected to very severe stresses.

The disadvantage of this type of core is that if one of the tubes is clogged, the cooling effect of the entire tube is lost.

The **cellular type** of core is also known as the **air tube cellular core.** This type of radiator consists of a number of horizontal tubes which carry atmospheric air. The space between the tubes is used for the flow of hot water which is to be cooled. Thus the cellular core is composed of a large number of individual air cells which are surrounded by water. Due to its appearance, the cellular type of core is also known as the **honey comb radiator.**

The ends of the tubes are expanded into hexagonal shape and then soldered together. The spacing of the tubes depends on the dimensions of the expanded ends. This spacing is provided for the flow of water from the upper tank to the lower tank. In Figure, the expanded ends of the cellular tubes have been shown.

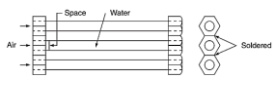
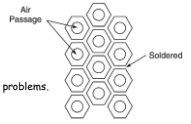


Figure shows the assembly of the ends of the cellular tubes. In this core all the metal sheet is in contact with water at the outer side and with air on the inside. Thus 12 to 25% more heat is transferred per unit area of the sheet used in comparison to the core in which only a part of the area comes in contact with air.

The cellular core type of radiator is best adapted for use where air speeds are high and low weight is the primary consideration. Therefore the cellular type radiators are preferred in racing cars. However, the higher cost has limited the general use of this type of radiators in the field of automobiles.

The chief advantages of cellular radiators are:



(a) The cellular radiator provides better cooling.
(b) It does not require stronger fans.
(c) Air resistance is minimised.
(d) The clogging of the passage for water flow does not give rise to serious problems.
(e) It is light in weight.

The disadvantages are:

(a) Its initial cost is more.
(b) It is not robust due to the various joints.

3. Material for Radiators: Radiator cores are made of copper or brass. Copper has high thermal conductivity and good resistance to corrosion. Due to its property of ductility, it is easy to work with in the press. Brass is stronger than copper and also cheaper. Due to these properties of copper and brass, copper is used to form the core of the radiator, whereas brass is used to make the upper and lower tanks of the radiator. Brass is also resistant to corrosion. The side members of the radiator are made of pressed steel.

Anti-freezing Compounds

When a vehicle is in operation having pump circulated water in the cooling system, there is practically no chance of freezing of water. However, freezing may occur when the car is parked in a place or area where temperatures are below freezing point. When water freezes, it expands approximately 10% in volume. Expansion of water on freezing usually results in damage to the radiator, the cylinder block or the cylinder heads. Therefore it is essential to prevent freezing of water in cold climate. To prevent freezing, various mixtures are added to water in winter to lower the freezing point of water below freezing atmospheric temperatures. The ideal requirements for an **antifreeze mixture** are:

1. The antifreeze should be harmless to all parts of the cooling system.
2. It should easily dissolve in water.
3. Its cost must be reasonable.
4. Its boiling point must be high and it should not evaporate.
5. It must be stable and should not decompose. It must also not react with raw water.

The antifreezes that are employed to prevent the freezing of the coolant are:

1. Methyl, ethyl, and isopropyl alcohol,
2. A solution of alcohol and water,
3. Ethylene glycol
4. A solution of water and ethylene glycol.

The percentage by volume of anti-freeze used in solution with water depends on the atmospheric temperature. If the temperature drops below the freezing point of the antifreeze solution, the solution does not freeze to a solid but forms a slush. The water particles freeze but the antifreeze solution remains in liquid form which produces the slush. The slush formed does not crack the cylinder block or damage the radiator, but it clogs the small passages of the radiator tubes and passages in the water jacket. This directly affects water circulation and causes overheating of the engine.

Alcohol is more volatile and readily evaporates. Therefore the antifreeze solution requires constant (periodic) additions of alcohol. For this reason, the alcohol mixture must be checked frequently.