1

VEHICLE STRUCTURE & ENGINES

PART-A

1. Name the resistance to the vehiclemotion.

- Air resistance
- Rolling resistance
- Gradient resistance

2. What are the types of cross sectional frames used inautomobile?

- Channel section
- Box section
- Tubular Section
- I-Section

3. What are the forces acting on the runningvehicles?

- Load of short duration
- Combined loads of moment any duration
- Inertialoads
- Impactloads
- Load due to the wheel impact
- Static loads

4. Give the typical specification of anautomobile.

Vehicle name: Maruthi Suzuki K10
ENGINE & TRANSMISSION
Top Speed -145 Kmph
Acceleration (0-100 kmph) -13.3 Seconds
Engine Displacement(cc)- 998
Maximum Power -67.1bhp@6000rpm

Maximum Torque -90Nm@3500rpm
Engine Description -1.0-litre 67.1bhp 12V K Series Petrol engine
Turning Radius- 4.6 metres
No. of Cylinders- 3
Drive Type -FWD
Turbo Charger -No
Super Charger -No
Valves Per Cylinder 4
Compression Ratio – 10.1:1
Fuel Supply System- MPFi
Gear box- 5 Speed
Steering Gear Type- Rack & Pinion

5. Why a gearbox is required in anautomobile?

- The variation of resistance to vehicle motion at different speeds
- The variation of tractive effort of the vehicle required at various speeds

For above said reasons, a gearbox is necessary in an automobile.

6. What are the advantages of diesel engines incars?

Diesel engines has higher fuel efficiency compared to the gasoline engines due to the higher compression ratio on the engine, and also

Diesel engine has higher torque figure on lesser rpms and so riding on the city traffic becomes less gear shift.

7. How are the automobiles classified based upon capacity?Give examples.

- Based on Make & Model
- Based on Fuel
- Based on Body Style
- Based on No. of Wheels

8. What are the functions of aframe?

- To support the chassis components and the body.
- To withstand static and dynamic loads without undue deflection or distortion.
- To carry the load of the passengers or goods carried in the body.

9. List out the various materials used in the construction of chassis frames.

- Low Carbon Steel - 0.18 or 0.20 % carbon content
- High Carbon Steel - 0.25 % carbon content
- Alloy Steel – With alloying elements like Ni & Cr

10. Write down any two main sections of vehicleconstruction.

- Chassis construction
- Body construction

11. What are two types of vehiclesuspensions?

- Rigid axle suspension
- Independent suspension

12. What loads are coming toaxle?

Vertical bending load due to vehicle weight

- Driving torque
- Braking torque
- Side thrust

13. What are the functions of a gear box?

- It has to provide torque multiplication
- It has to provide neutralposition
- It has to provide the means to reverse a vehicle

14. Why is the frame narrow atfront?

The frame is narrowed at the front to provide a better steering lock.This also permits smaller turning circle radius.

15. List out the various materials used in the construction of vehicle body

- Wood
- Metals
- Plastics

Mixed construction of all these materials

16. Why are the side members of the frame upswept at twoplaces?

The frame is upswept at the rear and front to accommodate the movement of the axles due to springing. It also keeps the chassis height low.

17. What is the function of abumper?

A bumper is the front-most or rear-most part, which is designed to allow the vehicle to sustain an impact without damage to the vehicle's safety systems

18. What are the stresses to which the frame members are subjectedto?

- Frame longitudinal members – bending stress
- Frame side members – twisting stress

19. Name few components ofengine.

- Cylinder block
- Cylinder head
- Crankcase
- Cylinder
- Piston
- Connecting rod
- Crankshaft
- Camshaft
- Valves
- Spark plug (in the case of petrol engine)
- Fuel injector (in the case of diesel engine)

20. What are the types offrames?

- Ladder type frame
- Perimeter type frame
- X typeframe
- Backbone type frame

21. List the various manufacturers of automobile products inIndia.

- Maruti Suzuki, Hyundai, Nissan, Ford – Passenger Vehicles
- Tata, Ashok Leyland – Heavy Commercial Vehicles
- Bajaj, Hero, Honda, TVS, Suzuki – Two Wheelers
- Bajaj, Mahindra – Three Wheelers

22. State the major types of automobiles according to the fuelused.

- Petrol Engines (SI engines)
- Diesel Engines (CI engines)
- Gas Engines (either SI or CI mode)

23. Classify automobiles with respect to the drive of thevehicle

- Front wheel drive
- Rear wheel drive
- All four wheel drive
- Left hand drive
- Right hand drive

24. What is meant by the termChassis?

A complete vehicle without a body structure is known as Chassis. It comprises of basic structure, power unit, transmission system, controls and auxiliaries.

25. How automobiles are classified into differenttypes?

- Based on Make & Model
- Based on Fuel
- Based on Body Style
- Based on No. of Wheels
- Based on Drive
- Based on Transmission

26. What are the two types of cylinderliners?

- Dryliners
- Wetliners

27. What are the functions of pistonrings?

To provide a gas tight seal between the piston and cylinder liner to prevent the escape of gases from top side of the piston to the underside.

28. What are the two types of pistonrings?

- Compression rings
- Oil rings

29. What are the different methods of enginecooling?

- Air cooling
- Oil (or) Water cooling

30. What are the advantages of air-cooledengines?

- Less weight-power ratio
- Does not require radiator and water pump
- No antifreeze agents required
- No salt and mud deposits in the system
- Air cooled engines are cheaper

31. What are the components of water coolingmethod?

Water pump, radiator tube, upper tank, lower tank, thermostat valve etc.

32. State the difference between S.I and C.Iengine.

SIEngine	CI Engine
Type offuel: Petrol	Type of fuel:Diesel
Compression Ratio: Low (6 to 10)	Compression Ratio Low: High (12 to 24)
Operating cycle:Ottocycle	Operating cycle: Diesel or Dual cycle
Thermalefficiency:Low	Thermal efficiency:High

33. What is clearance volume? And what are itseffects?

The volume above the piston, when it reaches TDC is known as clearance volume. The clearance volume is inversely proportional to the compression ratio.

34. What are the functions of piston, connecting rod, crank shaftand cylinderhead?

- Piston – The piston assembly transfers the force from the power stroke to the crankshaft
- Connecting rod – converts reciprocating motion of piston into rotary motion of crankshaft
- Cylinder head – it acts as a top cover to the cylinder block. The valves are placed in the cylinder head in an overhead valve engine.

35. What is the purpose of coolingsystem?

The purpose of cooling system is to cool the engine components in order to keep their temperature below certain limit and thereby avoiding excessive thermal stress in those components.

36. State the merits and demerits of air and water coolingsystem.

Air Cooling

Merits

- Less weight-power ratio
- Does not require radiator and water pump
- No antifreeze agents required
- No salt and mud deposits in the system
- Air cooled engines are cheaper

Demerits

- Cooling efficiency is lower
- Non uniform cooling
- Engines are noisier.
- It needs impellor or blower to blow air over the fins

Water Cooling

Merits

- Cooling efficiency is better
- More uniform cooling
- Engine operation is silent in nature
- It does not need an impeller or blower

Demerits

- More number of components like radiator, water pump

- Antifreeze agents needed (Ethylene Glycol, Methanol)
- More salt and mud deposition in the system
- Engines are costlier

37. What is the purpose of lubricating system? State itstypes.

The purpose of lubrication system is to supply the lubricating oil between the moving parts of the engine in order to

- Reduce the friction
- Provide the cooling effect
- Carry away the deposits formed due to wear and tear

Types: -

- Mist lubrication
- Splash lubrication
- Pressure feed lubrication
- Combined splash & pressure feed lubrication

38. What are the various pollutants in I.Cengine?

- HC
- CO
- NOx
- Particulates
- SO2
- CO2

39. What is meant by P.C.V? And what are itseffects?

PCV – Positive Crankcase Ventilation

It is used to reduce the blow-by and thereby unburned hydrocarbon emissions

40. What is aCatalyst?

Catalyst is a chemical substance which increases the rate of chemical reaction. Examples are Platinum, Palladium and Rhodium.

41. Write down the firing order a 4 cylinder and 6 cylinderengine

4 cylinder engine firing order: 1-4-3-2

6 cylinder engine firing order: 1-5-3-6-2-4

42. List atleast two IC engine components and materials they are made up of (Apr/May 2018)

1. Cylinder block: It is made of grey cast iron or aluminium with steel sleeves.
2. Piston: The piston is made of cast iron, aluminium alloy, chrome- nickel n nickel-iron alloy and cast steel
3. Connecting rod: It is generally made of plain carbon steel, aluminium alloy and nickel alloy steels.

43. Mention any two moments connected with vehicles aerodynamics. (Apr/May 2018)

1. Mass moment of inertia of additional flywheel.
2. Angular deceleration or angular moment of friction torque.

44. List down the various aerodynamic forces and moments acting on a vehicle in motion. (Nov/Dec 2018)

1. Various aerodynamic forces:
   a) Drag force
   b) Lift force and
   c) Cross wind force
2. Various moments are
   a) Pitching moments
   b) Yawing moments
   c) Rolling moment

45. Write the need of using I cross section rod design. (Nov/Dec 2018)

An I- cross section is an efficient way of reducing weight while keeping the strength of a structure in the correct position to maximize compressive tensional and torsional resistances. I section is easy to cast, easy to machine and easy to produce in quantity as well.

46. What is VVT? Mention its advantages. Apr/May 2019)

Ininternalcombustionengines,variablevalvetiming(VVT)isthe processofalteringthetimingofavalveliftevent,andisoftenusedto improve performance, fuel economy or emissions. It is increasinglybeing usedincombinationwithvariablevalveliftsystems.Therearemanyways inwhichthiscanbeachieved,rangingfrommechanicaldevicestoelectro- hydraulic and cam less systems. Increasingly strict emissions regulations are causing many automotive manufacturers to use VVTsystems.

Advantages of VVT

1. It allows to recirculate internal exhaust gas.
2. \better fuel economy.
3. It reduces nitrogen oxide.
4. Hydrocarbon emission can be controlled.
5. Increased torque can be obtained.

47. Mention the necessity of an oil ring in an IC engine.(Apr/May 2019).

The oil ring wipes of the excess oil from cylinder walls. It also returns excess oil to the oil sump through slot provided in the rings, These rings are made up of cast iron coated with chromium or cadmium.

excess

PART-B

1. Discuss the frame type chassis construction with neat sketch.

Requirements of Good Frame

It must be strong, light and designed in such a way that it may withstand the shock blows, twists, vibrations and other strains to which it is subjected to the road conditions.

It should also resist the distorting force such as:

(a) Weight of the components and passengers causing a sagging effect due to bending action.

(b) Horizontal forces caused by roadirregularities.

(c) Upward twisting forces caused by road shocks to provide a torsional effect.

Frame Construction

Inordertoprovideagoodresistancetobendingandtorsionaleffect,theframe sections are made of proper forms. A typical passenger car frame is shown in Figure1.7

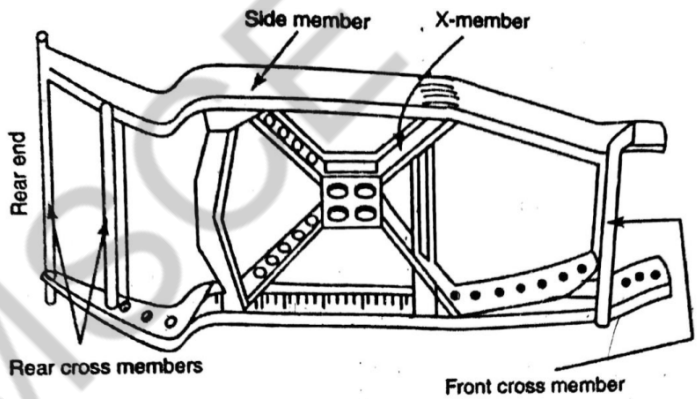


Figure 1.7 A typical car frame

There are three common types of frame sections i.e., channel tubular and box. These are made from cold rolled open earth steel or heat-treated alloy steel.

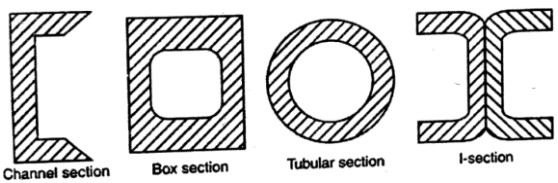


Figure 1.8 Frame sections

Channel section provides good resistance to bending but it is poor in torsion wiletubularsectionprovidesgoodresistance3totorsionandpoorresistanceto bending. The box sections are comparatively resistant to bending and torsion. These sections are shown in Figure1.8.

Theframeisnarrowatthefrontendbecauseofshortturningradiusoffront wheels. It is widening out at the rear end to provide a bigger space forbody.

The rear and front of the frame are curved upward to accommodate the movement of the axle due to springing and also kept the chassis height as low. It also avoids impact due to the rear axle bouncing. Figure 1.9 shows the simplified diagram of the frame. It consists of two longitudinal of side members of channelsection.

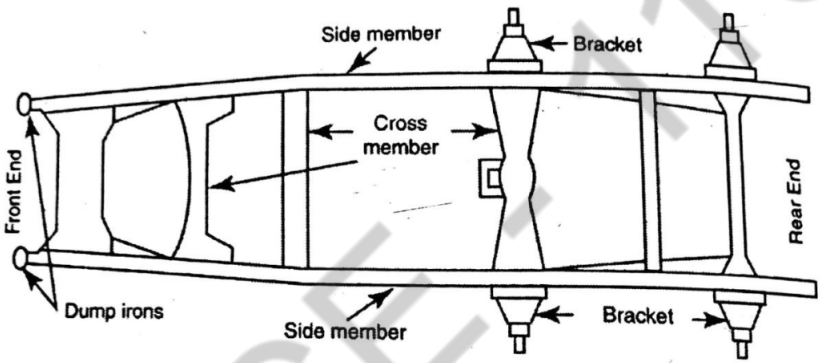


Figure 1.9 Conventional frame

The side members are braced by a number of cross members of channel or tubular section. In conventional design, the cross members are at right angles to side members as shown in Figure 1.9. Several modern chassis frame have cross members that cross in the form of 'X' between the side members as shown in Figure 1.10.

The brackets are provided to connect the springs and support running boards. If necessary, more brackets are provided to support the engine, gear box etc.

The engine, clutch and gearbox are bolted together to form one rigid assembly. It is mounted usually on the front end of the frame by means of rubber pads to withstand engine vibrations.

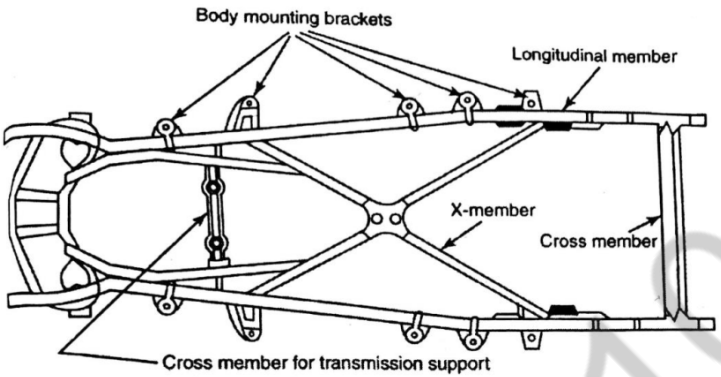


Figure 1.10 X-type frame

Load on Chassis Frame

A Chassis frame is subjected to the following loads:

1. Loads of shortduration:

When the vehicle is crossing a broken patch of road, it is acted upon by heavy and suddenly applied loads of short duration. This load results in longitudinal torsion.

2. Combined loads of moment any duration:

These loads occur while negotiating curve, applying brakes and striking a pot hole.

3. Inertia loads:

These loads are applied on the vehicle due to application of braked for short period. This load tends to bend the side members in the vertical plane.

4. Impact loads:

These loads are applied during collision of vehicle with another object. It results in a general collapse.

5. Load due to road camber:

Loadduetoroadcamber,sidewind,andcorneringforcewhiletakingaturn.It results in lateral bending of sidemembers.

6. Load due to wheelimpact:

Loadduetowheelimpactwithroadobstaclesmaycausethatparticularwheel toremainobstructedwhiletheotherwheeltendstomoveforward.Itwilltend to distort the frame to parallelogramshape.

7. Staticloads:

Loads due to chassis parts such as engine, steering, gearbox, fuel tank, body etc are constantly acting on the frame.

8. Overloads:

The load of the vehicle which is loaded beyond the specified design load is known as overloads.

2. Write short notes on the following engines parts:

(a)Piston (b) Cylinder head (c) Piston ring (d) Gudgeon pin (e) Flywheel (f) Exhaust valve (g) Lubrication pump.

Piston:

It is a cylindrical shaped mass that reciprocates inside the cylinder. The piston severs the following purposes:

- It acts as movable gas tight seal to keep the gases inside the cylinder.
- It transmits the force of explosion in the cylinder to the crankshaft through connecting rod.

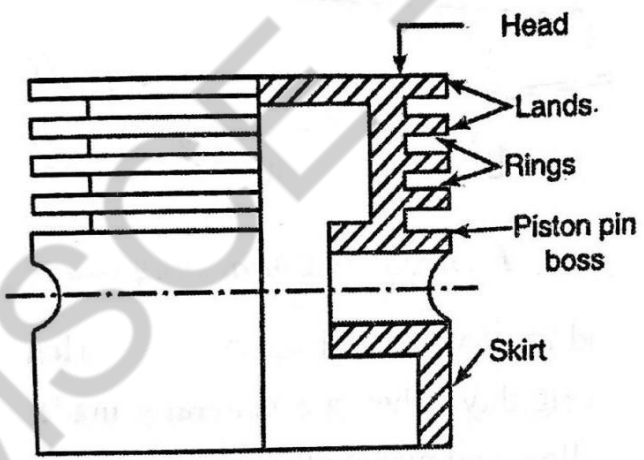


Figure 1.50 Piston

The top of the piston is called as crown and sides are called as skirt. It has grooves to hold piston rings and oil ring. It is opened at the bottom end and closed at the top. Sometimes, T-slots are provided in the skirt to allow expansion.

Cylinder head:

The cylinder head is bolted at the top of the cylinder block. It houses the inlet andexhaustvalvesthroughwhichthechargeistakeninsideofthecylinderand

burntgasesareexhaustedtotheatmospherefromthecylinder.Italsocontains spark plug hole or injector hole and cooling water jacket. The materials used for cylinder heads are cast iron, aluminum alloy etc.

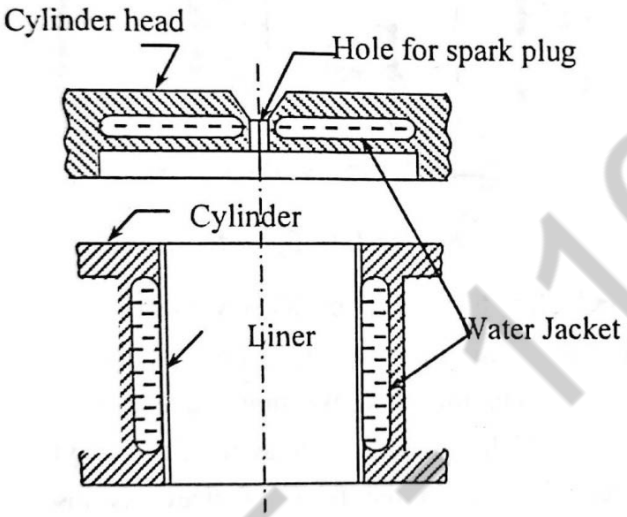


Figure 1.48 Engine cylinder

Piston rings:

They are used to maintain air tight sealing between piston and cylinder to prevent gas leakages. Piston rings are fitted in the grooves which areprovided for them in the top portion of the piston skirt. Two types of piston rings are used in a piston.

Flywheel:

The flywheel is heavy and perfectly balance wheel usually connected to the rear end of the crankshaft. Flywheel serves as a energy reservoir. It stores energy during power stroke and releases during other strokes. Thus, it gives a constant output torque. It is usually made iron or cast steel.

Valves:

Valvesareusedforclosingandopeningpassageofthecylinder.Therearetwo valves in an engine cylinder namely inlet and exhaust valves. Fresh air-fuel mixtureorairaloneentersintothecylinderthroughinletvalve.Exhaustgases are forced out through the exhaust valves. Valves are operated by cam and rocker arm mechanisms. There are three types of valves: Sleeve valve, rotary valve and tappet valve. Tappet valves are most commonly used.

Lubrication pump:

The oil pump in an internal combustion engine circulates engine oil under pressure to the rotating bearings, the sliding pistons and the camshaft of the engine. This lubricates the bearings, allows the use of higher-capacity fluid bearing and also assists in cooling the engine.

Aswellasitprimarypurposeforlubrication,pressurizedoilisincreasingly used as a hydraulic fluid to power small actuators. One of the first notable uses in this way was for hydraulic tappets in camshaft and valve actuation. Increasingly common recent uses may include the tensioner for a timing belt or variators for variable valve timingsystems.

Gudgeon pin: In internal combustion engines, the gudgeon pin connects the piston to the connecting rod and provides a bearing for the connecting rod to pivot upon as the piston moves. In very early engine designs (including those driven by steam and also many very large stationary or marine engines), the gudgeon pin is located in a sliding crosshead that connects to the piston via a rod. A gudgeon is a pivot or journal.

4. Write short notes onfollowing:

(a) Valve mechanism (b)Crankshaft.

Valve Mechanisms

The valves are actuated by cams mounted on a cam shaft. Different types of valve operating mechanisms are

i. Side valvemechanism
ii. Overhead valvemechanism
iii. Overhead inlet and side exhaust valvemechanisms.

Side valve mechanism:

This mechanism is shown in Figure 1.56. The cam mounted on the camshaft operates the valve tappet during its rotation. The valve tappet is pushed up. The valve tappet pushes the valve from its sheet against the spring force. Thus, the valve is opened. When the cam is not in action, the valve returns back to its seat by the valve spring and spring retainer.

Overhead valve mechanism:

Figure 1.57 shows overhead valve mechanism. Here, the valves are located in the cylinder head. When the cam rotates, the valve lifter will push the push rod upwards. Push rod moves the rockerarm.

Since the rocker arm is pivoted at its center, it pushes the valve off its seat against the spring force. Thus, the valve is opened. When the cam is not in action,thevalvereturnsbacktoitsseatbythevalvespringandspringretainer.

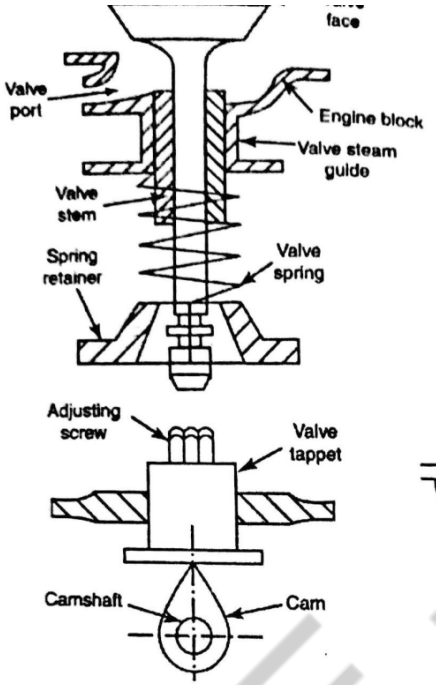


Figure 1.56 Side valve mechanism valve

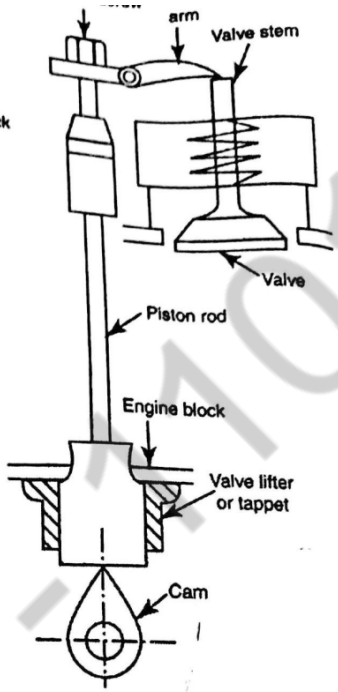


Figure 1.57 Overhead mechanism

Crank shaft:

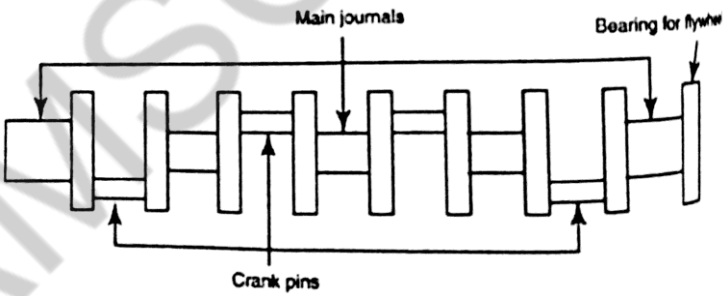


Figure 1.53 Crank shaft

It is used to convert reciprocating motion of the piston into rotary motion. Big end of connection rod is connected to crank shaft. It can be single crank type for single cylinder engines and multiple crank type for multi cylinder engine. The crankshaft is held in position by the main bearings. There are minimum two bearings provided to support the crankshaft.

The material of the crankshaft should be strong enough to resist heavy impact force of the piston. They are made from a hot billet steel, carbon steel, nickel-chromium and other heat treated alloy steels.

5. What are the functions ofcarburetor?

Functions of carburetor

1. It maintains a small reserve of petrol in the float chamber at aconstant head.
2. It atomizes and vaporizes the fuel.
3. It prepares a mixture of petrol and air in correct proportions.
4. It supplies a fine spray ofpetrol.
5. It produces a homogeneous mixture.
6. It measures and supplies the proper quantity and proportions of air and fuel under all conditions of engine operations such as temperature, speed and load. Similarly, an extremely rich mixture having a ratio of 9:1 is required during coldstarting.

Types of Carburetor

The carburetors can be classified according to the following considerations.

1. According to the direction offlow.

a. Uplift carburetors or updraftcarburetors.

b. Down draftcarburetors

6. Discuss the different types ofautomobiles.

Types ofAutomobiles

Automobiles can be classified with respect to different purposes which are as follows:

i. With respect to thepurpose:

   a. Passenger vehicles. Examples: Car, Bus, Jeep, Scooter, Mopeds, Motorcycle.

   b. Goods carriers, Examples: Trucks,Lorrys.

ii. With respect to the fuelused

   a. Petrolvehicles

   b. Dieselvehicles

   c. Gasvehicles

   d. Electric vehicle

   e. Solarvehicle

iii. With respect tocapacity:

a. Heavy Transport vehicle or Heavy Motor vehicles. Examples: Bus, Lorries, Trucks,Tractors.

b. Lighttransportvehicleorlightmotorvehicles.Example:Car,Scooter, Mopeds, Motor cycles,Jeeps.

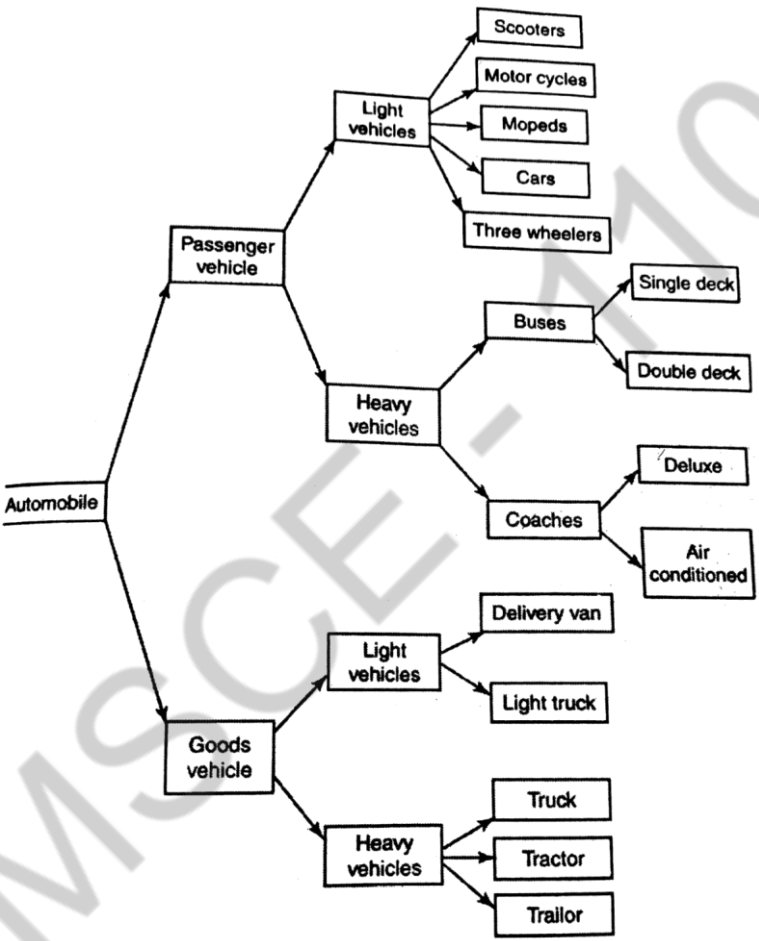


Figure 1.2 Classification of automobiles

iv. With respect to the number ofwheels:

a. Two wheelers. Examples: Scooters, Mopeds.

b. Four wheelers. Examples: Car, Jeep, Buses,Trucks.

c. Three wheelers. Examples: Auto,Tempos

d. Six wheelers. Examples: Heavytrucks.

v. With respect to drive of thevehicle:
   a. Single wheel drivevehicles.
   b. Two wheel drivevehicles.
   c. Four wheel drivevehicles.
   d. Six wheel drivevehicles.

vi. With respect to the side ofdrive:
   a. Left hand drive. Example: Most of the American, UAEvehicles.
   b. Right hand drive. Example: Most of the Indianvehicles.

vii. With respect totransmission:
   a. Conventional. Example: Most of Indianvehicles.
   b. Semi-automatic. Example: Most of Britishvehicles.
   c. Automatic. Example: Americanvehicles.

viii. With respect to theirconstruction:
   a. Single unitvehicles.
   b. Articulated vehicles andtractors.

7. Draw the layout of an automobile and indicate the various components.

Automobile is also provided with steering for directional control, acceleration for speed control and brakes for stopping purposes. The speed of the cart is very slow as compared to the automobile. Due to this fact, the automobile is subjected to more shocks which inturn put more strains on the frame. Therefore, the automobile is needed robust frame and shock absorbers to bear all stresses andstrains.

Theaxleisnotdirectlyfittedwiththeframeintheautomobile.Itissuspended with the frame through strong springs. In order to arrest shocks and save the passengers from jerks and jolts due to rough road condition, shock absorbers are provided.

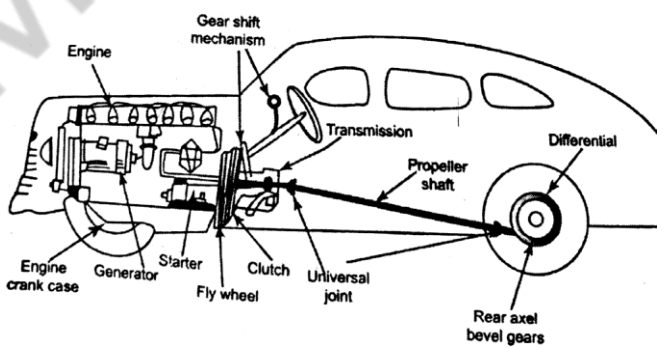


Figure 1.4 Layout of a car

Figure 1.4 shows the layout of a car. It consists of an engine which is located at the front of the vehicles followed by transmission systems. The radiator is located in front of the engine.

Various other parts of the vehicle shown in the Figure 1.4 are generator, starter, steering, clutch, rear axle, differential, universal joint, wheel, tyres, body, lamp etc.

Thepowerdevelopedbytheengineistransmittedtotherearwheelthrough clutch, gearbox, propeller shaft, universal joint, and differential. Lamps are providedwiththeautomobilesothatthesecouldbedrivensafelyduringnight hours. Horn is provided for making warning sound to the other roadusers.

Thebodyorsuperstructureisbuiltuptofulfilltherequirementsortrendsof thepassengers.Brakeisprovidedtothevehicletostoporslowdownthespeed whenever required. Fuel tank is provided to store the required amount of fuel. Radiator is provided for cooling the engine and related parts of the vehicle.

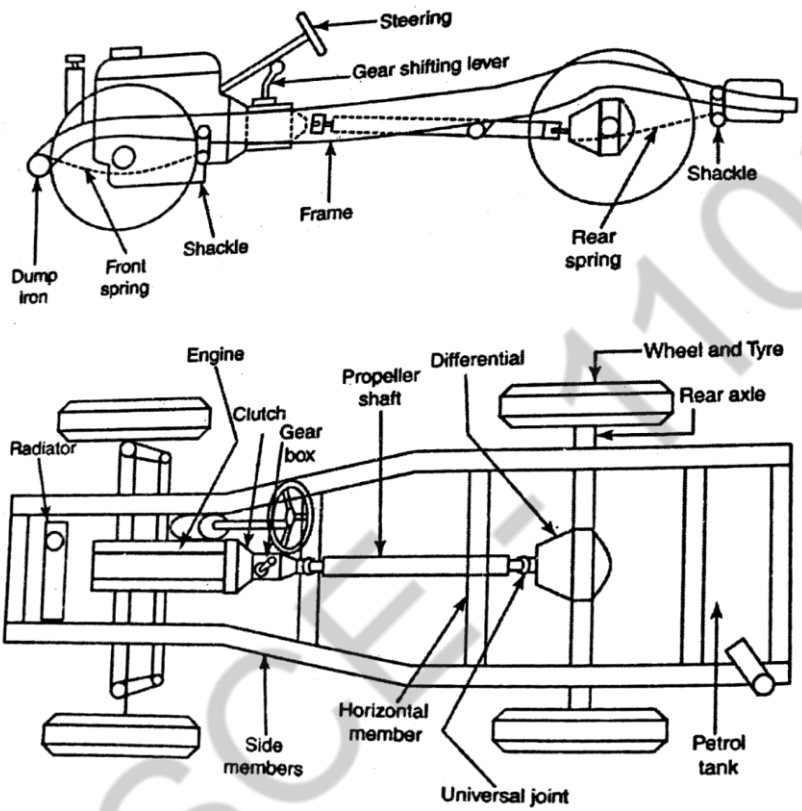
CHASSIS

To construct any automobile, chassis is the basic requirement. Chassis is a French term and was initially used to denote the frame or main structure of a vehicle. It is now extensively used in complex vehicles except the body. A vehicle without body is called achassis.

Main Components of Chassis

1. Frame
2. Frontsuspension
3. Steeringmechanism
4. Engine, clutch and gear box
5. Radiator
6. Propellershaft
7. Wheels
8. Rear and front springs and shockabsorber
9. Differentialunit
10. Universaljoint
11. Brakes and brakingsystems
12. Storagebattery
13. Fueltank
14. Electricalsystems
15. Silencer

Layout of Chassis



8. Discuss the various resistance encountered by anautomobile.

RESISTANCES TO VEHICLE MOTION

A moving vehicle has to overcome the following resistances:

1. Airresistance:

It is the resistance offered by air to the vehicle motion. It depends upon the following factors:

1. Size ofvehicle
2. Shape
3. Speed
4. Windvelocity

2. Gradientresistances:

Itisthecomponentofthevehicle'sweightwhichisparalleltotheplaneofthe road.Thiscomponentremainsconstantbutindependentofthevehicle'sspeed.

3. Miscellaneousresistance:

Other resistances such as rolling resistances depend upon the following parameters:

1. Road characteristics
2. Tyre characteristics
3. Vehicleweight
4. Vehiclespeed.

AERODYNAMICS OF AUTOMOBILE BODY

Aero means air, dynamics means motion. Aerodynamics is, therefore, the behavior of air in motion relative to the vehicle body. The body design pertaining to shape and size of the vehicle must have acceptable aerodynamic characteristics.

The following are various forces acting on the vehicle:

i. Drag force(F_x).

Force of air drag is acting in the direction of vehicle motion with the wind acting along the longitudinal direction axis. This force is also called air resistance.

This offers resistance to the motion of the vehicle. The various factors, such as profile drag (57% of total vehicle), induced drag (8%), skin friction (10%) affects the total drag. The total aerodynamic drag can be calculated by using the equation.

$$F_x = C_x \rho V^2 \frac{A}{2}$$

where,

C_x – drag coefficient

ρ- density of air

V- Velocity of air

A – Projected area of the vehicle viewed from front.

The profile of the body should be carefully selected to avoid. The drag force stream lines of air flow around the body should be continuous and separation of the boundary layer should be avoided. Skin friction drag can be reduced by using very smooth and well polished body. Avoiding excessive projections such as door handles, mirrors, aerials helps in reducingdrag.

ii. Lift force(F_z):

Aerodynamic lift force is the vertical component of the resultant force caused by the pressure distribution on the body.

Lift force can be calculated by using the equation

$$F_z = C_z \rho V^2 \frac{A}{2}$$

where,

C_x – drag coefficient

ρ – density of air.

Theaerodynamicliftwilltendtoreducethepressurebetweenthetyresandthe ground which causes loss of steering on the front axle and loss of traction on the rear axle.

iii. Cross wind force(F_y):

Cross wind force is acting in the lateral direction, on the side of the vehicle. This is formed by the asymmetric flow f air around the vehicle body. Theseforcesareactingatthecentreofpressureinsteadofcentreofgravity and hence cause moments as follows:

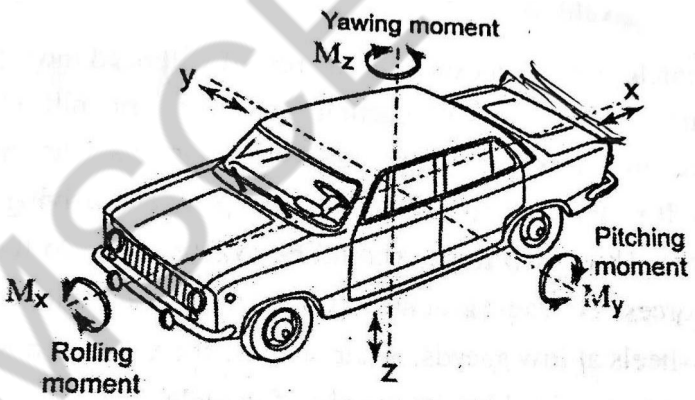


Figure 1.28 Forces and moments acting on the vehicle body

i. **Pitching moment (M_y)** which caused by the drag force F_x or lift force $F_z$about Y axis. This moment makes the rear wheels lift off the ground and further reduces the available traction.

ii. **Yawing moment (M_z)** which is caused by the cross wind force F_y about Z axis.

iii. Rollingmoment(M_y)whichiscausedbythecrosswindforce$F_y$aboutZ.

Figure 1.28 shows the forces and moment acting on the vehiclebody.

9. Givereasons:

For using two cylinder two stroke petrol engines on two wheelers

Reasons for using single – cylinder two – stroke air – cooled petrol engine on two – wheelers

Following are the reasons:

1. Atwo–strokecycleismorecompactthanafour–strokecycleengine forthesameamountofpowerhandled.Thereforeatwo–strokecycle engine is preferred over a four stroke cycle engine in a two – wheeler as it requires lessspace.
2. Two – wheelers, i.e, scooters, mopeds and motor cycles, are light duty vehicles to carry one or two passengers. A single cylinderengine develop enough power to carry suchloads.
3. Apetrolenginerunsatalowercompressionratiothanadiesel engine. Therefore, the weight – power ratio of petrol engine is less than a diesel engine.
4. A lighter engine (two – stroke cycle petrol engine) makes the vehicle (two – wheeler) lighter. Hence for the same tractive force, a two – wheeler gives higher acceleration. (force = mass ×acceleration)
5. An air – cooled engine does not require water, radiator and water circulating pump. Therefore the weight – power ratio of a an air – cooled engine is decreased.

From the reasons stated, it is seen that an engine required for a two – wheeler is compact in size, light in weight, and capable of giving higher acceleration and generating power to carry load.

(ii) For using multi cylinder diesel engine in commercialvehicles

Reasons for using multi – cylinder diesel engine for commercialvehicles

Trucks and buses are commercial vehicle and multi- cylinder engine. The reason for the use of multi – cylinder engine are:

1. A multi – cylinder engine develops more power. A commercial vehicle needs greater force to propel the vehicle because it carries greater loads.
2. Adieselenginerunsatahighercompressionratio(about22)and at such high compression ratios the thermal efficiency of a multi –

cylinderengineishigherthananottocyclepetrolengine.This,means that a diesel engine gives better fuel economy perkilometer.

3. A multi – cylinder engine has a greater swept volume and also its surfacevolumeratioisincreased.Thisresultsingreaterengineoutput (power) and also better cooling which is essential for the protection of engine parts like cylinder head, cylinder line, piston etc. the lubricating oil is also prevented from partial oxidation.

4. Inamulti–cylinderengine,vibrationsaredecreasedduetobalancing of the crank.

10. List the engine parts, materials, method of manufacture and their functions.

List of engine parts, material, method of manufacture and functions:

Name of the part		Material	Function	Method of manufacture
1.	Cylinder	Hard grade cast – iron	Contains under pressure and guides the piston.	Casting
2.	Cylinder head	Cast – iron or aluminium	Main function is to seal the working and of the cylinder and not to permit entry and exit of gauss on overhead value rod.	Casting, forging
3.	Piston	Cast – iron or aluminium alloy	It acts as a face to receive gas pressure and transmits the thrust to the connecting rod.	Casting, forging
4.	Piston rings	Cast – iron	Their main function is to provides a good sealing fit between the piston and cylinder	Casting
5.	Gudgeon pin	Hardened steel	It supports and allows the connecting rod to swivel	Forging
6.	Connecting rod	Alloy steel; for small engines the material may be aluminium	It transmits the piston load to the crank, causing the later to turn, thus converting the reciprocating motion of the piston into rotary motion of the crank shaft	Forging
7.	Crank shaft	In general the crank shaft is made from a high tensile forging, but special cast- irons are sometimes used to procedure a light does not require a lot of machining	It converts the reciprocating motion of the piston into the rotary motion	Forging

8.	Main bearings	The typical bearing half is made of steel or bronze back to which a lining of relativelysoft bearing material is applied	The function of bearings is to reduce the friction and allow the parts to move easily	Casting
9.	Flywheel	Steel or cast – iron	In engine it takes care of fluctuations of speed during thermodynamic cycle	Forging
10.	Intel value	Silicon chrome steel with about 3% carbon	Admits the air or mixture of air and fuel into engine cylinder.	Forging
11.	Exhaust value	Austenitic steel	Discharge the product of combustion	Forging

10. Briefly explain with sketches different types of vehicle chases and body. (Apr/May 2018)

Requirements of Good Frame

It must be strong, light and designed in such a way that it may withstand the shock blows, twists, vibrations and other strains to which it is subjected to the road conditions.

It should also resist the distorting force such as:

(d) Weight of the components and passengers causing a sagging effect due to bending action.

(e) Horizontal forces caused by roadirregularities.

(f) Upward twisting forces caused by road shocks to provide a torsional effect.

Frame Construction

Inordertoprovideagoodresistancetobendingandtorsionaleffect,theframe sections are made of proper forms. A typical passenger car frame is shown in Figure1.7

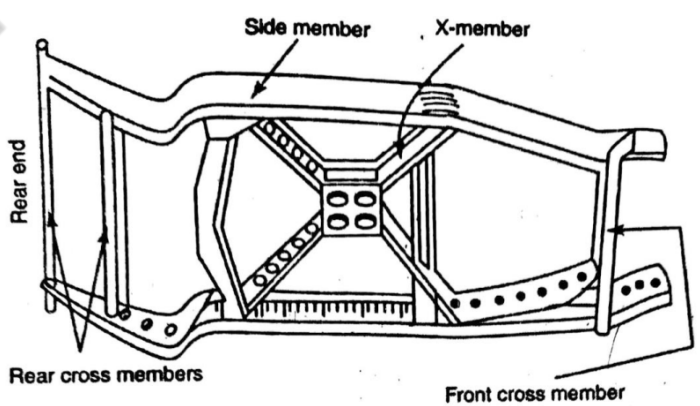


Figure 1.7 A typical car frame

There are three common types of frame sections i.e., channel tubular and box. These are made from cold rolled open earth steel or heat-treated alloy steel.

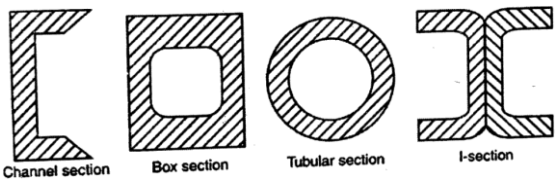


Figure 1.8 Frame sections

Channel section provides good resistance to bending but it is poor in torsion wiletubularsectionprovidesgoodresistance3totorsionandpoorresistanceto bending. The box sections are comparatively resistant to bending and torsion. These sections are shown in Figure1.8.

Theframeisnarrowatthefrontendbecauseofshortturningradiusoffront wheels. It is widening out at the rear end to provide a bigger space forbody.

The rear and front of the frame are curved upward to accommodate the movement of the axle due to springing and also kept the chassis height as low. It also avoids impact due to the rear axle bouncing. Figure 1.9 shows the simplified diagram of the frame. It consists of two longitudinal of side members of channelsection.

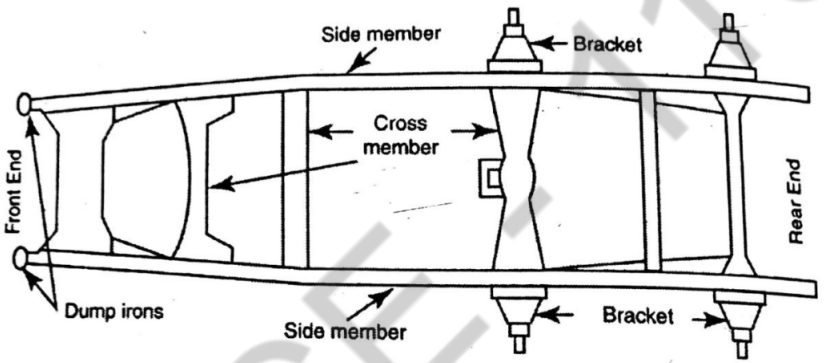


Figure 1.9 Conventional frame

The side members are braced by a number of cross members of channel or tubular section. In conventional design, the cross members are at right angles to side members as shown in Figure 1.9. Several modern chassis frame have cross members that cross in the form of 'X' between the side members as shown in Figure 1.10.

The brackets are provided to connect the springs and support running boards. If necessary, more brackets are provided to support the engine, gear box etc.

The engine, clutch and gearbox are bolted together to form one rigid assembly. It is mounted usually on the front end of the frame by means of rubber pads to withstand engine vibrations.

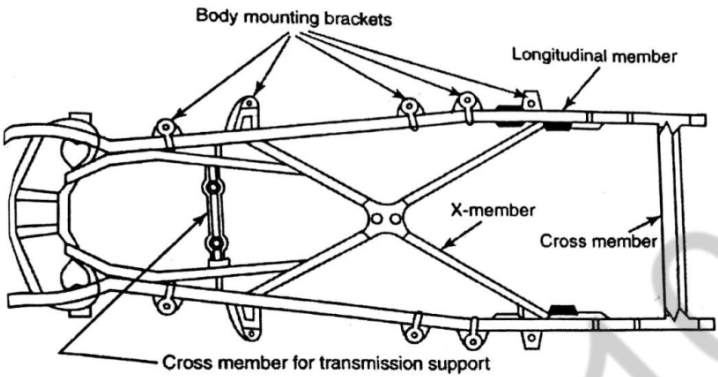


Figure 1.10 X-type frame

Load on Chassis Frame

A Chassis frame is subjected to the following loads:

9. Loads of shortduration:

When the vehicle is crossing a broken patch of road, it is acted upon by heavy and suddenly applied loads of short duration. This load results in longitudinal torsion.

10. Combined loads of moment any duration:

These loads occur while negotiating curve, applying brakes and striking a pot hole.

11. Inertia loads:

These loads are applied on the vehicle due to application of braked for short period. This load tends to bend the side members in the vertical plane.

12. Impact loads:

These loads are applied during collision of vehicle with another object. It results in a general collapse.

13. Load due to road camber:

Loadduetoroadcamber,sidewind,andcorneringforcewhiletakingaturn.It results in lateral bending of sidemembers.

14. Load due to wheelimpact:

Loadduetowheelimpactwithroadobstaclesmaycausethatparticularwheel toremainobstructedwhiletheotherwheeltendstomoveforward.Itwilltend to distort the frame to parallelogramshape.

15. Staticloads:

Loads due to chassis parts such as engine, steering, gearbox, fuel tank, body etc are constantly acting on the frame.

16. Overloads:

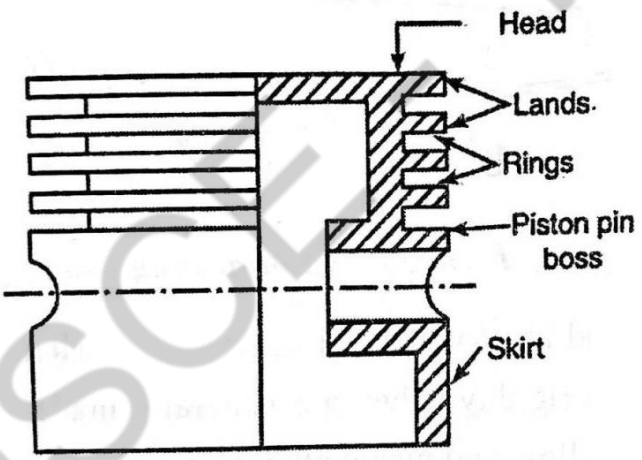
The load of the vehicle which is loaded beyond the specified design load is known as overloads.

11. List atleast six IC engine components and mention their functioning, material they are made up of and schematic of the same.(Apr/May 2018)

Piston:

It is a cylindrical shaped mass that reciprocates inside the cylinder. The piston severs the following purposes:

- It acts as movable gas tight seal to keep the gases inside the cylinder.
- It transmits the force of explosion in the cylinder to the crankshaft through connecting rod.



12. Figure 1.50 Piston

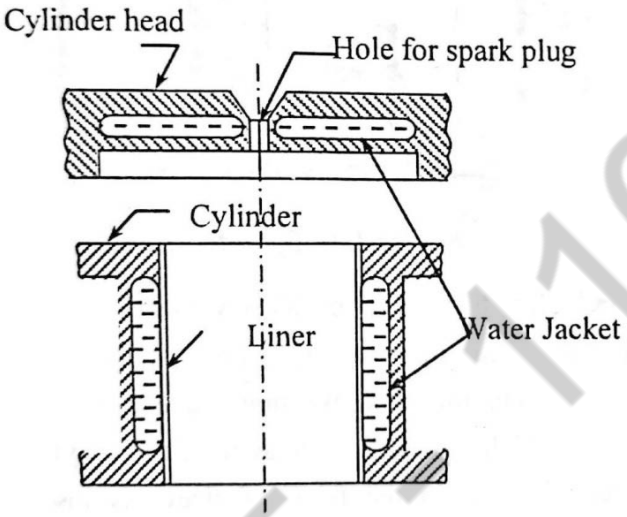
The top of the piston is called as crown and sides are called as skirt. It has grooves to hold piston rings and oil ring. It is opened at the bottom end and closed at the top. Sometimes, T-slots are provided in the skirt to allow expansion.

Cylinder head:

The cylinder head is bolted at the top of the cylinder block. It houses the inlet

andexhaustvalvesthroughwhichthechargeistakeninsideofthecylinderand

burntgasesareexhaustedtotheatmospherefromthecylinder.Italsocontains spark plug hole or injector hole and cooling water jacket. The materials used for cylinder heads are cast iron, aluminum alloy etc.



Piston Ring

They are used to maintain air tight sealing between piston and cylinder to prevent gas leakages. Piston rings are fitted in the grooves which areprovided for them in the top portion of the piston skirt. Two types of piston rings are used in a piston.

Flywheel:

The flywheel is heavy and perfectly balance wheel usually connected to the rear end of the crankshaft. Flywheel serves as a energy reservoir. It stores energy during power stroke and releases during other strokes. Thus, it gives a constant output torque. It is usually made iron or cast steel.

Valves:

Valvesareusedforclosingandopeningpassageofthecylinder.Therearetwo valves in an engine cylinder namely inlet and exhaust valves. Fresh air-fuel mixtureorairaloneentersintothecylinderthroughinletvalve.Exhaustgases are forced out through the exhaust valves. Valves are operated by cam and rocker arm mechanisms. There are three types of valves: Sleeve valve, rotary valve and tappet valve. Tappet valves are most commonly used.

Lubrication pump:

The oil pump in an internal combustion engine circulates engine oil under pressure to the rotating bearings, the sliding pistons and the camshaft of the engine. This lubricates the bearings, allows the use of higher-capacity fluid bearing and also assists in cooling the engine.

Aswellasitprimarypurposeforlubrication,pressurizedoilisincreasingly used as a hydraulic fluid to power small actuators. One of the first notable uses in this way was for hydraulic tappets in camshaft and valve actuation. Increasingly common recent uses may include the tensioner for a timing belt or variators for variable valve timingsystems.

Gudgeon pin: In internal combustion engines, the gudgeon pin connects the piston to the connecting rod and provides a bearing for the connecting rod to pivot upon as the piston moves. In very early engine designs (including those driven by steam and also many very large stationary or marine engines), the gudgeon pin is located in a sliding crosshead that connects to the piston via a rod. A gudgeon is a pivot or journal.

List of engine parts, material, method of manufacture and functions:

Name of the part		Material	Function	Method of manufacture
1.	Cylinder	Hard grade cast – iron	Contains under pressure and guides the piston.	Casting
2.	Cylinder head	Cast – iron or aluminium	Main function is to seal the working and of the cylinder and not to permit entry and exit of gauss on overhead value rod.	Casting, forging
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6.	Connecting rod	Alloy steel; for small engines the material may be aluminium	It transmits the piston load to the crank, causing the later to turn, thus converting the reciprocating motion of the piston into rotary motion of the crank shaft	Forging

7.	Crank shaft	In general the crank shaft is made from a high tensile forging, but special cast- irons are sometimes used to procedure a light does not require a lot of machining	It converts the reciprocating motion of the piston into the rotary motion	Forging

8.	Main bearings	The typical bearing half is made of steel or bronze back to which a lining of relativelysoft bearing material is applied	The function of bearings is to reduce the friction and allow the parts to move easily	Casting
9.	Flywheel	Steel or cast – iron	In engine it takes care of fluctuations of speed during thermodynamic cycle	Forging
.10.	Intel value	Silicon chrome steel with about 3% carbon	fAdmits the air or mixture of air and fuel into engine cylinder.	Forging
11.	Exhaust value	Austenitic steel	Discharge the product of combustion	Forging

12. **With indicative sketches , describe about the chassis layout used in engine front wheel drive. (Nov/Dec 2018)**

For answer refer question No.7, and page No. 19 in question bank

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13. Explain about the construction operation of a variable valve timing mechanism adopted in an IC engine. N0v/Dec 2018)

internalcombustionengines,variablevalvetiming(VVT)isthe processofalteringthetimingofavalveliftevent,andisoftenusedto improve performance, fuel economy or emissions. It is increasinglybeing usedincombinationwithvariablevalveliftsystems.Therearemanyways inwhichthiscanbeachieved,rangingfrommechanicaldevicestoelectro- hydraulic and camless systems. Increasingly strict emissions regulations are causing many automotive manufacturers to use VVTsystems.

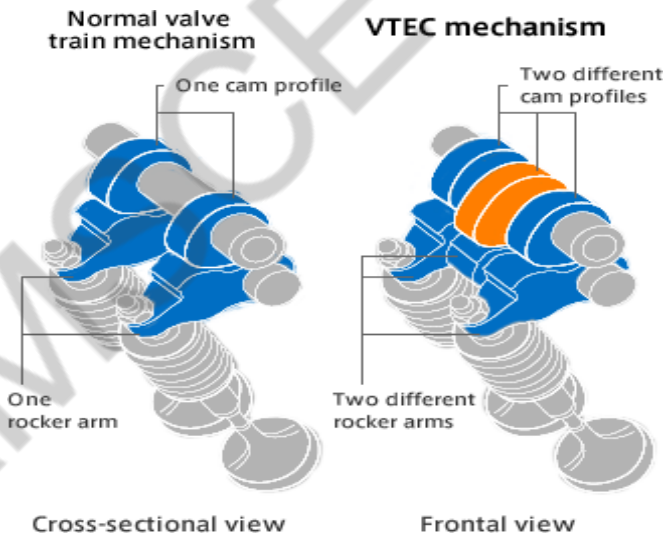
The valves within an internal combustion engine are used to control the flow of the intake and exhaust gases into and out of the combustion chamber.Thetiming,durationandliftofthesevalveeventshasasignificant impact on engine performance. Without variable valve timing or variable valve lift, the valve timing must be the same for all engine speeds and conditions, therefore compromises are necessary.[1] An engine equipped with a variable valve timing actuation system is freed from this constraint, allowing performance to be improved over the engine operating range.

Piston engines normally use valves which are driven by camshafts. The cams open (lift) the valves for a certain amount of time (duration) during each intake and exhaust cycle. The timing of the valve opening and closing, relative to the position of the crankshaft, is important. The camshaft is driven by the crankshaft through timing belts, gears or chains.

Anenginerequireslargeamountsofairwhenoperatingathighspeeds. However, the intake valves may close before enough air hasentered each combustion chamber, reducing performance. On the other hand, if the camshaft keeps the valves open for longer periods of time, as with a racing cam, problems start to occur at the lower engine speeds. Opening the exhaust valve while the intake valve is still open may cause unburnt fuel to exit the engine, leading to lower engine performance and increased emissions.

Earlyvariablevalvetimingsystemsuseddiscrete(stepped)adjustment. For example, one timing would be used below 3500 rpm and another used above 3500 rpm.

More advanced "continuous variable valve timing" systems offer continuous (infinite) adjustment of the valve timing. Therefore, the timing can be optimized to suit all engine speeds and conditions.



14. With suitable illustration discuss about different types of vehicles layout and body/ chassis construction. (Apr/May 2019)

For answer refer question No. 10(April/May 2018) page No 26

15.i) Mention the various resistances and moments acting on an automobile. Also represent the same with the help of a schematic. (Apr/May 2019)

ii) Mention different types of automobiles.

i) For answer refer question No.8

ii) Different types of automobiles are

For answer refer question No 6

2

ENGINE AUXILIARY SYSTEMS

PART-A

1. What are functions of the turbocharger?

- To increase density of intake air
- To increase power output
- To utilize energy from exhaust gas

2. Define "continuous injection" of petrolengines.

Inacontinuousinjection-equippedengine,theamountoffueldeliveredtothe cylindersisnotvariedbypulsingtheinjectorsonandoff.InsteadCISinjectors spray fuel continuously. What does vary is the amount of fuel contained in the spray. CIS systems do this by maintaining a constant relative fuel system pressure and metering the amount of fuel to the injectors.

3. State the diesel vehicle emission norms of BS IV in g/km

Petrol Emission Norms (All figures ing/km)

EmissionNorm	CO	HC	NOx
BS-IV 1.00	0.10	0.08	

Diesel Emission Norms (All figures in g/km)

EmissionNorm	CO	HC	NOx	HC+NOx	PM
BS-IV 0.50	---	0.25	0.30	0.025	

4. Why a gearbox is required in anautomobile?

- The variation of resistance to vehicle motion at different speeds
- The variation of tractive effort of the vehicle required at various speeds

For above said reasons, a gearbox is necessary in an automobile.

5. Mention the principle of operation of a distributor typepump.

In distributor systems, the fuel is metered at a central point. A pump which pressurizesthefuelalsometersthefuelandtimestheinjection.Thefuelpump

aftermeteringtherequiredamountoffuelsuppliesittoarotatingdistributorat thecorrecttimeforsupplytoeachcylinder.Thefuelisdistributedtocylinders incorrectfiringorderoperatedbypoppetvalveswhichareopenedtoadmitfuel to the nozzles. Distributor pumps use control sleeves for metering theinjected quantity. Thus they can be easily be made to work with an electronically controlled solenoidactuator.

6. Enlist the limitation of turbocharging?

Main limitation of the turbocharger is Turbo Lag. Turbo lag is the time between the demand for an increase in power (the throttle being opened) and the turbocharger providing increased intake pressure, and hence increased power. Turbo lag occurs because turbochargers rely on the buildup of exhaust gas pressure to drive the turbine.

7. Write the main requirements of an injectornozzle?

- To inject fuel at a sufficiently high pressure so that the fuel enters the cylinderwithahighvelocity.Thiscreatesfinerdropletsizeoffuel.The momentum of smaller droplets is less. Hence, penetration isalso.
- Penetration should not be high so as to impinge on cylinder walls which may results in poor starting.
- Fuel supply and cut-off should be rapid. There should be no dribbling.

8. What is Gasoline DirectInjection?

The gasoline (petrol) is directly into the cylinder at the end of compression strokeassuchindieselengines.ThisiscalledGasolineDirectInjection(GDI).

9. What is conventional ignitionsystem?

The conventional ignition system gets its electrical voltage either frombattery ordynamo,whichwillbeboostedtoaveryhighvoltageduetowhichsparkis produced in the cylinder to combust the mixture.

10. Define common rail injectionsystem.

A common rail which is maintaining high fuel pressure is connected to individual fuel injectors of a multi cylinder engine.

11. What is unit injectionsystem?

Itisanintegrateddirectfuelinjectionsystemfordieselengines,combiningthe injector nozzle and the injection pump in a singlecomponent.

12. What is a rotarydistributor?

The rotary distributor has a rotating element, which releases a high intensity spark to the individual spark plugs according to the engine firing order.

13. What is the function of a sparkplug?
The spark plug is a device to produce electric spark to ignite the compressed air-fuel mixture inside the cylinder.

14. What is an Electronic ignitionsystem?
The ignition system, in which the mechanical contact points are replaced by electronic triggering and switching devices, is known as electronic ignition system.

15. What are the functions of Turbochargers?

- To produce more power from the same size engine
- To provide the altitude compensation
- To improve more complete combustion & hence less emissions

16. Why the engine emissions to becontrolled?
Someoftheengineemissionsarecarcinogenic.Moreover,theengineemissions led to greenhouse effect. For these reasons, the engine emissions need to be controlled.

17. What are the advantages of petrolinjection?

- High power can be developed
- It has quick starting characteristics
- It has lowest specific fuel consumption
- Less engine emissions than carburetted engines

18. What is supercharging?
The process of increasing the density of inducted charge/ air is known as supercharging. It is performed for the following reasons.

- To produce more power from the same size engine
- To provide the altitude compensation
- To improve more complete combustion & hence less emissions

19. What is meant by carburetion in I.Cengine?
The method of preparing the air-fuel mixture in an IC engine is known as carburetion. The device used for this purpose is known as carburettor.

20. What are the advantages of electronic fuel injection systemover conventional injection?

- Cold starting is easier
- High fuel economy
- Less engineemissions
- Quick response to varying engine operating conditions

21. What are the functions of generator and startingmotor?
Thefunctionofthegeneratoristoproduceelectricitytochargethebattery.The starting motor is used to crank the engine during the startingcondition.

22. What is the function of an ignition system in I.Cengine?
The function of an ignition system is to ignite the air-fuel mixture at the end of the compression stroke.

23. State the requirements of ignition system? And state itstypes

- It should consume minimum of power and produce high intensity spark across spark plug electrodes
- It should have a sufficient spark duration which is sufficient to establish burning of air-fuel mixture under all operating conditions
- It should provide sufficient ignition energy over the entire speed range of the engine
- Good performance at high speed
- Longer life of contact breaker points and spark plug
- Adjustment of spark advance with speed and load

Types:

- Battery ignition
- Magneto ignition
- Electronicignition

24. What is the ignition advance?
When the speed of the engine increases, the ignition timing also needs to be advanced for proper combustion. This process is known as ignition advance.

25. What are the difference between battery coil ignition and magneto ignitionsystem?

BatteryIgnition	**MagnetoIgnition**
Battery is needed	No batteryneeded
Battery supplies current inprimarycircuit	Magneto produces the required current for primary circuit
A good spark is available atlow speed	During starting the quality of spark is poor due to slowspeed
Occupiesmorespace	Very much compact
Recharging is a must incase battery getsdischarged	No such arrangementrequired
forwhichitisrequiredtocranktheengine	Mostly employed in car and bus
	Used on motorcycles, scooters, etc
Battery maintenance is required	No battery maintenance problems

26. What is the sealed head lampsystem?

Asealedheadlampsystemisatypeofunitizedlampwithaparabolicreflector, one or more filaments and a glass or polycarbonate lens all permanently attached together andsealed.

27. What is the function ofcarburetor?

The function of a carburetor is to prepare the air-fuel mixture according to the engine operating conditions.

28. What are the merits and demerits of mono point and multi point fuel injectionsystem?

Mono PointFuelInjection	**Multi Point FuelInjection**
Single injectorissufficient	Separate fuel injector forindividual Cylinder
Low cost	Highcost
Low injection pressure	Comparatively higher injection pressure
Slightly higher SFC and emissionsthanMPFI	Low SFC and engine emissions

29. List the different methods of batterycharging.

- Constant current charging
- Constant voltage charging
- High ratecharging
- Slow ratecharging

30. State the principle of working of anA.C.Generator.

Thebasicprincipleofacgeneratoriselectromagneticinductionwhenacoilof aconductormovesinamagneticfieldtheelectronsinitstartsmovingbecause of attraction and repulsion of magnetic field. Thus, an emf is induced init.

31. In what respect does a Dynamo differ from anAlternator?

i). Dynamo produces Direct Current (DC), while Alternatorproduced Alternating Current (AC) which can be converted to DC using rectifiers.

ii). Alternator is lighter in construction than dynamo for the sameoutput.

32. What is the purpose of Stator in the TorqueConverter?

Thestatorresidesinthecenterofthetorqueconverter.Itsjobistoredirectthe fluidreturningfromtheturbinebeforeithitsthepumpagain.Thisdramatically increases the efficiency of the torqueconverter.

33. What are the components of lead acidbattery?

- Lead terminals
- Electrolyte

- Internal plates (positive and negative plates)
- Resilient Plastic container

34. What are the different types of starter motordrives?

- Bendix drive
- Overrunning drive
- Outboard drive

35. What are the chemicals used inbattery?

PbO_2 – Positive plate
Pb – Negative plate
Electrolyte – Diluted Sulphuric acid

36. What is a dry chargedbattery?

The battery is built, charged, washed and dried, sealed, and shipped without electrolyte.Itcanbestoredforupto18months.Whenputintouse,electrolyte and charging arerequired.

37. What is the purpose of thegrid?

Themore"plates"inthegrid,themoresurfaceareaexposedtotheelectrolyte, hence the more power produced.

38. Howwillyoudistinguishapositiveplatefromanegativeplateinalead acid battery?

The positive plates are coated with PbO2 and chocolate brown in colour
The negative plates are coated with spongy lead and grey in colour.

39. What is the function a cut out in a chargingsystem?

The cut out permits the current flow from dynamo/alternator to battery for charging while it does not permit the reverse flow of current.

40. What is the function of regulators in a chargingsystem?

- Currentregulator–regulatesthealternator/dynamocurrentforcharging the battery (constant current chargingmode)
- Voltage regulator – regulates the alternator/dynamo voltage for charging the battery (constant voltage charging mode)

41. What is meant by turbocharging?

Increasing the density of inducted charge/air by using a compressor which gets its power from exhaust driven turbine is known as Turbo charging.

42. Mention atleast two types of electronic ignition systems. (Apr/May 2018)

a) Capacitance discharge ignition system
b) Transistorized iginition system

43. Are Euro and Bharat norms the same? If not then the difference between them. (Apr/May 2018)

No, Both Euro and Bharat norms are not exactly the same even though the emission standards are same. The Bharat Stage norms have been styled to suit specific needs and demands of Indian conditions.The differences lie essentially in environmental and geographical needs. For instant, Euro 0-III is tested at sub-zero temperature in European countries whereas in India, the test is done between 24 to 28°C which is the average annual temperature ranges. Another major difference is in the maximum speed at which the vehicle is tested. A speed of 90 km/hr is stipulated for BS-III whereas it is 120km/hr for Euro-III.

44. Write the expansion of VGT type turbocharger and write the significant of it. (Nov/Dec 2018)

VGT – Variable Geometry Turbocharger.

It is possible to increase the charge air mass by about 10 to 20 % at a low speed range. As a result of this, the exhaust smoke is reduced and the fuel consumption is improved.

45. Compare the differences between MPFI and GDI systems.(Nov/Dec 2018)

MPFI	GDI
1.The fuel is injected into the intake manifold at low pressure	1. The fuel is injected directly into the combustion chamber at high pressure.
2.Inject fuel into each cylinder separately (via) Intake valve.	2.Gas is directly injected into engine cylinder with some pressure.
3.It is grouped into single point and multi point injection	3.It is grouped with port injection and throttle body injection

46. Decode TCIS and WGT.(Apr/May 2019)

47. Why a catalytic converter in a modern day IC engine is called three way catalytic converter. (Apr/May 2019).

A catalytic converter is a device which is placed in the vehicle exhaust systemtoreduceHCandCObyoxidizingcatalystandNObyreducing catalyst. It reduces the three emission , so it is called as three way catalytic converter.

The basic requirements of a catalytic converter are:

i. High Surface area of the catalyst for betterreactions.

ii. Goodchemicalstabilitytopreventanydeteriorationinperformance.

iii. Low volume heat capacity to reach the operating temperatures.

iv. Physical durability with attritionresistance.

PART-B

2. Discuss about CRDIsystem.

Common Rail Direct Injection System (CRDI)

Generally, diesel engines have the specific advantage of good fuel efficiency and low CO2 emissions. Therefore, the new various technologies have been developedinordertoreduceharmfulnessofemission.Oneofsuchtechnologies iscalledcommonrailsystemofdirectfuelinjection.Thissysteminjectsdiesel accurately five times more than the normal injection system by high response injectors with electronic control. It results the greater reduction of particulate matter and NO_x thereby improving fuel efficiency and increasing its torque. So, they lead to reduce engine noise andvibration.

A common rail system consists of pressure accumulator, called rail which is mounted along the engine block. The rail is fed by a high pressure multi-cylinder fuel pump. The injectors are activated by solenoid valves. Both the solenoid valves and fuel pump are electronicallycontrolled.

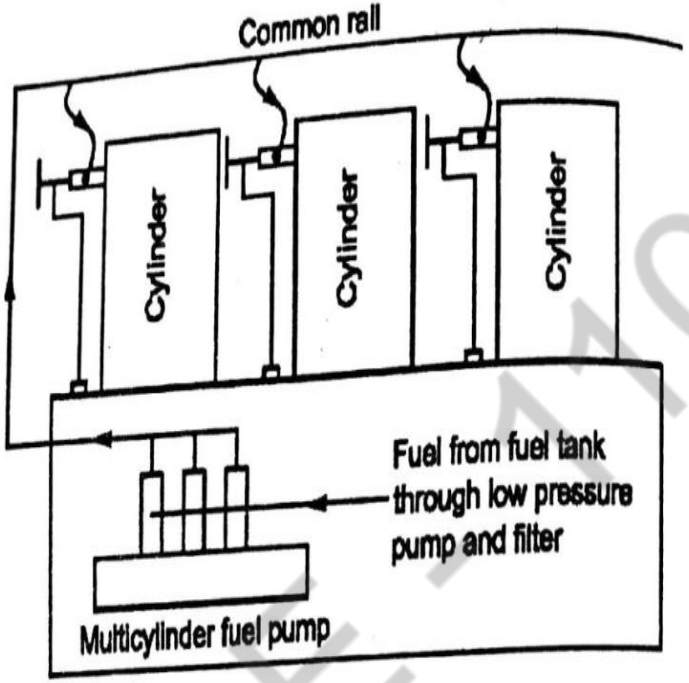


Figure 2.30 Common rail direct injection system

In the common rail injection system, the injection pressure does not depend on engine speed and load. So, the control of injection parameters is easier. Usually, a pilot injection is introduced in order to reduce in engine noise and NO_x emissions. The injectors use a needle and seat- type valve to control fuel flow. The fuel pressure is fed to both the top and bottom of the needle valve. The pressure on the bottom will push the needle off its seat by bleeding some of the pressure off the top. Thus, fuel will flow through the nozzleholes.

Common rail technology is a prerequisite for contiguous usage and greater viability of diesel-powered passenger cars in Europe and elsewhere. So, the common rail technology is always upgraded with Europe's upcoming EURO-4 emissions regulations.

3. Explain about the working principle of three way catalyticconvertor.

Catalytic converter:

- A catalytic converter is a device which is placed in the vehicle exhaust systemtoreduceHCandCObyoxidizingcatalystandNObyreducing catalyst.
- The basic requirements of a catalytic converter are:

i. High Surface area of the catalyst for betterreactions.

ii. Goodchemicalstabilitytopreventanydeteriorationinperformance.

iii. Low volume heat capacity to reach the operating temperatures.

iv. Physical durability with attritionresistance.

v. Minimum pressure drop during the flow of exhaust gases through the catalyst bed; this will not increase back pressure of theengine.

Fig. 2.171 shows a catalytic converter, developed by the Ford Company. It consists of two separate elements, one for NO_x and the other for HC/CO emissions.Thesecondaryairisinjectedaheadofthefirstelement.Theflowin the converter is axial.

Three-way, Two-way and noble metal catalytic converters:

1. Three-way catalytic converter:

Ifanengineisoperatedatalltimeswithanair-fuelratioclosetostoichiometric, then both NO reduction and CO and HC oxidation can be done in a single catalyst bed. The catalyst effectively brings the exhaust gas composition to a near equilibrium state at these exhaust conditions, i.e., a composition of CO_2, H_2O and N_2. Enough reducing gas will be present to reduce NO, and enough O_2 to oxidize the CO and hydrocarbons (HC). Such a converter is calledthree-

way catalytic converter, since it removes all the three pollutants. There is a narrow band of air-fuel ratios near stoichiometric in which high conversion efficiencies for all three pollutants are available. Commercial three-way catalystscontainplatinum,rhodiumwithsomeA_2O_3,NiOandCeO_2.Alumina is the preferred supportmaterial.

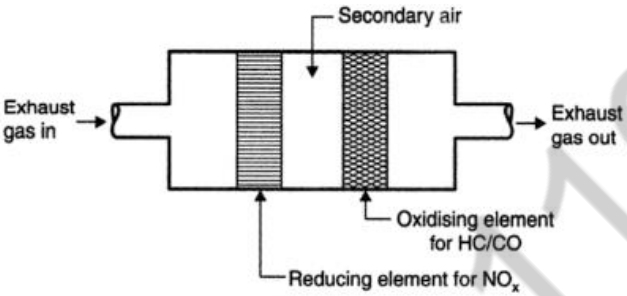


Fig. 2.171. Catalytic converter.

Oxidation catalytic reactions. CO HC and O_2 from air are catalytically converted to CO_2 and H_2O and number of catalysts are known to be effective noble metals like platinum and plutonium, copper, vanadium, iron, cobalt, nickel, chromium etc.

Reduction catalytic reactions. The primary concept is to offer the NO molecule an activation site, say nickel or copper grids in the presence of CO but not O_2 which will cause oxidation, to form N_2 and CO_2. The NO may react withametalmoleculetoformanoxidewhichtheninturn,mayreactwithCO to restore the metal molecule.

3. Discuss the construction and working of rotary distributor type diesel injectionsystem.

Rotary DistributorSystem

Figure 2.29 shows a schematic diagram of the rotary distributor system. In distributor systems, the fuel is metered at a central point. A pump which pressurizesthefuelalsometersthefuelandtimestheinjection.Thefuelpump aftermeteringtherequiredamountoffuelsuppliesittoarotationdistributorat thecorrecttimeforsupplytoeachcylinder.Thefuelisdistributedtocylinders incorrectfiringorderoperatedbypoppetvalveswhichareopenedtoadmitfuel to the nozzles. Distributor pumps use control sleeves for metering theinjected quantity. Thus they can be easily be made to work with an electronically controlled solenoidactuator.

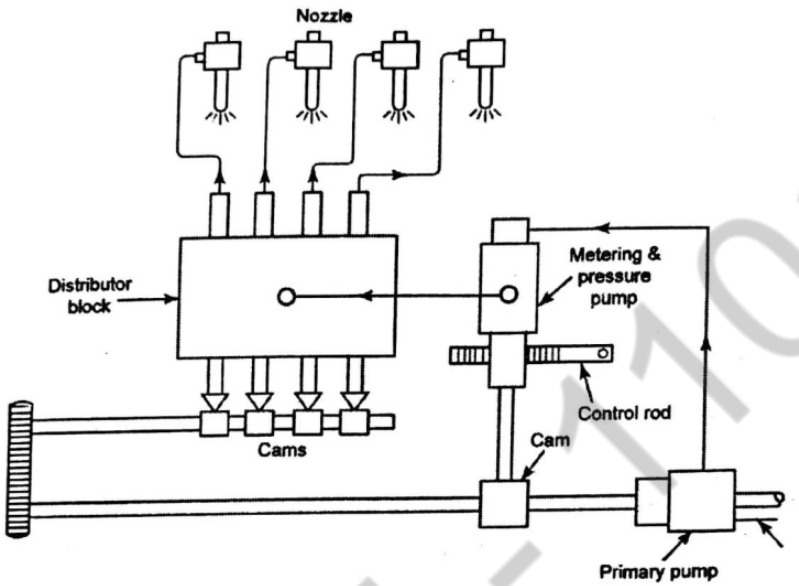


Figure 2.29 Distributor system

4. What are the advantages of Transistorizes coil ignition (TCI)system?
Transistorized ignitionsystem
A transistor interrupts a relatively high current carrying circuit. i.e.., controls a high current in the collector circuit with a small current the base circuit. Therefore,atransistorisusedtoassisttheworkofcontactbreaker.Hencethis system is known as Transistor-assist ignition system or transistorized ignition system.

Construction:
It consists of battery, ignition switch, transistor, collector, emitter, ballast resistor, contact breaker, ignition coil, distributor and spark plugs. Theemitter of the transistor is connected to the ignition on through a ballast resistor. Collector is connected to thebattery.

Working:
The cam in the distributor is rotated by the engine. This opens and closes the contact breaker points.

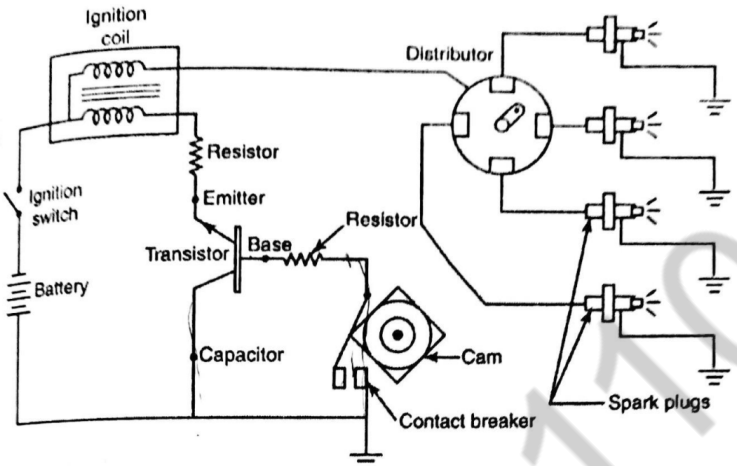


Figure 2.37 Transistorised ignition system

When the contact breaker points are closed:

1. A small current flows in the base circuit of thetransistor.
2. Alargecurrentflowsintheemitterorcollectorcircuitofthetransistor and the primary winding of the ignition coil due to the normal transistor action.
3. A magnetic field is set up in the primary winding of thecoil.

When the contact breaker points are open:

1. The current flow in the base circuit isstopped.
2. The primary current and the magnetic field in the coil collapse suddenly due to the immediate reverting of the transistor to the non-conductivestate.
3. This produces a high voltage in the secondarycircuit.
4. Thishighvoltageisdirectedtotherespectivesparkplugsthroughthe rotor of thedistributor.
5. This high voltage produces a spark when it is tried to jump the spark plug gap. This ignites air-fuel mixture in thecylinder.

Advantages:

1. It increases the life of contact breaker points.
2. It gives higher ignition voltage.
3. It gives longer duration ofspark.
4. It has very accurate control of timing.
5. Less maintenance.

Disadvantages:

1. Mechanical points are needed as in conventionalsystem.
2. It has a tendency to sidetracking.

5. Sketch and explain the Capacitive Discharge Ignitionsystem.

Capacitive Discharge Ignition system

CDI (capacitive discharge ignition) ignition is most widely used today on automotive and marine engines. A CDI module has capacitor storage of its own and sends a short high voltage (about 250+ volts) pulse through the coil. The coil now acts more like a transformer and multiplies this voltage even higher. Modern CDI coils step up the voltage about 100:1. So, a typical 250V CDI module output is stepped up to over 25,000V output from the coil. The CDI output voltage of course can be higher.

The huge advantage of CDI is the higher coil output and hotter spark. The spark duration is much shorter (about 10-12 microseconds)

6. Describe the working of distributor type fuel pump with asketch.

Rotary DistributorSystem

Figure 2.29 shows a schematic diagram of the rotary distributor system. In distributor systems, the fuel is metered at a central point. A pump which pressurizesthefuelalsometersthefuelantimestheinjection.Thefuelpump aftermeteringtherequiredamountoffuelsuppliesittoarotatingdistributorat thecorrecttimeforsupplytoeachcylinder.Thefuelisdistributedtocylinders incorrectfiringorderoperatedbypoppetvalveswhichareopenedtoadmitfuel to the nozzles. Distributor pumps use control sleeves for metering theinjected quantity. Thus they can be easily be made to work with an electronically controlled solenoidactuator.

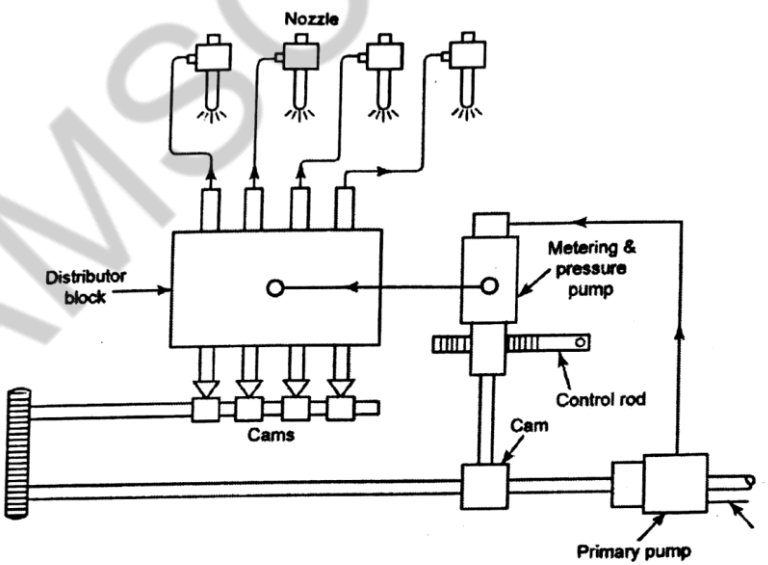


Figure 2.29 Distributor system

7. Explain the function of various components of an electronically controlled gasoline injectionsystem.

Working of Electronically Controlled Gasoline Injection System

In electronically controlled gasoline injection system for SI engines, fuel supply and timings are controlled by electronic means. Electronic fuel injection has developed with the development of solid-state electronicdevices such as diodes and transistors. Recent days, these systems are commonlyused as they function quickly and respond automatically to the change in manifold airpressure,enginespeed,crankshaftangleandmanyothersecondaryfactors. This system is developed by Robert Bosch Corporation. Figure 2.27 shows on electronic gasoline injection system of Bosch L-type. It consists of the following four units:

i. Fuel deliverysystem
ii. Air inductionsystem
iii. Sensors and air flow controlsystem
iv. Electronic control unit.

i. Fuel deliverysystem:

The reason for using gasoline fuel injection is to control the air-fuel ration of the engine more precisely. This system consists of an electrically driven fuel pump which draws fuel from the fuel tank through filter and forces it into the pressure line. At the end of the pressure line, fuel pressure regulator is placed. Thefuelpressureregulatorisconnectedtotheintakemanifold.Thepressureis keptconstantbythisregulatorsothatthequantityoffuelinjectedisdependent only on the injection open time. In this Bosch L-type system, fuel metering is controlled by engine speed and by measuring the intake airflow.

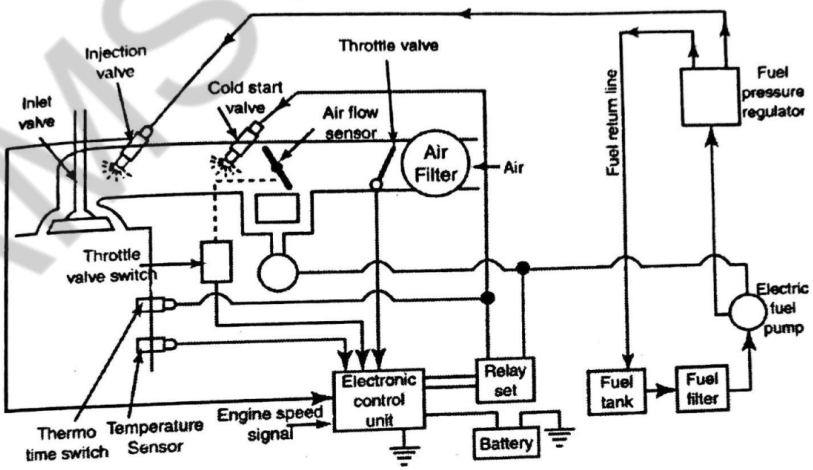


Figure 2.27 Electronic gasoline injectionsystem

ii. Air inductionsystem:

The incoming air from atmosphere flows initially through air filter and then throughairflowsensor.Thisairflowsensormeasurestheamountofairflowin the manifold and generates a voltage signal which is dependent on theamount of air flow. The air flow meter consists of a rectangular plate which turns in a rectangular shaped channel to a defined angular position dependent on the pressurefromtheflowingair.Itreturnsbacktooriginalpositionduringnormal condition by using a spiral coilspring.

iii. Sensors and air flow controlsystem:

Typical sensors used in electronic gasoline injection system are as follows:

i. **Air flow sensor:** A sensor used to tell the ECU how much air is being drawn into the intake manifold for adjusting the quantity of fuel.

ii. **Intakeairtemperaturesensor:**Thissensormeasuresthetemperatureof the intake air for fine tuning the mixture strength.

iii. **Exhaust gas oxygen (EGO) sensors**: A sensor located in the exhaust system which tells the ECU the amount of oxygen in the exhaust gases, from this the ECU can determine if the air/fuel ratio is correct.

iv. **Manifold absolute pressure (MAP) sensor**: This senses the vacuum pressure in the engines inlet manifold, this gives an indication of the load the engine is workingunder.

v. **Speed/crankshaft sensor**: This tells the ECU has fast the engine is rotating and sometimes the position of thecrankshaft.

vi. **Engine Temperature sensor**: This sensor senses the temperature of the coolant in the engine. Coolant temperature is used determine if more fuel is needed when the engine is cold or warmingup.

vii. **Crankshaft position sensor**: The ECU needs to know how fast the engine's spinning and where the crankshaft is in its rotation. This lets the ECU fire the spark and injectors at the righttime.

viii. **Knocksensor**:Theknocksensorisamicrophonetypesensorthatdetects thesoundsofknocking(detonation)sothatignitiontimingcanberetarded.

Acoldstartvalveisfittedjustbehindtheinjectionvalvetoinjectadditionalfuel for cold start. This valve has exceptionally good atomization characteristics. The operation of cold start valve is controlled by a thermo time switch sensor to ensure cold start up to 33°C. The extra fuel needed by ordinary startingand warm up period is also supplied by thisvalve.

After cold start, the additional air required with richer air-fuel mixture is supplied by an auxiliary air valve during idling condition which by-passes the throttle valve. This is the additional idling speed. The opening of the air valve varies as a function of the engine temperature.

A throttle valve switch is attached to the throttle valve. This is equipped withasetofcontactswhichgeneratesasequenceofvoltagesignalsduring opening of the throttle valve. This signal results in injection ofadditional

fuel required for acceleration through electronic control unit.

iv. Electronic control unit (ECU):

It is the heart of fuel injection system. This contains a computer which takes informationfromsensorsandcontrolstheamountoffuelinjectedbyoperating the injectors for just the right amount of time. The unit contains a number of printed circuit boards on which a series of transistors, diodes and other electronic components are mounted. This makes vital data analysis circuits respond to various input signals. The data measured in the form of signals by various sensors such as manifold air pressure, engine speed, crank angle, oxygen in exhaust .

8. Draw the layout of an electronically controlled ignition system and mention the function of each component.

Electronic Ignition System

There are some drawbacks in the above discussed magneto ignition system. Firstly, the contact breaker points will wear out or burn when it is operated with heavy current.

Secondly, the contact breaker is only a mechanical device which cannot operate precisely at higher speed due to the reason that the dwell period is not sufficientforbuildingupthemagneticfieldtoitsfullvalueatthatspeeds.The conventional contact breaker can give satisfactory performance only at about 400sparkspersecondwhichlimitstheenginespeed.Atlowspeeds,relatively highcurrentisdrawnfromthebatteryduetothecontactsremainingclosedfor longer time. Thus, the system becomes inefficient at lowspeeds.

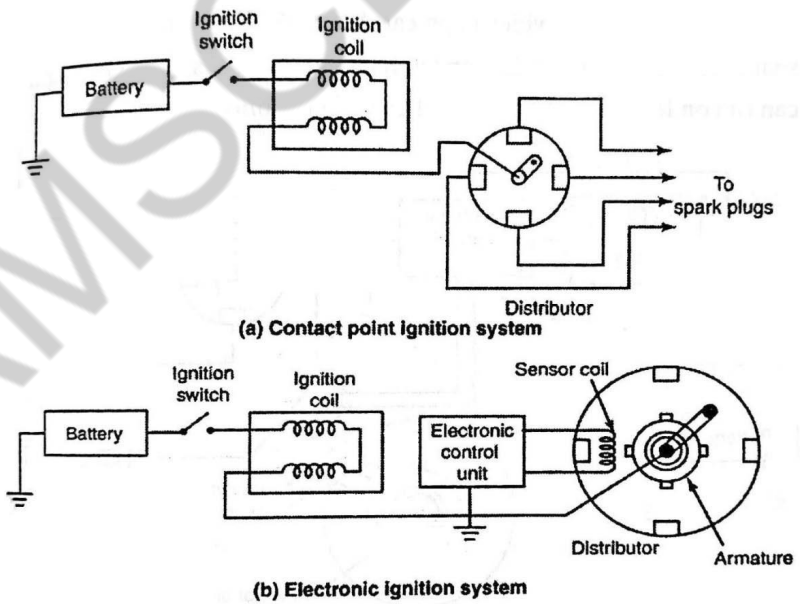


Figure 2.34 Difference between contact point and electronic ignition system

The disadvantages of the convention contact breaker assisted ignition system can be completely eliminated by the use of electronic controlled ignition system using contactless triggers to give timing system.

Thebasicdifferencebetweencontactpointandtheelectronicignitionsystems is in the primary circuit. In the contact breaker system, the primary circuit is opened and closed by the electronic control unit as shown in Figure 2.34. The secondary circuits are practically same as the previoussystems.

In secondary circuit, the distributor, ignition coil, and wiring are altered to handle the higher voltage that the electronic ignition system produces. The high voltage (about 47,000volts) has the advantage that the spark plugs with wider gaps can be used. This result in a longer spark which can ignite leaner air-fuelmixtures.Asaresult,enginescanrunonleanermixturesforbetterfuel economy.

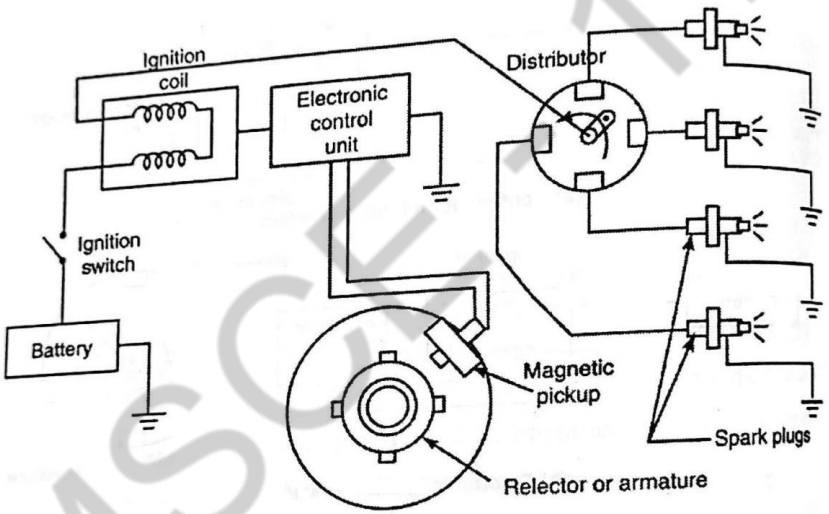


Figure 2.35 Electronic ignition system

Construction:

A schematic diagram of an electronic ignition system is shown in Figure

It consists of a battery, ignition switch, electronic control unit, magnetic pick-up, reluctor or armature, ignition coil, distributor and spark plugs. The constructionofbattery,ignitionswitch,ignitioncoil,distributorandspark plug issameaspreviousmethods.Inthissystem,amagneticpick-upisusedinstead of contact breaks points in conventional system. Also cam is replaced by a reluctor or armature.

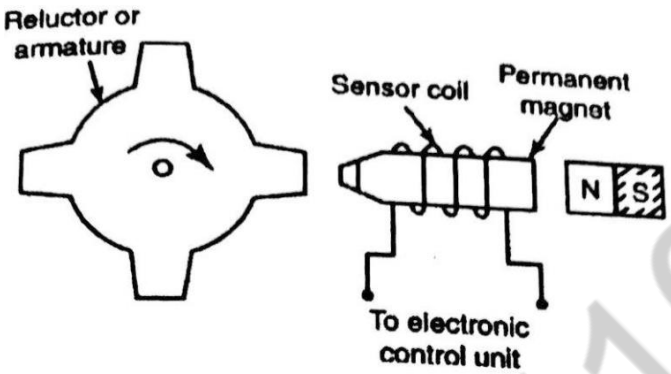


Figure 2.36 Magnetic pickup control unit

The magnetic pick-up is shown in Figure 2.36. It consists of a sensor coil throughwhichpassesthemagneticfluxisgeneratedbyapermanentmagnet.A starshapedrotorcalledreluctororarmatureismountedonthedistributorshaft whichmodulatesthefluxdensityinthecoilandduetotheconsequentchanges in the flux voltage induced in thecoil.

Thisvoltageservesasatriggersignalforthehighvoltagegeneratorcircuit. Since there is one spark plug per cylinder, the number of teeth of armature is equal to the number of engine cylinders.

Working:

When the ignition switch is closed (i.e. switch is 'ON'.), the reluctor rotates which makes the teeth of the reluctor cone closer to the permanent magnet. This reduces the air gap between the reluctor tooth and the sensor coil. Thus, the reluctor provides a path for the magnetic lines from the magnet. The magnetic field is passed on to the pick up every time when the reluctor teeth pass the pickup coil in which an electric pulse is generated. This small current thentriggerstheelectroniccontrolunitwhichstopstheflowofbatterycurrent to the ignition coil. The magnetic field in the primary winding collapses and thehighvoltageisgeneratedinthesecondarywinding.Thisledtothesparkin spark plug via distributor. Meanwhile, the reluctor teeth pass past the pickup coil. Therefore, the pulse unit is ended. This causes the electronic control unit to close the primary circuit.

Advantages:

1. The parts such as reluctor, magnetic pickup and electronic control module are not subjected to wear as in case of mechanical contact breaker.

2. Periodic adjustment of engine timing is notnecessary.
3. It gives very accurate control of timing.

9) What is CRDI? Explain in detail with relevantsketch.

Common Rail Direct Injection System(CRDI)

In Common Rail Direct Injection, commencement of combustion takes place directly into the main combustion chamber; which is located in a cavity on the top of the piston crown. Today, manufacturers use CRDi technology to overcome some of the deficiencies of conventional diesel engines which were sluggish, noisy and poor in performance; when implemented, especially in passengervehicles.ACommonRailsystemusesa'common-for-all-cylinders' fuel-rail or in simple words a 'fuel distribution pipe'. It maintains optimum residualfuelpressureandalsoactsasasharedfuelreservoirforalltheinjectors. In CRDi system, the fuel-rail constantly stores and supplies the fuel to the solenoid valve injectors at the required pressure. This is quite opposite to the fuelinjectionpumpsupplyingdieselthru'independentfuellinestoinjectorsin case of earlier generation (DI)design.

Generally, diesel engines have the specific advantage of good fuel efficiency and low CO_2 emissions. Therefore the new various technologies havebeendevelopedinordertoreduceharmfulnessofemissions.Oneofsuch technologiesiscalledcommonrailsystemofdirectfuelinjection.Thissystem injects diesel accurately five times more than the normal injection system by high response injectors with electronic control. It results the greater reduction ofparticulatematterandNO_xtherebyimprovingfuelefficiencyandincreasing its torque. So, they lead to reduce engine noise andvibration.

A common rail system consists of pressure accumulator, called rail which is mounted along the engine block. The rail is fed by a high pressure multi-cylinder fuel pump. The injectors are activated by solenoid values. Both the solenoid values and fuel pump are electronically controlled.

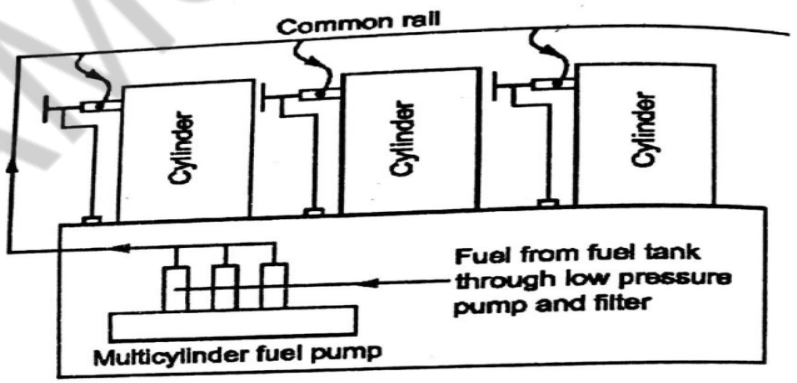


Figure 2.30 Common rail direct injection system

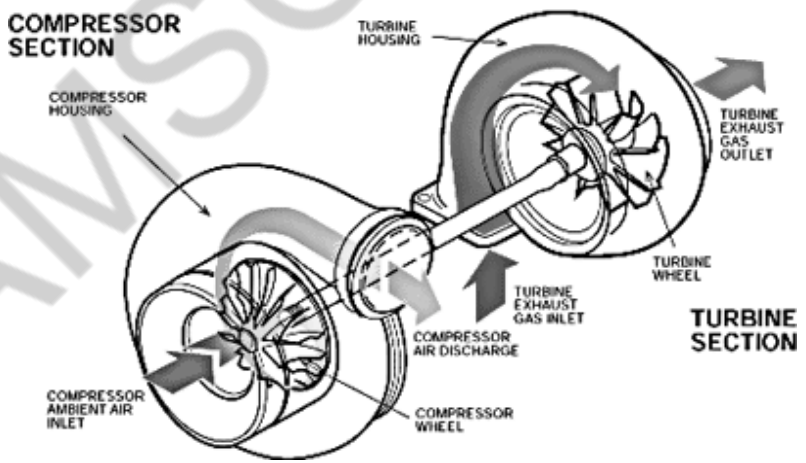
In the common rail injection system, the injection pressure does not depend on engine speed and load. So, the control of injection parameters is easier. Usually, a pilot injection is introduced in order to reduce in engine noise and NO_x emissions. The injector use a needle and seat – type value to control fuel flow. The fuel pressure is fed to both the top and bottom of the needle off its seat by bleeding some of the pressure off the top. Thus will flow through the nozzle holes.

Working of CRDi –A high-pressure pump generates pressurised fuel. The pump compresses the fuel at the pressures of about 1,000 bar or about 15,000 psi.Itthen,suppliesthepressurisedfuelviaahigh-pressurepipetotheinletof the fuel-rail. From there, the fuel-rail distributes it to the individual injectors; which then, inject it into the cylinder's combustionchamber.

Most modern CRDi engines use the Unit-Injector system with Turbocharger, which increases power output and meets stringent emission norms. This improves engine power, throttle response, fuel efficiency and controls emissions. Barring some design changes, the basic principle & working of the CRDi technology remains primarily the same across the board. However, its performance depends mainly on the combustion chamber design,fuel pressures and the type of injectorsused.

Common rail technology is a prerequisite for contiguous usage and greater viability of diesel – powered passenger cars in Europe and elsewhere. So, the common rail technology is always upgraded with Europe's upcomingEUROP – 4 emissions regulations.

10, Explain the working principle ofTurbochargers.



Turbochargers are a type of **forced induction system**. They **compress** the air flowing into the engine The advantage of compressing the air is that it lets theenginesqueezemoreairintoacylinder,andmoreairmeansthatmore

fuel can be added. Therefore, you get more power from each explosion in each cylinder. A turbocharged engine produces more power overall than the same engine without the charging. This can significantly improve the power-to-weight ratio for the engine In order to achieve this boost, the turbocharger uses the exhaust flow from the engine to spin a **turbine**, which in turn spins an **air pump**. The turbine in the turbocharger spins at speeds of up to150,000 rotationsperminute(rpm)--that'sabout30timesfasterthanmostcarengines cango.Andsinceitishookeduptotheexhaust,thetemperaturesintheturbine are also very high.

Basics One of the surest ways to get more power out of an engine is to increasetheamountofairandfuelthatitcanburn.Onewaytodothisistoadd cylinders or make the current cylinders bigger. Sometimes these changes may not be feasible -- a turbo can be a simpler, more compact way to add power, especially for an aftermarketaccessory.

Turbochargers allow an engine to burn more fuel and air by packing more into the existing cylinders. The typical boost provided by a turbocharger is 6 to 8 pounds per square inch (psi). Since normal atmospheric pressure is 14.7 psiatsealevel,youcanseethatyouaregettingabout50percentmoreairinto theengine.Therefore,youwouldexpecttoget50percentmorepower.It'snot perfectlyefficient,soyoumightgeta**30-to40-percentimprovement**instead.

One cause of the **inefficiency** comes from the fact that the power to spin the turbineisnotfree.Havingaturbineintheexhaustflowincreasestherestriction in the exhaust. This means that on the exhaust stroke, the engine has to push against a higher back-pressure. This subtracts a little bit of power from the cylinders that are firing at the sametime.

The turbocharger also helps at **high altitudes**, where the air is less dense. Normal engines will experience reduced power at high altitudes because for each stroke of the piston, the engine will get a smaller mass of air. A turbocharged engine may also have reduced power, but the reduction will be less dramatic because the thinner air is easier for the turbocharger topump.

Oldercarswithcarburetorsautomaticallyincreasethefuelratetomatchthe increasedairflowgoingintothecylinders.Moderncarswithfuelinjectionwill also do this to a point. The fuel-injection system relies on oxygen sensors in theexhausttodetermineiftheair-to-fuelratioiscorrect,sothesesystemswill automatically increase the fuel flow if a turbo isadded.

If a turbocharger with too much boost is added to a fuel-injected car, the system may not provide enough fuel -- either the software programmed into the controller will not allow it, or the pump and injectors are not capable of supplying it. In this case, other modifications will have to be made to get the maximum benefit from the turbocharger.

The turbocharger is bolted to the **exhaust manifold** of the engine. The exhaust from the cylinders spinsthe **turbine**, which works like a gas turbine engine.Theturbineisconnectedbyashafttothe**compressor**,whichislocated

between the air filter and the intake manifold. The compressor pressurizes the air going into the pistons.

The exhaust from the cylinders passes through the **turbine blades**,causing the turbine to spin. The more exhaust that goes through the blades, the faster theyspin.

Ontheotherendoftheshaftthatheturbineisattachedto,the**compressor** pumpsairintothecylinders.Thecompressorisatypeofcentrifugalpump -- it draws air in at the center of its blades and flings it outward as it spins. In order to handle speeds of up to 150,000 rpm, the turbine shaft has to be supported very carefully. Most bearings would explode at speeds like this, so mostturbochargersusea**fluidbearing**.Thistypeofbearingsupportstheshaft on a thin layer of oil that is constantly pumped around the shaft. This serves two purposes: It cools the shaft and some of the other turbocharger parts, and it allows the shaft to spin without much friction. There are many tradeoffs involved in designing a turbocharger for anengine.

11..List down the advantages of using gasoline fuel injection system over the carburetedsystem.

Following are the drawbacks of simple carburetor
The Drawbacks of a Simple Carburetor

1) At a very low speed, the mixture supplied by a Simple Carburetor is so weak that it will not ignite properly and for its enrichment, at such conditionssomearrangementinthecarburetorisrequiredtobemade.

2) The working of simple carburetor is affected by changes of atmospheric pressure.Carburetorsusedinaircraftaretobeprovidedwithaltitudecontrol, astherichmixtureisunnecessarilyavailable,duetolessdensityofair.

3) The working of simple carburetor is affected by changes of atmospheric temperature. If the setting is done in winter season, it will be found to give too rich mixture in the summer. This is happened due to less density of airwiththeriseoftemperaturetoagreaterextentthanthedensityoffuel.

4) It gives the proper mixture at only one engine speed and load, therefore, suitableonlyforenginesrunningatconstantspeedincreaseordecrease ,the quantity of fuel issuing out will change and not match the velocity of air flowing through the venturi and proper mixture is not take place. To overcome this various modifications have to be made in simple carburetor.

5) Insimplecarburetor,themixtureisweakenedwhenthethrottleissuddenly opened because of Inertia effect of the fuel which prevents the proper quantity of fuel from flowingimmediately.

These drawbacks are somewhat removed by some improved designs such as air bleed method, acceleration compensation method etc.

MPFI solves most of the issues giving following advantages;

Improved Fuel Consumption

- Vehicles with dual point fuel injection or carburetors do not get nearly the fuel economy of those with multi-point fuel injection. The underlying reason is that fuel delivery systems of these older vehicles are less precise. A multi-point fuel injection system, which uses one fuel injector for each cylinder of the engine, delivers just the right amount of gas to each cylinder. Thus, gas is not wasted in the process. Overtime,thegassavedwithamulti-pointfuelinjectionsystemsaves the vehicle owner loads of money.

Emissions

- Emissions test results are an important factor today. A car from this century emits a small fraction of what a vehicle emitted even a few decades ago. Multi-point injection systems are better for the environment because the emissions of hazardous chemicals being released when fossil fuels are burned are minimized. As mentioned above,themoreprecisedeliveryoffueltotheenginemeansthatfewer noxious byproducts are released when the fuel combusts within the engine. The implements within the engine meant to clean the exhaust have been fine-tuned in a multi-point system to work more efficiently. Therefore, the engine--and the air--is cleaner as a result of multi-point systems.

Better Performance

- The performance of an engine suffers with the use of a carburetor, but multi-pointfuelinjectionallowsforfarbetterengineperformance.This is due to a few factors. Instead of allowing for additional air intake, multi-pointinjectionatomizestheairthatistakenthroughasmalltube. Becausemulti-pointinjectorsareusuallycontrolledbycomputers,each functionofacarburetorisperformedbyadifferentsystemcomponent. These systems also improve the cylinder-to-cylinder distribution of an engine, which allows it to conserveenergy.

13. Explain with a sketch the functioning of a capacitive discharge ignition system. List its merits over a transistorized coil ignition system. (Apr/May 2018)

A transistor interrupts a relatively high current carrying circuit. i.e.., controls a high current in the collector circuit with a small current the base circuit. Therefore,atransistorisusedtoassisttheworkofcontactbreaker.Hencethis system is known as Transistor-assist ignition system or transistorized ignition system.

Construction:

It consists of battery, ignition switch, transistor, collector, emitter, ballast resistor, contact breaker, ignition coil, distributor and spark plugs. Theemitter of the transistor is connected to the ignition on through a ballast resistor. Collector is connected to thebattery.

Working:

The cam in the distributor is rotated by the engine. This opens and closes the contact breaker points.

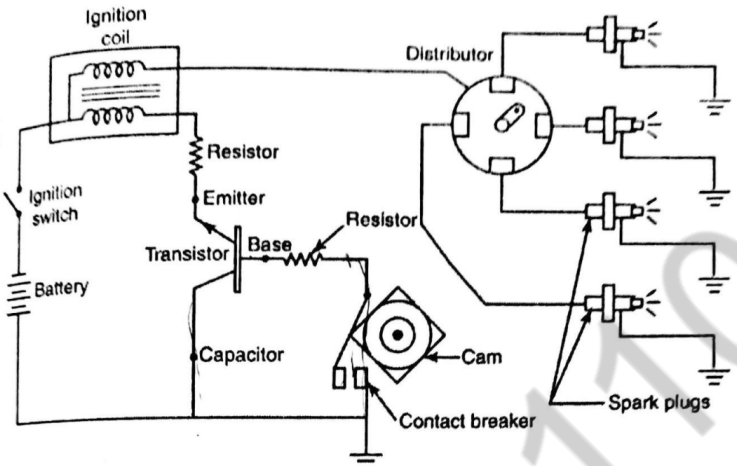


Figure 2.37 Transistorised ignition system

When the contact breaker points are closed:

4. A small current flows in the base circuit of thetransistor.
5. Alargecurrentflowsintheemitterorcollectorcircuitofthetransistor and the primary winding of the ignition coil due to the normal transistor action.
6. A magnetic field is set up in the primary winding of thecoil.

When the contact breaker points are open:

6. The current flow in the base circuit isstopped.
7. The primary current and the magnetic field in the coil collapse suddenly due to the immediate reverting of the transistor to the non-conductivestate.
8. This produces a high voltage in the secondarycircuit.
9. Thishighvoltageisdirectedtotherespectivesparkplugsthroughthe rotor of thedistributor.
10. This high voltage produces a spark when it is tried to jump the spark plug gap. This ignites air-fuel mixture in thecylinder.

Advantages:

6. It increases the life of contact breaker points.
7. It gives higher ignition voltage.
8. It gives longer duration ofspark.
9. It has very accurate control of timing.
10. Less maintenance.

Disadvantages:

3. Mechanical points are needed as in conventionalsystem.
4. It has a tendency to sidetracking.

14. With the help of an illustration. Explain the working of a port fuel injection system in a SI engine. Mentions its merits and demerits with regards to throttle body injection.(Apr/May 2918)

In a petrol injection system, the fuel is injected into the intake manifold through fuel injection valve. The are two basic gasoline injection systems

i) Multi point injection

ii) Mono point injection.

Multipoint fuel injection system:

It is also called port injection system. In this system there is an injection valve for each engine cylinder. Each injection valve is placed in the intake port near the intake valve. The main advantages of the system is it allows more time for mixing of petrol and air

Mono point injection system:

It is also called throttle body injection systems. In this systems an injection valve is positioned slightly above each throat of a throttle body. The injection valves sprays fuel into the air just before it passes through the throttle valve and enters the intake manifold. This method simply the construction of a cylinder block. It does not obstruct hot spot near the valve affect in cooling water jacket size at that place. It simply the construction of electronic control units, Thus it reduces the cost of the system.

16. Elaborate about the working of a rotary distributor type diesel injection system with a neat sketch. (Nov/Dec 2018)

9. Rotary DistributorSystem

Figure 2.29 shows a schematic diagram of the rotary distributor system. In distributor systems, the fuel is metered at a central point. A pump which pressurizesthefuelalsometersthefuelandtimestheinjection.Thefuelpump aftermeteringtherequiredamountoffuelsuppliesittoarotatingdistributorat thecorrecttimeforsupplytoeachcylinder.Thefuelisdistributedtocylinders incorrectfiringorderoperatedbypoppetvalveswhichareopenedtoadmitfuel to the nozzles. Distributor pumps use control sleeves for metering theinjected quantity. Thus they can be easily be made to work with an electronically controlled solenoidactuator.

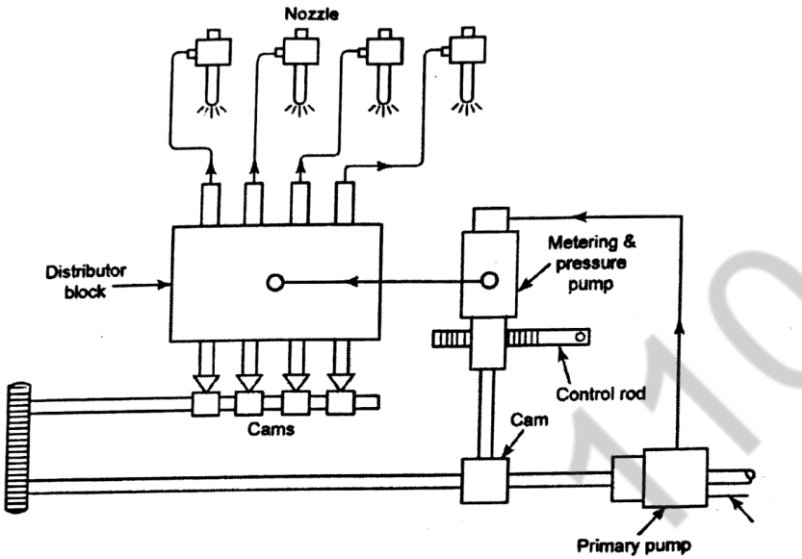


Figure 2.29 Distributor system

17. (i) With the aid of a cutaway sketch explain about the working of a three way catalytic converter used in vehicles. (Nov/Dec2018)

(ii) write down the various chemical reactions relevant to emission control in a three way catalytic converter.

(i)Catalytic converter:

- A catalytic converter is a device which is placed in the vehicle exhaust systemtoreduceHCandCObyoxidizingcatalystandNObyreducing catalyst.
- The basic requirements of a catalytic converter are:

i. High Surface area of the catalyst for betterreactions.

ii. Goodchemicalstabilitytopreventanydeteriorationinperformance.

iii. Low volume heat capacity to reach the operating temperatures.

iv. Physical durability with attritionresistance.

v. Minimum pressure drop during the flow of exhaust gases through the catalyst bed; this will not increase back pressure of theengine.

Fig. 2.171 shows a catalytic converter, developed by the Ford Company. It consists of two separate elements, one for NO_x and the other for HC/CO emissions.Thesecondaryairisinjectedaheadofthefirstelement.Theflowin the converter is axial.

Three-way, Two-way and noble metal catalytic converters:

1. Three-way catalytic converter:

Ifanengineisoperatedatalltimeswithanair-fuelratioclosetostoichiometric, then both NO reduction and CO and HC oxidation can be done in a single catalyst bed. The catalyst effectively brings the exhaust gas composition to a near equilibrium state at these exhaust conditions, i.e., a composition of CO_2, H_2O and N_2. Enough reducing gas will be present to reduce NO, and enough O_2 to oxidize the CO and hydrocarbons (HC). Such a converter is calledthree-

way catalytic converter, since it removes all the three pollutants. There is a narrow band of air-fuel ratios near stoichiometric in which high conversion efficiencies for all three pollutants are available. Commercial three-way catalyststcontainplatinum,rhodiumwithsomeA_2O_3,NiOandCeO_2.Alumina is the preferred supportmaterial.

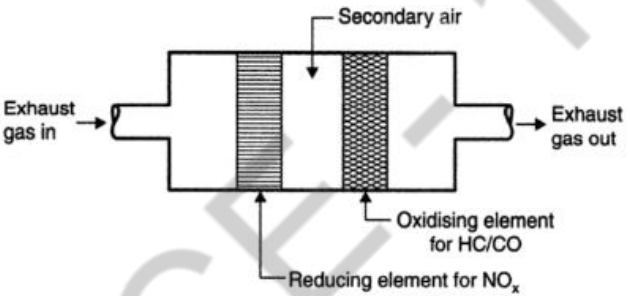


Fig. 2.171. Catalytic converter.

(ii) Oxidation catalytic reactions. CO HC and O_2 from air are catalytically converted to CO_2 and H_2O and number of catalysts are known to be effective noble metals like platinum and plutonium, copper, vanadium, iron, cobalt, nickel, chromium etc.

Reduction catalytic reactions. The primary concept is to offer the NO molecule an activation site, say nickel or copper grids in the presence of CO but not O_2 which will cause oxidation, to form N_2 and CO_2. The NO may react withametalmoleculetoformanoxidewhichtheninturn,mayreactwithCO to restore the metal molecule.

18. i)Explain with a sketch the functioning of a three wat catalytic converter (.Apr/May 2019)

ii)Briefly discuss the operation of a turbocharger and its merits.

i) For answer refer question No. 3

ii) For answer refer question No 9

19. With the help of an illustration explain the working of a gasoline direct injection system in a SI engine. Mention its merits and demerits

with regards to port fuel injection (Apr/May 2019).

For answer refer question No, 7 page No 38

3

TRANSMISSION SYSTEMS

PART-A

1. What is the function of clutch?

The function of the clutch is to connect and disconnect the engine with road wheels. The clutch has to be disengaged during gear shifting, idling etc.

2. What are the types of clutch?

Friction clutches

- Single plate clutch
- Multi plate clutch
- Cone clutch
- Semi centrifugal clutch
- Centrifugal clutch

Fluid clutches

- Fluid flywheel

3. State the requirements of an automotiveclutch

- Torque transmission should be maximum
- Gradual engagement of clutch plates
- Heat dissipation should be more
- Dynamic balancing of clutch components
- Vibration damping
- Size should be small
- Inertia should below
- Clutch free pedal play should be sufficient
- Ease of operation

4. What is the function of gear box? State its types.
The functions of the gearboxare

- To provide the leverage ratio
- To provide the neutral position
- To provide a means to reverse the vehicle.

Types

- Sliding mesh gearbox
- Constant mesh gearbox
- Synchromesh gearbox
- Automatic gearbox – Torque converter

5. Why is gear box necessary inautomobile?

- The variation of resistance to vehicle motion at different speeds
- The variation of tractive effort of the vehicle required at various speeds

For above said reasons, a gearbox is necessary in an automobile.

6. What is tractive effort?
It is the force available at the road wheels for propelling the vehicle.

$$T = \mu W$$

Where, T = Tractive effort
μ – Coefficient of friction between tyre and road surface
W – Load of the vehicle

7. Why is sliding mesh gear box notpreferred?

- More noise
- More wear and tear on the gears
- For smooth, quiet and quick change of gears, the driver requires great skill

For the above-said drawbacks, the sliding mesh gearbox is generally not preferred.

8. What is automatic transmission?
In the automatic transmission, for changing the gear ratios, manual effort is not at all needed. The change of gear is performed automatically according to the vehicle speed.

9. What is an overdrive?
When the speed of the output shaft is greater than the speed of the input shaft, then the drive is known as overdrive.
Example: 0.8:1 or 0.9: 1

10. What is a universal joint? What are itstypes?

Universaljointisatypeofflexiblejointbetweentwoshaftswhoaxesintersect and may assume different inclinations at different times. It is used to transmit power even at inclined angles of theshaft.

Types

- Yoke joint
- Single cardan joint
- Double cardan joint
- Rag joint
- Canfield joint

12. State the functions of a slipjoint.

The function of a slip joint is to accommodate the propeller shaft length variations, when a vehicle is moving over a bump or bit.

13. What is the necessity of a propellershaft?

The propeller shaft is used to transmit the power from the gearbox to the final drive. It is also used to cover the span between these twocomponents.

14. What is Hotchkiss drive and Torque Tubedrive?

- In Hotchkiss drive, the loads such as vehicle weight, driving torque, braking torque and side thrust all are taken by leaf springs. Two universal joints and one slip joint are must needed.
- In Torque tube drive, the driving torque and braking torque are taken by torque tube while the vehicle weight and side thrust are taken care of by leaf springs. One universal joint is just sufficient.

15. What is the function of differentialunit?

The function of a differential unit is to permit the vehicle turns without wheel skidding. It permits higher speed for outer wheels and reduced speedfor inner wheels duringturning.

16. What is the function of pressure plate in aclutch?

The function of a pressure plate is to hold the friction (clutch) plate tightly against the engine flywheel.

17. What is meant by differentiallock?

A Differential lock will transmit the same amount of power to both wheels on the axle - which is very useful in 4WD applications where a truck might be stuck and have problems getting out of deep mud or snow.

18. What is a fluidcoupling?
Fluidcouplingisdevicewhichtransmitstorqueduetothekineticenergyofthe moving fluid. In a fluid coupling, two members namely impeller and turbine are present.

19. What is the use of torqueconvertor?
The torque converter is device which provides a varying torque ratio using fluid energy. In a torque converter, three members namely impeller, turbine and stator are present.

20. State the forces act on the rearaxle

- Shear force due to vehicle weight
- Bending moment due to vehicle weight
- Driving torque
- Shear force due to side thrust
- Bending moment due to side thrust

21. What are the different types of rearaxles?

- Semi floating rear axle
- Full floating rear axle
- Three quarter floating rear axle

22. What is the purpose of Stator in the TorqueConverter?
The stator changes fluid flow between the turbine and pump and thus permits the torque multiplication. Without a stator, a torque converter will simply act as a fluid coupling.

23. WhySynchronizerisrequiredintheautomotivetransmissionsystem?
Synchronizer is used to equalize the speed of two mating surfaces, before the contact is established. By doing so, wear & tear and noise can beavoided.

24. What is transfer box? Where it isused?
The transfer box is used to convert 2 wheel drive into 4 wheel drive. This is mainly used in hilly regions.

25. Why slip joint isimportant?
Slip joints can be designed to allow continuous relative motion of two components or it can allow an adjustment from one temporarily fixed position to another. Examples of the latter are tripods, hiking poles, or similar telescoping device. The position is fixed using a clamping mechanism based on a cam, a set screw or similar locking mechanism. Slip joints can also be non-telescoping, such as the joints on some older wooden surveyor's leveling rods. These use a joint that keeps the sections offset from each other but able to be slid together fortransport.

26. What is known as one wayclutch?

The one way clutch or uni – directional clutch will transmit a drive when rotated in one direction and will 'freewheel' when turned in the opposite direction. Spring clutch, Truncated Clutch, or a free-wheel clutch is some one way clutch.

27. What is a fluid flywheel? Where is it used?(Apr/May 2018)

The member which couples the driving member with driven member through a media of fluid is known as fluid coupling or fluid flywheel. It is used in automobile vehicles.

28. What is torque tube drive? Where it is used? (Apr/May 2018)

Torque tube drive is a hollow tube which encloses the propeller shaft. The tube is rigidly connected to the differential housing at one end. The other end of the tube is connected to the gear box casing by a flexible ball and socket arrangement. The driving thrust and rear end torque are carried by a hollow tube/ The tube is used in bearing to support the propeller shaft. Only one universal joint is enough at the gear box. There is no sliding joint needed in the propeller shaft.

29. Mention the need of using an over drive in two wheelers. (Nov/Dec 2018)

When the speed of the output shaft is greater than the speed of the input shaft then the over drive is needed (eg) 0.8 : 1 or 0.9 : 1

30. Write down the importance of using slip joints in the drive line of a vehicle. (Nov/Dec 2018)

A slip joint is used between propeller shaft and universal joint connecting the propeller shaft to compensate for the change of length and it helps to transmit power from engine to rear axle at the same time.

31. Are AMT and CVT type gear box one and the same? Comment. (Apr/May 2019)

Yes. AMT is a Automatic manual gear box. It is a manual gear box that is automated by using simple technology. AMT only eliminates driver effort for the operation of clutch and gear shifting selection are both done automatically where as continuous variable transmission CVTit replaces the gear with two variable diameter pulley. The CVT transmission is better because it as infinite gear ratio .Also CVT is smoother than AMT.

32. State the function of an axle. Apr/May 2019)

1. To carry weight of automobile.
2. To transmit power from differential to wheels.
3. The axle has to take bending load due to weight of the vehicles.
4. To take the torque loads due to braking of the vehicles.

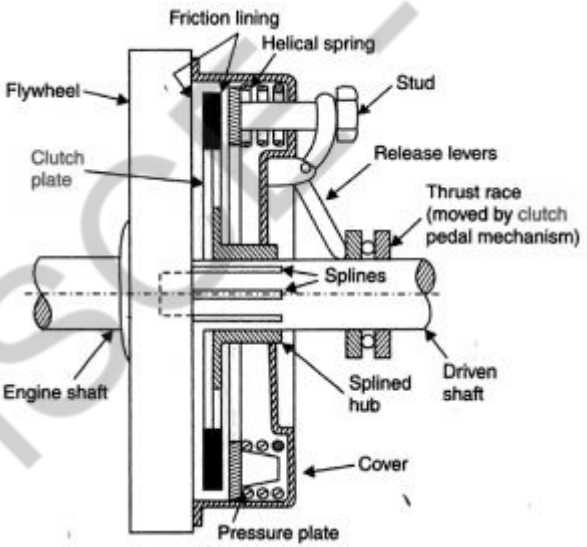
PART-B

1. Discuss about working principles of single plateclutch.

Clutchslipoccursiftheresistingtorqueonthedrivenshaftexceedsthefriction torque at the clutch.

Fig. 7.3. Single plate clutch (Disengaged position).

Diaphragm spring type single plate clutch. This type of clutch is similar in



construction to that of the single plate type of clutch described above except that here diaphragm springs (also called Belle ville springs) are used instead of the ordinary coil springs. In the free condition, the diaphragm spring is of conical form (Fig.7.4) when assembled, it is constrained to an approximately flat condition because of which it exerts a load upon the pressure plate.

Single Plate Clutch

Fig.7.3showsasimplifiedschematicdiagramofasingleplateclutchwhichis commonly used in most cars and small commercialvehicles.

Construction.Theflywheelisrigidlyfixedtotheengineshaft,thedrivenshaft to the gear box being supported at the engine end by spigot bearing in the fly wheel. A clutch plate is attached to a splined hub which is free to slide axially onthesplinescutonthedriveshaft.Aringoffrictionliningisattachedtoeach side of the clutch plate. One end of each of a number of helical compression springs bear on the back of a pressure plate, the other ends of the springs pressing against a cover, attached to the flywheel and rotating with it. Three release levers on pivots mounted on the cover, bear on the bottoms of the nuts onthestudsinthepressureplateandareactuatedbytheleftwardmovementof the thrust race which in turn is moved by the clutch pedalmechanism.

Working. The diagram shows the pressure plate pulled back by the release leversagainstthecompressionsprings;sothatthefrictionliningsontheclutch platearefreeofflywheelandpressureplate.Theflywheelthenrotateswithout driving the clutch plate and hence the drivenshaft.

When the pressure of the thrust race is released the compression springs are free to move the pressure plate to the left so bringing it in contact with the clutch plate. The pressure plate continues so move to the left, sliding the clutch plate, on its splined hub, along the driven shaft until the friction lining touches the flywheel. The compression springs now cause the linings to be gripped between the pressure plate and the flywheel and the friction between theliningsandflywheelandpressureplatecausetheclutchplatetorevolve,so turning the drivenshaft.

2. Explain about gear shifting mechanism with neatdiagram.

Sliding MeshGearbox

Among the manual gear transmissions, this sliding mesh type is the simplest in construction.

1. Outputshaft
2. Low and reverse slidinggear
3. Second slidinggear
4. Clutch
5. Inputshaft
6. Clutch gear
7. Counter shaft drivegear
8. Countershaft

9. Low speedgear
10. Secondgear
11. Reverse gear
12. Reverse idler gear
13. Gear shiftfork

It is the simplest type of gearbox. In this gearbox, spur gears are used. Fig. shows the construction of a sliding mesh type transmission having three forward and one reverse speeds. There are three gears (1,6, and 5) attached on the main shaft and four gears (2,3,4 and 7) on the layshaft.

Thetwogearsonthemainshaftcanslideandmeshwiththegearsonlayshaft. Therefore,itiscalledslidingmeshgearbox.Aseparategearismountedonthe idlershaft(8).Thegears1and6aremountedonthesplinedmainshaft.These gears can be slided by a shaftingyoke.

i. Gears inneutral:

When the engine is running and the clutch is engaged, the counter shaft is driven by the clutch gear. The clutch gear rotates in opposite direction to the clutch shaft. The low speed and high speed gears are fitted on the transmission main shaft or gearbox shaft which does not rotate. At the same time, they are not engaged with any driving gears. Therefore, there isnomotiontransmittedfromclutchtopropellershaft.Hence,thevehicle is stationary.

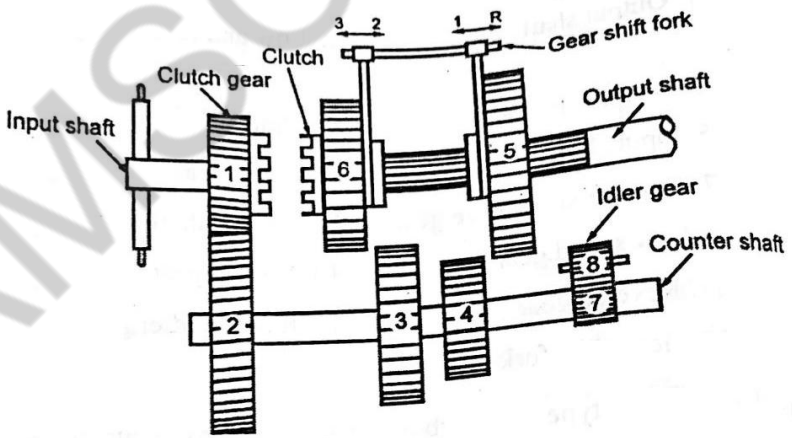


Figure 3.16 Sliding mesh gearbox

ii. First or low speedgear:

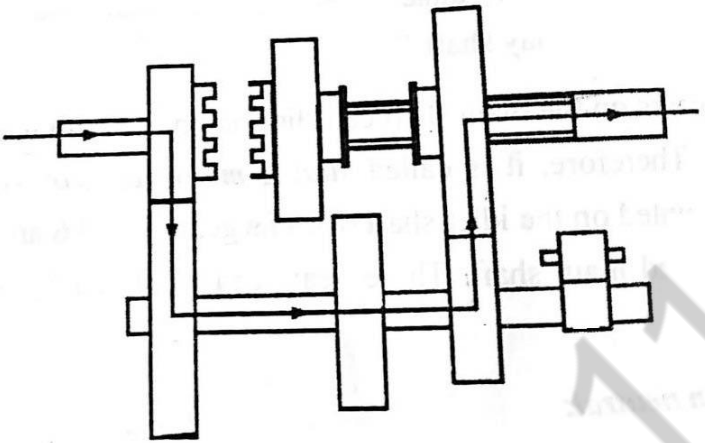


Figure 3.17

When the gear shift fork moves towards direction (1) by operating the gear shift lever, the sliding gear (5) on the output shaft will be shifted forward to mesh with low speed gear (4) on the countershaft.

It results the rotations of input shaft being transmitted in the order (1) =>(2) =>(4)=>(5)toturntheoutputshaft.Thisgearcombinationistheonethat produces the lowest speed from the input shaft and lowtransmission.

iii. Secondgear:

When the gear shift fork is moved toward direction 2, the second sliding gear (6) will be shifted backward to mesh with the second speed gear (3) but (5) and (4) are unmeshed.

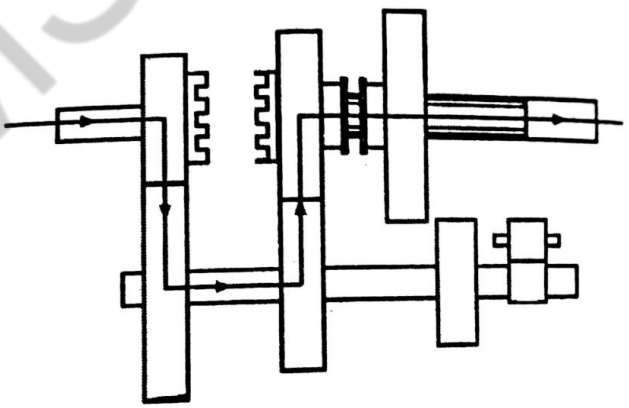


Figure 3.18

The rotation of input shaft is transmitted in the order (1) => (2) => (3) => (6) to turn the output shaft. This is the transmission in the second speed.

iv. Third or Topgear:

When the gear shift fork is moved toward direction 3, the clutch will be meshed (6) and (3) are unmeshed. Due to this, both the input and output shafts are coupled and rotated together. This is the transmission in the third or top speed.

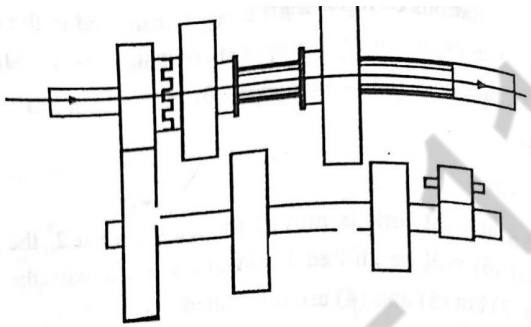


Figure 3.19

v. Reversegear:

When the gear shift fork is moved toward direction R, the sliding gear(5) will be shifted backward to mesh with the reverse idler gear (8). Then the rotationofinputshaftistransmittedintheorder(1)=>(2)=>(7)=>(8) =>(5)toturntheoutputshaftinreversedirection.Thisisthetransmission in reversespeed.

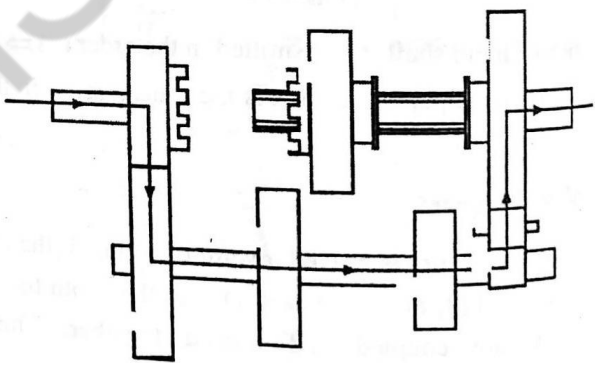


Figure 3.20

Even though there is no measure to allow easy meshing of gears "double clutching" technique must be acquired for shifting gears.

3. Explain the working principles of torque convertor with neat diagram.

Torque Converter Gearbox

The constructional features of a torque converter are similar to the fluid flywheel.Theonlydifferenceisthatithasanadditionalstationarymember called"statororreactionmember".Allthemembershavebladesorvanes of specific shape. But the operation is not similar. In the case of fluid flywheel,thesametorqueistransmittedasgiventoitbytheengineshaft.

But the torque converter increases the torque in the ratio of about 2:1 to 3:1. So, the torque converter does the same purpose as that of a gearbox thattooinabetterway.Onlyfinitenumberofstepsintorquevariationcan be obtained in gearbox. But, the output torque variation is continuously obtained. Hence, the efficiency of a torque converter is high only within narrow limits ofspeed.

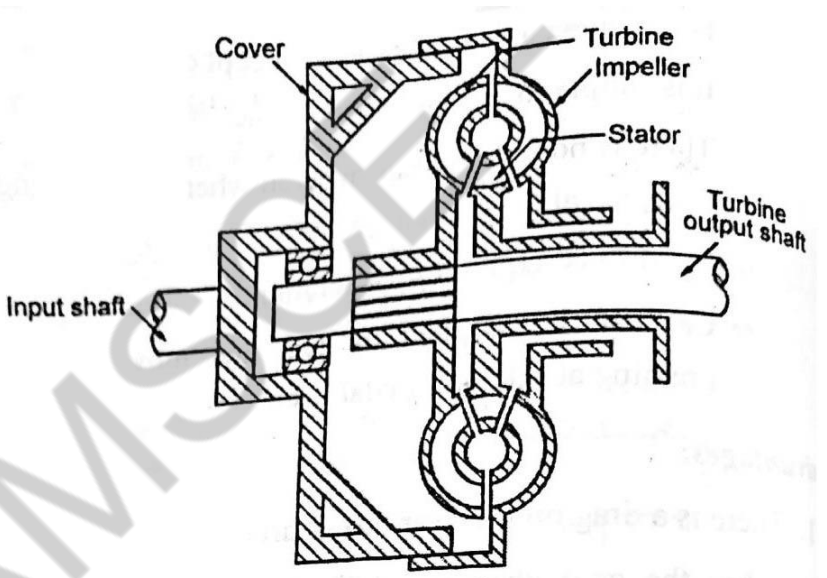


Figure 3.39 Torque converter

A single stage torque converter is shown in Fig. 3.39. It consists of three main parts, i.e.,

1. Theimpellerorthedrivingmember:Thisdrivingmemberisconnected to the engine.

2. Theturbineorthedrivenmember:Thisdrivenmemberisconnectedto the road wheels through the transmission gears and the drive line,and
3. The stator: It is connected to the frame through a freewheel.

Apart from this, a transmission oil pump keeps the converter full ofoil under pressure. This oil pressure is necessary to keep the converter when it is rotating. Due to rotation, the oil is pushed in the outward direction by the centrifugal force. It tends to form air pockets near the centre of the converter. The phenomenon of forming air pockets due to low pressure is called cavitation.Thiscanbeavoidedbykeepingtheconverterpressurebetween200 to 1200kpa. The impeller is started to rotate when the engine starts. First, the oil from the impeller is pushed into the turbine due to higher centrifugal force at the impeller. By this, the engine is driven. At that time, the turbine is held stationary.Duetothis,theoilgetshighkineticenergyfromtheenginethrough the impeller which hits the outer edge of theturbine.

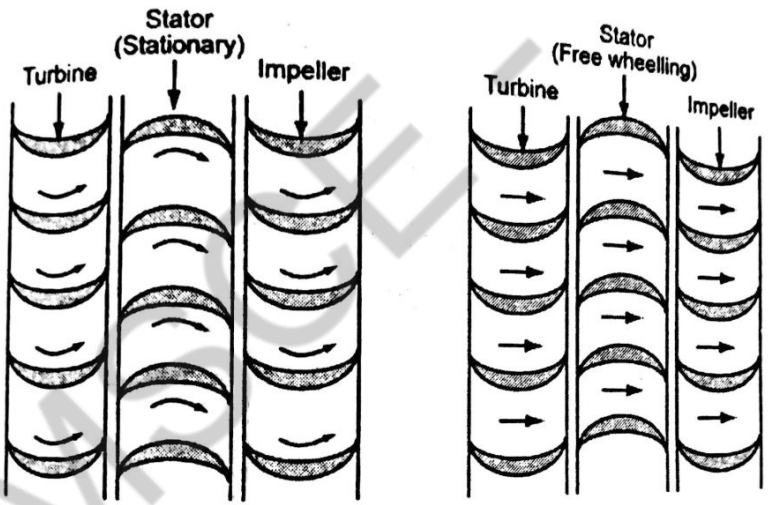


Figure 3.40

The flow of the high-energy oil creates enough force that tends to rotate the turbine. This force increases with increase in engine speed. When it is great enough, the turbine starts rotating. Thus, the vehicle moves the turbine at the centre.Now,itsdirectionisentirelybackward.Ifthereisnostator,itwillenter the impeller directly and push the impeller in the opposite direction. Thus it will cause a loss of power. The fluid from the turbine is just made to strike a stationary member to avoid this dragging action on theimpeller

4. **(i)Discussaboutworkingprinciplesofdifferentialwithneatsketch.**

Differential:

Need for the Differential Gear Unit

Both the right and left wheels are always rotated at same speed when the vehicle is running due to road conditions. For that, the wheels are so designed to rotate at different speeds.

The path of the inside wheel (A) and the path of the outside wheel (B) of a vehiclewhenitturnsalongacurveareillustratedinfigure3.48forcomparison. The outside wheel (B) draws an arc with the radius of distance OB and the inside wheel (A) draws an arc with radius of distance OA. Therefore, the distance travelled by the outside wheel is longer than the insidewheel.

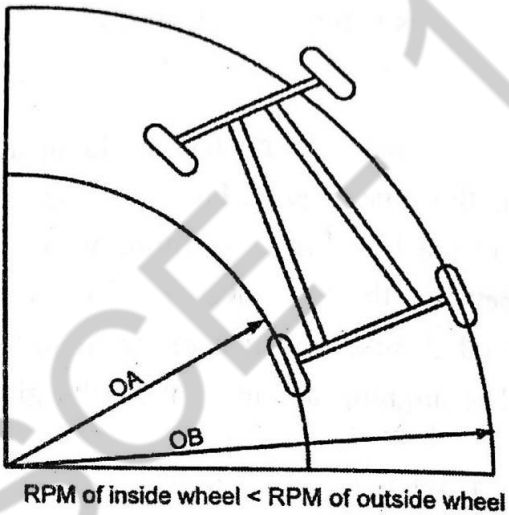


Figure3.48

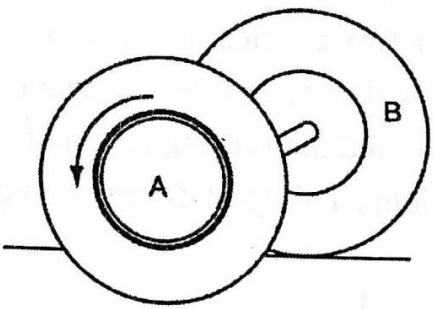


Figure3.49

The outside wheel is forced to move faster and rotated more than the inside wheel. The wheel (A) on the rough surface naturally must run at a higher rpm than the other wheel (B) on the flat surface. Both the wheels will run at an identical rpm even on ordinary roads due to contact between the road surface andthetwowheels.Differenceinrpmbetweentherightandleftwheelsoccurs due to the difference in the amounts of tire inflation and wear. Mostly both the wheels are forced to run at the same rpm even any one of them will slip. So, tyres will wear faster. Therefore, the driving performance of the vehicles will be affected slightly. Thus, a differential device is incorporated to allow differences in rpm when it is transmitting equaltorque.

Basic Principle of Operation

The operation of the simple differential is shown in Fig. 3.50. In fig.3.50 (a), two shafts A and B are connected to the large bevel gears C and D. It is meshed with the pinion E which is attached to the shaft F.

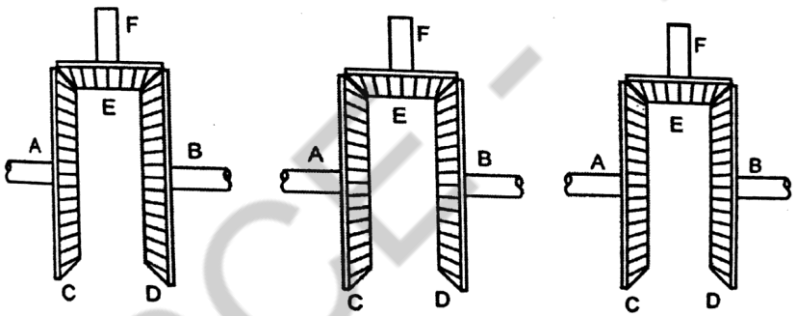


Figure 3.50 Differential action

When the shaft F is pulled forward but not rotated about its axis, the pinion E will not be revolved. Due to meshing of gears C and D, they will be turned about their axes. Hence, it is causing the shafts A and B to revolve equally in the same direction of shaft F beingpulled.

Construction

Figure3.52illustratesthebasicpartsofthetypeofdifferentialusedintherear- wheel-drive cars. (On the inner ends of each axle a smaller bevel gear called a differential side gear is mounted). Two bevel gears are put together to mesh both the driving and driven shafts at an angle of 90°. The differential case is mounted with two wheel axles and differential side gears. The differential case has bearings which rotate the two axles. Then the two pinion gears and their supporting shaft are called the pinion shaft. The shaft is fitted into the differentialcase.

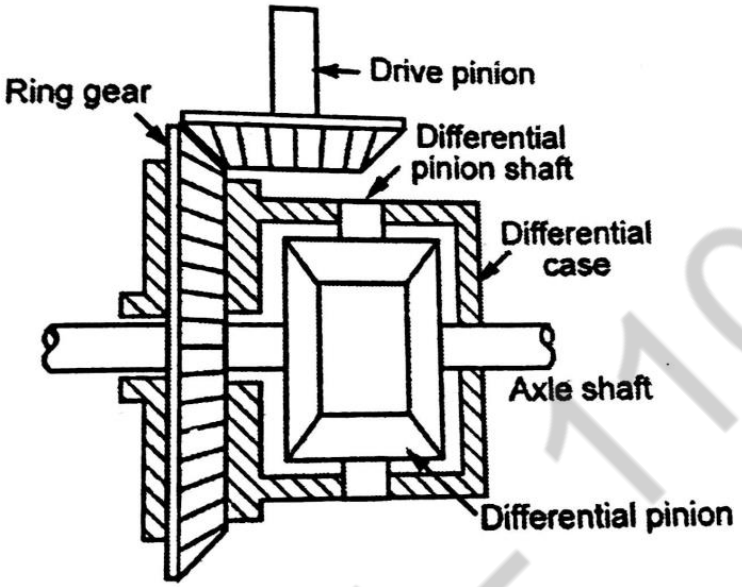


Figure 3.52 Rear wheel drive differential

The two pinion gears are placed in the pinion shaft. Then the pinion shaft is meshed with the two differential side gears connected to the inner ends of the axle shafts. Then the ring gear is mounted which is bolted to a flange on the differential case. The ring gear rotates the differential case. Finally, the drive pinion is mounted. The drive pinion is assembled with the differential housing called carrier. The driver shaft is connected with the driven pinion by auniversaljointandmeshedwiththeringgear.So,thedrivenpinionisrotated when the driver shaft turns. Thus, the ring gear isrotated.

Operation of Differential

While the car is running on a-straight road, the ring gear, differential case, differential pinion gears, and two differential side gears will turn as unit. The two differential pinion gears are not rotating on the pinion shaft due to equal force exerting on the two differential side gears. It results that the side gears rotate at the same speed as the ring gear makes both drive wheels to rotate at the same speed. When the car starts to move on a curved path, the differential pinion gears will also rotate on the pinion shaft.

It causes the outer wheel to turn faster than the inner wheel. If one wheel turns slower than the other as the vehicle turns on a curved path. At that time, the differential case rotates by rotating the pinion gears must rotate on their shaftstrictly.Itisduetotheslower-turningdifferentialsidegear.So,thepinion gears take additional rotary motion to the faster-turning outer wheel on the turn.Therefore,thedifferentialcasespeedisconsideredas100%.Therotating

action of the pinion gears takes only 90% of this speed to the slower-rotating innerwheel.So,110%ofthespeedistakenbythefaster-rotatingouterwheel. Therefore, the outer drive wheel travels a greater distance than the inner drive wheel when any vehicle moves around a turn. The two pinion gears rotate on their shaft and give more rotary motion to the outerwheel.

4 (ii)What are the types of rear axle casing ?

Classification of rear axle:

Rear axle classified by two methods.

1. According to the design ofaxle,
   - Split axle
   - Banjo axle
2. According to the method ofsupporting
   - Half floating rear axle
   - Three quarter floating rear axle
   - Full floating rear axle

5. What are types of rear axle drive? And explain with a neatsketch.

TYPES OF REAR AXLES

There are three types of live axles:

1. Semi-floationg,
2. Three-quarter floating,and
3. Full-floating.

Almost all modern American passenger-car axles are semi-floating type.

Semi-floating Axle:

The semi-floating axle called inner end is supported only by the differential side gear. The differential case carrying the inner bearing between these differential gears and axle housing are supported.

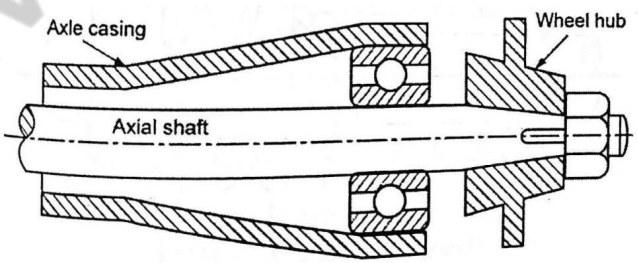


Figure 3.55 Semi floating axle

The inner end of the axle shaft should support the weight of the car by the axle housing. Since, the outer end should support the weight of the car and carry end thrusts called "semi-floating." The inner end of the axle shaft is splined to the differential side gear as shown in fig 3.55.

The outer end is flanged directly using bolts. The wheel bearing is supported by the axle housing placed inside its outer end. The wheel, drum, and bearing retainer plate should be removed to withdraw the axle shaft.

It results the axle shaft helping to support the weight of the car and also transmitting rotation to the wheels. The bearing is mounted on the axle by a retainer axle bearings are mostly pre-lubricated.

Three-Quarter Floating Axle:

A three-quarter floating axle is illustrated in fig 3.56. The single bearing supports the wheel hub located at the center of the wheel hub.

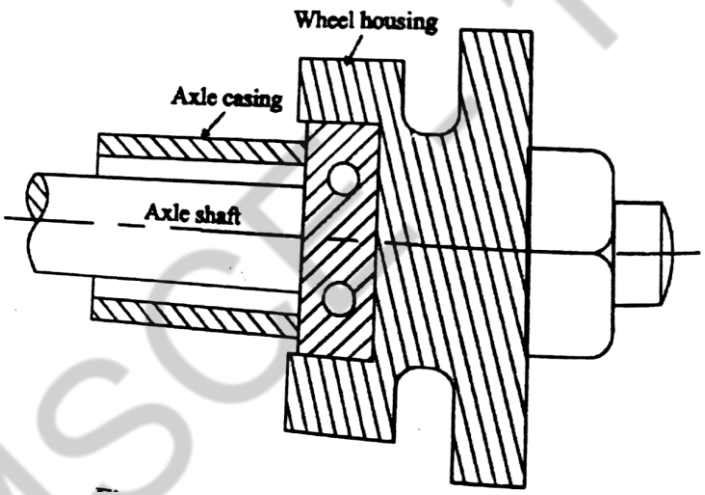


Figure 3.56 Three-Quarter floating axle

It runs on the axle housing. The axle shaft is keyed rigidly with the hub. So, it providesthedrivingconnectionandmaintainsthealignmentofthewheel.The construction of the inner end axle shaft is same as that of semi-floating axle. Still three-quarter floating axle has only one bearing at the outer end, it will carry some bending stresses. So, it is not a full- floatingtype.

Full-Floating Axle:

The wheel hub is supported by two bearing running directly upon the axle housing illustrated in fig 3.57. The axle shaft is connected with the wheel hub flange by coupling, through which the rotary motion of the axle shaft is transmitted to the hub and wheel. The axle shaft is removed from thehousing

without disturbing the wheel. It is done by simply removing the hubcap and coupling. Hence, the axle is relieved of all strains by the weight of the vehicle or end thrusts. So, it is called full- floating. The wheel comes off and the vehicle drops.

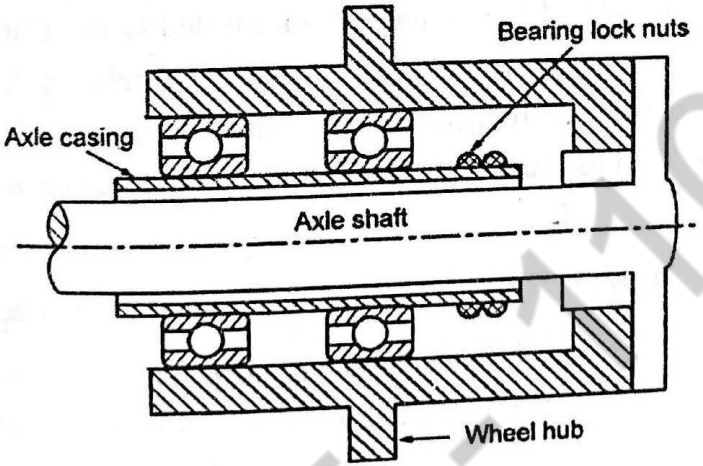


Figure 3.57 Full floating axle

The full-floating axle is used in most of the trucks. Either taper-roller or ball bearings can be used in all applications.

Plain axle:

In this type of live axles, the inner and outer bearings are mounted on the axle itself.

Semi-Boating axle:

In this type of axle, all loads are carried by axle shafts. This axle is widely used on most of light cars has differential supported on its inner end with the bearings. The bearings are supported by the axle housing with the final drive. Abearingisalsomountedbetweentheshaftandtheinsideoftheaxlehousing.

6. What are requirements of the clutch?

Characteristics of Requirements of a Clutch

A clutch must have the followingrequirements;

Transmission of torque:

It should be capable of transmitting maximum torque of the engine.

Gradual engagement:

The clutch should be able to engage gradually and positively without the occurrence of sudden jerks.

Dissipation of heat:

The design of the clutch is such that it should ensure the dissipation of heat sufficiently which is generated during operation.

Dynamic balancing:

The clutch should be dynamically balanced to the vibration in transmission system. It is very important requirement in modern cars which is operated at high speeds.

Vibration damping:

Asuitablemechanismshouldbeincorporatedwithintheclutchfordampingof vibration and eliminated of noise produced during the transmission.

Size of the clutch:

The size of the clutch should be as smaller as possible so that it will occupy minimum space.

Free pedal clutch play:

In order to reduce effective clamping load on the car thrust bearing as well as wear on it, a provision should be made for clutch free pedal play.

Non – exertive operation of disengagement:

The clutch must have non-tiresome operation of disengagement for the driver for higher power transmission.

7. Sketch and explain the working method of torque tube typepropeller shaft.

Torque Tube Drive

A hollow tube encloses the propeller shaft in this type. The tube is rigidly connected to the differential housing at one end. The other end of the tube is connected to the gearbox casing by a flexible ball and socked arrangement. Thedrivingthrustandrearendtorquearecarriedbyahallowtube.Thetubeis used bearing to support the propeller shaft. Only one universal joint isenough at the gearbox. There is no sliding joint needed in the propellershaft.

Helicalortorsionbarspringsareusedwhentherearendtorqueanddriving thrustarecarriedupbytorquetube.Iflaminatedspringsareused,shackleswill alsobeplacedatbothends.Thedrivingthrustistransferredtothefrontendof

theframethroughgearbox.InHotchkissdrive,thedrivingthrustistransferred to the rear end of frame through cup and gearboxshaft.

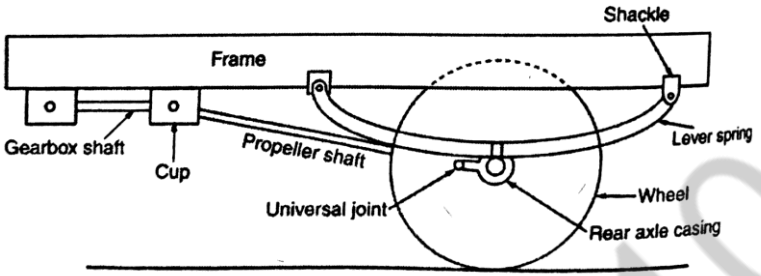


Figure 3.59 Torque tubedrive

The advantage of the torque tube over an open drive shaft is that the torque tube locates the rear axle much more accurately than an open drive shaft does. With an open drive line, the rear axle is usually located by the rear leaf springs themselves. Under acceleration, the axle can wind up, and twist the springs causing wheel hop. But a torque tube extend forward from the rear axle housing to the torque ball at the rear of the transmission. The torque ball istheonlypivotpointfortheentirerearend.Thetorquetubepreventstherear end from moving forward and backward, and prevents it from winding up on acceleration. The radius rod locates the axle from side toside.

8. Explain the principle of operation of a multi plate clutch with a neat sketch.

Multi-PlateClutch

Multi-plate clutches are used in heavy vehicles with racing cars and motorcycles for transmitting high torque. As compared to single plate clutch, these are smoother and easier to operate due to their assembly of friction surfaces contact. They may be used where space is very limited.

The multi-plate clutch of small size transmits approximately the same torque as a single plate clutch of twice of that diameter. These clutches may be wet or dry type. When the clutch of this type is operated in a bath of oil, it is called a wet clutch. But this oil immersed wet clutches are generally usedin conjuction with a part of the automatic transmission. The dry type multi-plate clutch is discussed below. The multi-plate clutch consists of number of clutch plates. Its construction is similar to that of single plate clutch except that the number of clutch plates.

Asthenumberofclutchplatesisincreased,thefrictionsurfaceswillbealso increased.Theincreaseinthefrictionsurfaceobviouslyincreasesthecapacity oftheclutchtotransmitmoretorqueforthesamesize.Thetotalnumberof

clutchplatesisdividedintotwosetsinwhichonefromeachsetisalternatively arranged as shown infig3.6.

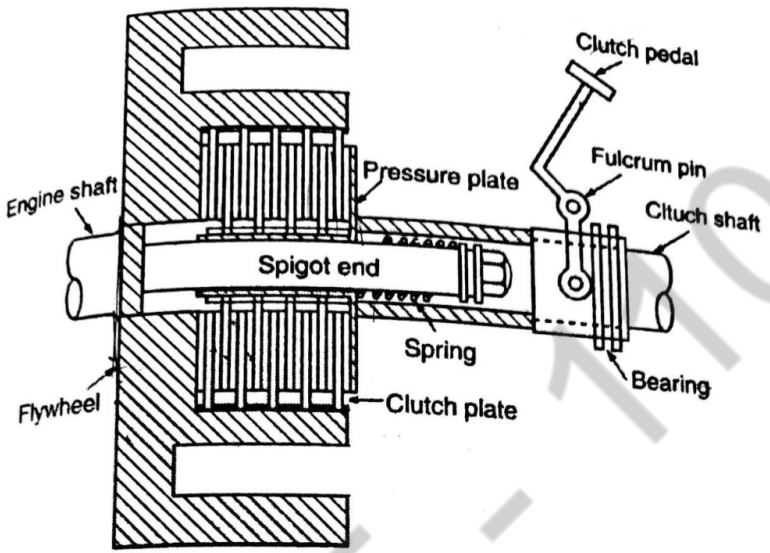


Figure 3.6 Multi-plate clutch

One set of plate slides in grooves on the flywheel and the other one slides on splines on the pressure plate hub. These plates are firmly pressed by a strong coil spring and assembled in a drum. Multiplate clutch works in the same way as the single plate clutch by operating the clutch pedal.

Advantages:

1. Increased torque transmission capacity could be obtained.
2. Thediameterisreducedasithasmorefrictionsurfacewhichreduces the size of the clutch assembly.
3. It is highly reliable.
4. It is suitable for heavyvehicles.

9. With a neat sketch discuss the construction and operation ofa constant mesh gearbox.

Constant Mesh Gearbox

In this type of gearbox, all the gears are in constant mesh having dog clutches for engaging and disengaging the gears. The dog clutches are mounted on the main shaft. One is connected between the clutch gear and reverse gear. The splines are provided on the main shaft.

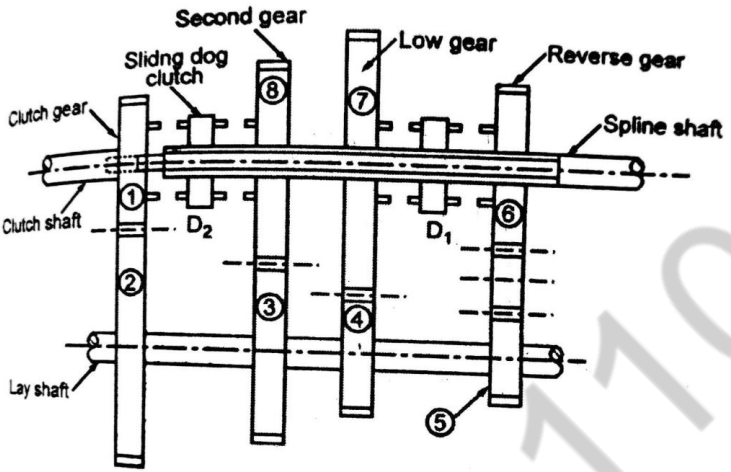


Figure 3.21 Constant mesh gearbox

All the idler gear, main shaft and lay shaft gears are engaged to obtain opposite and slow speed. Dog clutch can slide on the shaft and rotate along with it. All gears are rigidly fixed on the counter shaft. Only reverse gears are spur gear type and all others are helical gears.

i. First gear:

The dog clutch (D_1) is shifted to left side for engaging on (7). Now the power is transmitted through the gear (1)=> (2)=> (4)=> (7) are dog clutch D_1. Then, it transmits to the main shaft. Hence, the first gear speed is obtained.

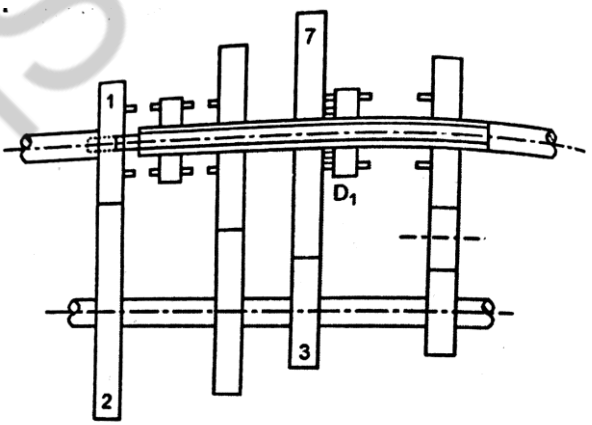


Figure 3.22

ii. Secondgear:

Inthis,thedogclutch(D_1)isdisengaged.Thedogclutch(D_2)isshiftedtoright tolockwiththegear(8).Therefore,thepoweristransmittedfromclutchshaft through (1) => (2) => (3) => (8) and dog clutch (D_2) to the main shaft. So, the main shaft rotates with the second gearspeed.

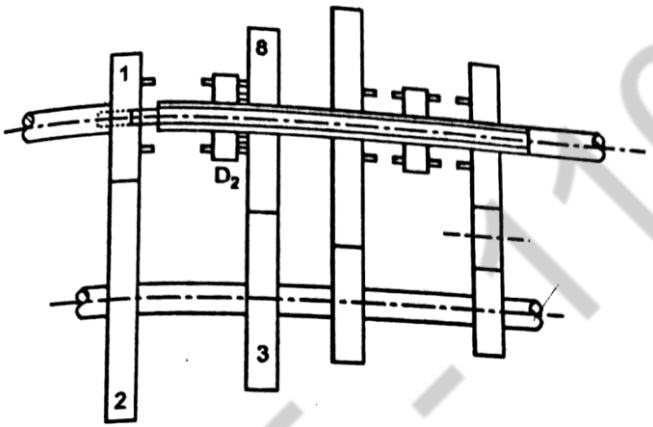


Figure 3.23

iii. Third or Topgear:

The dog clutch (D_2) is moved left to engage with the gear (1) on clutch shaft. Now, the engine speed is directly supplied to the main shaft. This is called as top gear speed.

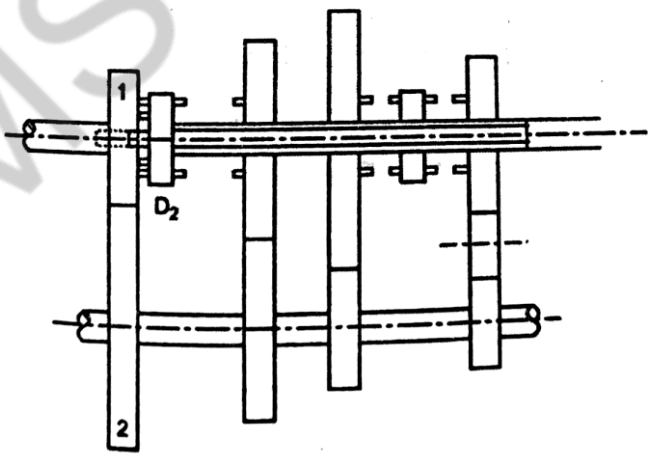
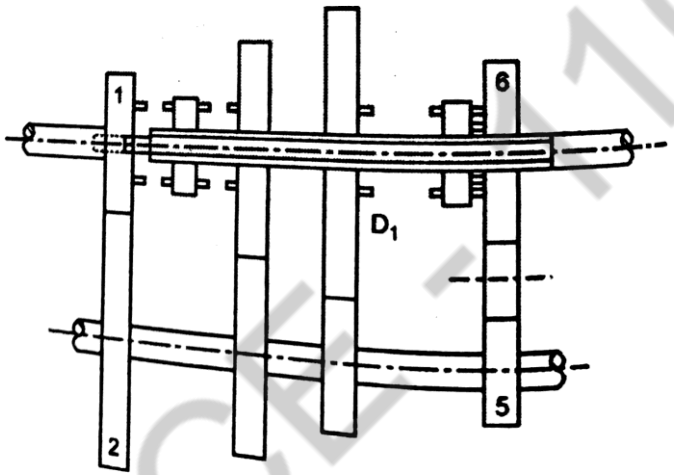


Figure 3.24

iv. Reversegear:

First,thedogclutchD_2isdisengaged.ThenthedogclutchD_2isshiftedtoright toengagewiththegear(6).Theidlergearcausesthemainshafttorotateinthe opposite direction.

As compared with the sliding mesh type, the constant mesh type gearbox meshed more readily with the gears having less danger of damaging during meshingbecausethegeardiametersaresmallerwithfewnumbersofteeth.So, thistypehasmoredefectswhencomparedtosynchromeshtype.Thenecessity of double clutching is needed so that it is not used to any largeextent.



10. Explain the type of gear boxes with neatsketches.

Types of gearBoxes

The following types of gear boxes are in automobiles:

1. Selectivetype
   (i) Slidingmesh
   (ii) Constant mesh
   (iii) Synchromesh
2. Progressivetype
3. Epicyclic or planetary type

Selective type Gear Boxes

It is that transmission in which any speed may be selected from the neutral position. In this type of transmission, neutral position has to be obtained before selecting any forward or reverse position.

Advantages of selective type gear boxes:

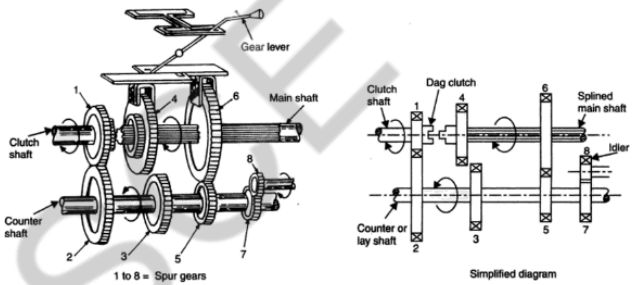
1. Simple inconstruction
2. Relatively free from troubles
3. Light andsmall
4. Low production costs

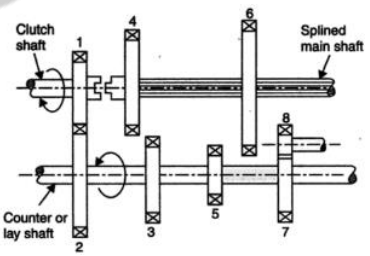
Disadvantages:

1. Gear ratios not being continuous but being in steps (3 to 5 steps), makingit necessary to shift gears each time when vehicle running conditions change.
2. Noisy inoperation

1. Sliding mesh gearbox:

It is that with gear box in which the gears on the splined main shaft are moved right or left for meshing them with appropriate gears on the layshft for obtaining different speeds. This types of gear box derives its same from the fact that the generates are meshed by sliding or crashing one on to the other. This box is also known as **crash – type gearbox.**





2. Constant mesh gearbox:

Refer fig. 7.23. it is that gear box in which all gears are in constant mesh each other (hence the name constant mesh gear box) all the time and this given a silent or quiet operation. Here, helical gears are used to make gear changing

easier. The gears on the main shaft which is splined, are free. The gears on the counter or layshaft are, however, fixed. Two dog clutches are provided on the main shaft – one between the clutch can side on the main shaft and rotates withit.

When the left – hand dog clutch is made to slide to the left by means of the gearshaft lever, it meshes with the clutch gear and the top sspeed gear is obtained. When the dog clutch meshes with the second gear the second speed gear is obtained respectively. However skilful handing is necessary on the part of the driver so that the speed of the locking dogs and respective pinion remain the same to effect a clash – free gear change.

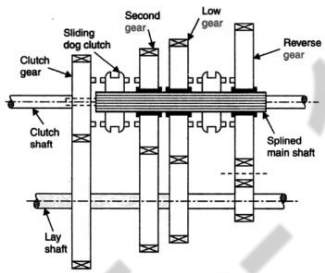


Fig. 7.23. Constant mesh gear box.

Inthisoftypesofgearbox,becauseallthegearsareinconstantmesh,theyare safe from being damaged and unpleasant grinding sound does not occur while engaging and disengaging them. However, this type has more defects than the synchromeshtypeandthereisthenecessityofdoubleclutchingsothatitisnot to any largeextent.

3. Synchromesh gearbox

It is that gear box in while sliding synchronizing units are provided in phase of sliding dog clutches as in case of constant mesh gear box. With the help of synchronizing unit, the speed of both the driving and driven shafts is synchronized before they are clutched together through train of gears. The arrangement of power flow for the various gears remains the same as in the constant mesh gear box.

Synchromeshgeardevicesworkontheprinciplethattwogearstobeengaged arefirstbroughtintofrictionalcontactwhichequalizestheirspeedafterwhich they are engaged readily and smoothly. The following types of such devices are mostly used in vehicle:

(i) Pintype

(ii) Synchronizer ringtype

11. (i) Enumerate the need of a transmission system in an automobile. (any four points)(Nov/Dec 2018)

1. It enables the leverage between the engine and driving wheel.
2. It enables the reduction of engine speed.
3. It enables the turn of the drive round through 90°
4. It enables the driving wheel to be driven at different speeds
5. It serves as a safety device by slipping when the torque transmitted through hit exceed a safe value, thus preventing the brakeage of parts in the transmission train

12. Write short notes on any one positive displacement type clutch used in vehicles (Nov/Dec 2018)

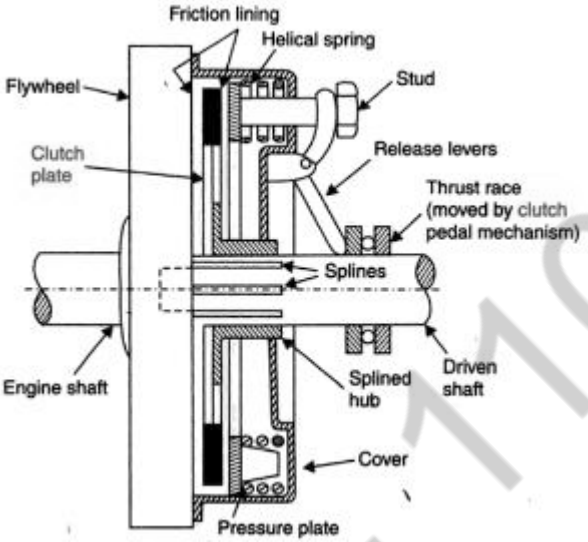
Single Plate Clutch

Fig.7.3showsasimplifiedschematicdiagramofasingleplateclutchwhichis commonly used in most cars and small commercialvehicles.

Construction.Theflywheelisrigidlyfixedtotheengineshaft,thedrivenshaft to the gear box being supported at the engine end by spigot bearing in the fly wheel. A clutch plate is attached to a splined hub which is free to slide axially onthesplinescutonthedriveshaft.Aringoffrictionliningisattachedtoeach side of the clutch plate. One end of each of a number of helical compression springs bear on the back of a pressure plate, the other ends of the springs pressing against a cover, attached to the flywheel and rotating with it. Three release levers on pivots mounted on the cover, bear on the bottoms of the nuts onthestudsinthepressureplateandareactuatedbytheleftwardmovementof the thrust race which in turn is moved by the clutch pedalmechanism

.**Working.** The diagram shows the pressure plate pulled back by the release leversagainstthecompressionsprings;sothatthefrictionliningsontheclutch platearefreeofflywheelandpressureplate.Theflywheelthenrotateswithout driving the clutch plate and hence the drivenshaft.

When the pressure of the thrust race is released the compression springs are free to move the pressure plate to the left so bringing it in contact with the clutch plate. The pressure plate continues so move to the left, sliding the clutch plate, on its splined hub, along the driven shaft until the friction lining touches the flywheel. The compression springs now cause the linings to be gripped between the pressure plate and the flywheel and the friction between theliningsandflywheelandpressureplatecausetheclutchplatetorevolve,so turning the drivenshaft.



13. Enumerate the components used and brief about their functions in the torque tube drive configuration. With a neat sketch. (Nov/Dec 2018)

Torque Tube Drive

A hollow tube encloses the propeller shaft in this type. The tube is rigidly connected to the differential housing at one end. The other end of the tube is connected to the gearbox casing by a flexible ball and socked arrangement. Thedrivingthrustandrearendtorquearecarriedbyahallowtube.Thetubeis used bearing to support the propeller shaft. Only one universal joint isenough at the gearbox. There is no sliding joint needed in the propellershaft.

Helicalortorsionbarspringsareusedwhentherearendtorqueanddriving thrustarecarriedupbytorquetube.Iflaminatedspringsareused,shackleswill alsobeplacedatbothends.Thedrivingthrustistransferredtothefrontendof

theframethroughgearbox.InHotchkissdrive,thedrivingthrustistransferred to the rear end of frame through cup and gearboxshaft.

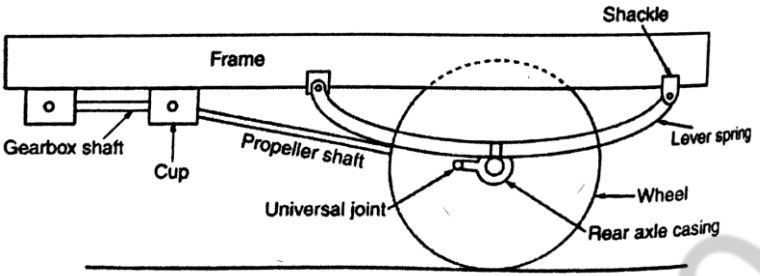


Figure 3.59 Torque tubedrive

The advantage of the torque tube over an open drive shaft is that the torque tube locates the rear axle much more accurately than an open drive shaft does. With an open drive line, the rear axle is usually located by the rear leaf springs themselves. Under acceleration, the axle can wind up, and twist the springs causing wheel hop. But a torque tube extend forward from the rear axle housing to the torque ball at the rear of the transmission. The torque ball istheonlypivotpointfortheentirerearend.Thetorquetubepreve ntstherear end from moving forward and backward, and prevents it from winding up on acceleration. The radius rod locates the axle from side toside

.

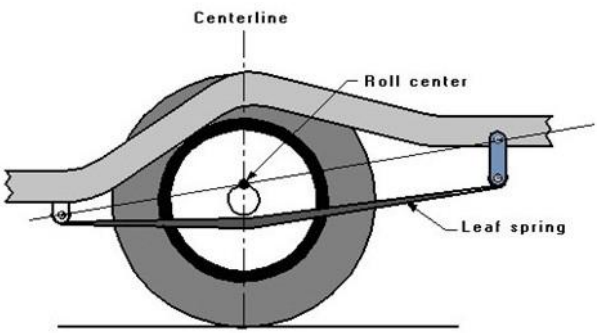
14. Discuss theworking and salient features of the following with a neat sketch. (Apr/May 2018)

i) Hotchkiss drive

ii) Transfer box mechanism

i) Hotchkiss drive

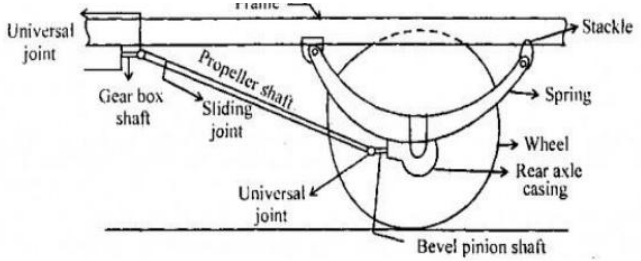
The Hotchkiss drive is the simplest of the drive systems and is the most widely used. The arrangement of the parts can be seen in the picture.



Hotchkiss Drive

The suspension spring are bolted rigidly to the rear axle casing. The front ends of the springs are pivoted on pins. These pins are carried in brackets bolted to the vehicle frame. The rear ends of the springs are connected to the frame by swinging links or shackles. This arrangement permits the deflection of the spring when the vehicle is accelerated or braked. The propeller shaft is provided with two universal joints one at each end and a sliding joint at one end. This arrangement permits the rear axle assembly to move up and down due to projections and depression on the road surface.

Enginepowerisalwaystransmittedfromthegearboxtothefinaldrive in the differential, through the propeller shaft. From the differential the driving torque is transmitted to the road wheels through the axle shafts. In this transmission system, the suspension springs act as torque and thrust members.



In the Hotchkiss drive, slip-splines eliminate thrust transmitted back up the driveshaft from the axle, allowing simple rear-axle positioning using parallel leaf springs. In the torque-tube type this thrust is taken by the torque tube to the transmission and thence to the transmission and motor mounts to the frame. While the torque-tube type requires additional locatingelements,suchasaPanhardrod,thisallowstheuseofcoilsprings.

iii) Transfer Box Mechanism

Transfer Box is a part of four wheel drive system used in four wheel drive vehicles. It is also called as Transfer Gear Case. The function of Transfer Box is to distribute the torque generated in the engine to all four wheels of the vehicle. The transfer box is connected to the engine front axle and rear axle drive shaft. The shifting mechanism is placed to the transfer case. The transfer gear box is controlled by the driver.

The control is located in the vehicle compartment. The front axle drive is disengage and the transfer box is put for longer shift lever in forward position when the vehicle is running on or surface and unleveled road. During the stage the shorter shift lever will control the gear ratio such as low and high. Only low gear will be engage when the longer shift lever is for front drive. The noise will be produced at a higher speed that inherent resonance behavior of spur gear train in the transfer box.

Function of the transfer box

1. It receives power from the transmission and send to both front and rear axle.
2. The on road transfer case coordinate the difference between rotation of the front and rear wheels
3. It locks the front and rear axle mechanically when required
4. It provides low and high range of speed

15. i), State the need for a differential in a vehicle. Draw a schematic of a differential and name the different parts.

ii), Elaborate on the Bharat stage VI norms.

iii). Show how a steering system is able to turn the wheels with a schematic.

i). Need for a differential.:

Both right and left wheels are always rotated at the same speed when the vehicle is running on flat road. But when the vehicles travelled on curved roads during turning the inner wheel need to run slower then the outer wheel as it required to travel less distance ,so the wheel are designed in such a way that the rotate at different speed,

16. State the need for a clutch in an automobile. Describe the diaphragm operated clutch system with a sketch.(Apr/May 2018)

Need for clutch in a automobile>

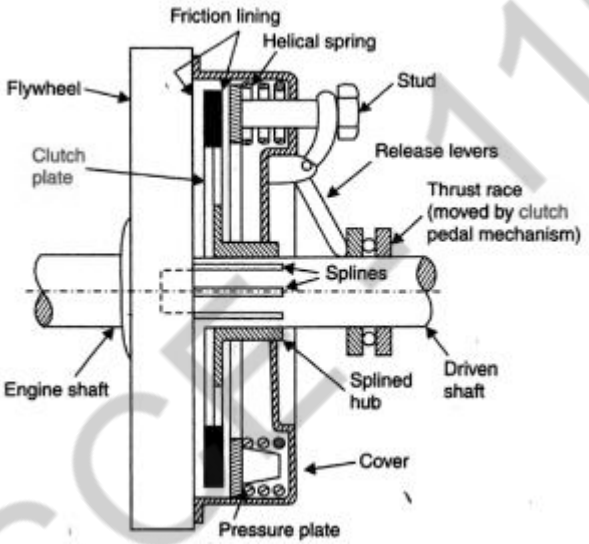
1, To transmit the engine power to the rear wheels smoothly without shocks.

2.To permit the engagement of the gears when the vehicles is in motion without damaging gear wheels.

3. To permit the engagement or disengagement of a gear when the vehicle is stationery and the engine is running.

Diaphragm operated clutch:

Diaphragm spring type single plate clutch. This type of clutch is similar in



construction to that of the single plate type of clutch described above except that here diaphragm springs (also called Belle ville springs) are used instead of the ordinary coil springs. In the free condition, the diaphragm spring is of conical form (Fig.7.4) when assembled, it is constrained to an approximately flat condition because of which it exerts a load upon the pressure plate.

17. i)State the need for a gear box in an automobile. Draw the sketch of a five speed synchromesh gear box clearly indicating different parts (Apr/May 2019).

ii)What is a torque tube drive? Where it is used?

Need for gear box in an automobile:

To provide the leverage ratio

To provide the neutral position

To provide a means to reverse the vehicle.

Synchromesh gear box

It is that gear box in while sliding synchronizing units are provided in phase of sliding dog clutches as in case of constant mesh gear box. With the help of synchronizing unit, the speed of both the driving and driven shafts is synchronized before they are clutched together through train of gears. The arrangement of power flow for the various gears remains the same as in the constant mesh gear box.

Synchromeshgeardevicesworkontheprinciplethattwogearstobeengaged arefirstbroughtintofrictionalcontactwhichequalizestheirspeedafterwhich they are engaged readily and smoothly. The following types of such devices are mostly used in vehicle:

(iii) Pintype

(iv)Synchronizer ringtype.

ii) Torque Tube Drive

A hollow tube encloses the propeller shaft in this type. The tube is rigidly connected to the differential housing at one end. The other end of the tube is connected to the gearbox casing by a flexible ball and socked arrangement. Thedrivingthrustandrearendtorquearecarriedbyahallowtube.Thetubeis used bearing to support the propeller shaft. Only one universal joint isenough at the gearbox. There is no sliding joint needed in the propellershaft.

Helicalortorsionbarspringsareusedwhentherearendtorqueanddriving thrustarecarriedupbytorquetube.Iflaminatedspringsareused,shackleswill alsobeplacedatbothends.Thedrivingthrustistransferredtothefrontendof

theframethroughgearbox.InHotchkissdrive,thedrivingthrustistransferred to the rear end of frame through cup and gearboxshaft.

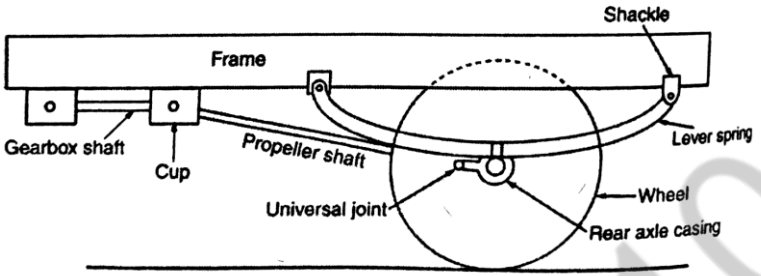


Figure 3.59 Torque tubedrive

The advantage of the torque tube over an open drive shaft is that the torque tube locates the rear axle much more accurately than an open drive shaft does. With an open drive line, the rear axle is usually located by the rear leaf springs themselves. Under acceleration, the axle can wind up, and twist the springs causing wheel hop. But a torque tube extend forward from the rear axle housing to the torque ball at the rear of the transmission. The torque ball istheonlypivotpointfortheentirerearend.Thetorquetubepreventstherear end from moving forward and backward, and prevents it from winding up on acceleration. The radius rod locates the axle from side toside

18. i). What is the function of a universal joint and brief on its working. Also discuss the different between slip joint and universal joint

ii). Differentiate between fluid flywheel and torque converter,(Apr/May 2019)

i) It is used to connect propeller shaft and gear box shaft and to provide between propeller shaft and gear box during transmission of rotary motion.

Universal joint are mainly used to make a flexible connection between two rigid shafts at an angle. It permit the transmission of varying power . It is used to connect a propeller shaft and a gear box shaft to transmit rotary motion

A universal joint consist of a two yoke these yoke are connected to each end of the shaft The two yokes are joined by a cross piece. The connecting cross piece will turn bearing of the yoke with the change I angularity between shafts They do not transmit motion uniformly if the shaft are operating at an angle. Hence the driven shaft increases to maximum and then it decreases to minimum The rise and fall of driven shaft are twice in each revolution due to rotation of pivot pins in different planes

Slip joint: A slip is used between a propeller shaft and a universal joint connecting the propeller shaft to compensate the change in length and it helps to transmit power from the engine to the rear wheel axle at the same time.

Universal joint:

Universal joint are mainly used to make a flexible connection between two rigid shafts at an angle. It permit the transmission of varying power . It is used to connect a propeller shaft and a gear box shaft to transmit rotary motion

Fluid coupling	Torque converter
Casing rotates with shafts	Casing is stationary
Output speed is less than the input speed	Output speed is more than the input speed
There are no stationary guide vanes in the flow path	Stationary guide vanes are provided in the flow path
There is no torque multiplication between shafts	Torque multiplication between shafts

1

4

STEERING, BRAKES AND SUSPENSION SYSTEMS

PART-A

1. Define wheel track and wheelbase.

- The distance between the tyre centers, mounted on the same axle is known as wheel track.
- The wheelbase is the distance between the centers of the front and rear wheels.

2. Give a brief note ondamper.

It is used to dampen the vibrations of the suspension springs. It is mostly used in independent suspension.

3. Distinguish between disc brake with drumbrake.

Drum Brakes	**Disc Brakes**
Relatively cheaper	Costlier
More weight	Lighter than drum brakes
Easily subjected to brake fading	Offer resistance to brake fading
Non uniform pressure distribution	Uniform pressure distribution

4. What is meant by bleeding ofbrakes?

The process of removing air from the hydraulic brakes is known as bleeding of brakes.

5. Define steeringgear.

The steering gear is used to convert the rotational movement of the steering wheel into linear movement of the steering linkage. Moreover it provides mechanical advantage.

6. What are the different types ofwheels?

- Pressed steel disc wheels
- Wire spoke wheels
- Light alloy casted wheels

7. What is the purpose of Toe-in andToe-out?

The purpose of providing a toe in and toe out is straight line stability of the vehicle, after negotiating a turn.

8. What are the different types of tyres used inautomobile?

- Cross ply tyres
- Radial ply tyres
- Belted bias tyres

9. What are the different types of springs used in suspensionsystem?

- Leaf springs (Rigid axle suspension)
- Coil springs (Independent suspension)
- Torsion bar (Independent suspension)

10. Define king pininclination.

The tilt of the king pin from the vertical reference line is known as King Pin Inclination (KPI). It is also called as Steering Axis Inclination (SAI).

11. Give the function oftyre?

- Supporting Vehicle Weight
- Transferring Traction & Braking forces to the Road Surface
- Changing & Maintenance Direction of Travel
- Absorbing Road shocks

12. Define castor andcamber.

Castor: The tilt of the king pin from the vertical reference line when viewed from side is known as castor.

Camber: The camber angle is the inward or outward tilt of the wheel relative to the vertical reference

13. What are the benefits of anti-lock brakesystem?

- Preventing the wheel from locking at the time of braking.
- Keeping the wheel rotating.
- Due to rotating wheel, it helps you to steer away the vehicle from the object, while applying brakes at the same time.
- It is even more effective in sand, snow, water, and mud where loss oftractionisevenhigher,asonthesesurfaces,withnormalbraking

system, it is even easier to lock wheels and loose traction but ABS worksexcellentintheseconditionsalsoandstopsthevehicleinamuch shorterdistance.

14. What is steeringratio?

The steering ratio is defined as the ratio of angle turned on the steering wheel to the angle turned by the stub axle.

Steering ratio = Angle turned on steering wheel / Angle turned by the stub axle

15. What is toe in and toe out?

The distance between the front ends of wheels is less than the rear end, the condition is said to betoe-in.

The distance between the front ends of wheels is more than the rear end, the condition is said to betoeout.

16. What are the types of steering gearbox?

- Worm & Worm wheel steering gear
- Worm and Nut steering gear
- Worm and Roller steering gear
- Recirculating Ball steering gear
- Rack and Pinion steering gear

17. What are main advantages of powersteering?

- The manual effort required to turn the vehicle is getting reduced.
- This layout also gives road feel to the driver.

18. What is function of suspension system inautomobile?

The function of the suspension system is to isolate the vehicle and its occupants from road shocks and vibrations generated by the road surface, while maintaining steering control and stability at all times.

19. What is the function of brake? State itstype.

The function of brake is to stop the vehicle within a short distance.

Types:

1. Mechanical brakes

- Drum brakes
- Discbrakes

2. Hydraulicbrakes

3. Powerbrakes

- Air brakes
- Air-hydraulic brakes
- Vacuumbrakes
- Electricbrakes

20. What are the functions of frontaxles?

- It carries the weight of the front of the vehicle
- It carries the horizontal and vertical loads on bumpy roads
- It works as a cushion through its spring for a comfortable side
- In a four wheel drive, it also transmits power to the road wheels
- When brakes are provided at the front wheels, it withstands bending stresses and torsional stresses

21. What I section at middle and oval section at end is preferred for front axle?

'I' section is suitable for bending loads and 'circular' or 'oval' section is suitable for torsional loads.
Hence I section at middle and circular or oval section at ends is provided in the front axle.

22. Whatarethedifferenttypesofstubaxles?Whichisthemostpreferred one?

- Elliot
- Reversed Elliot
- Lamoine
- Reversed Lamoine

Out of these four types, Reversed Elliot is the most preferred type.

23. What is meant by the term"tread"?

The tread of a tire refers to the patterns on its rubber circumference that makes contact with the road.

24. What is a self energizingbrake?

A brake is called self-energizing if it uses the rotational force of the wheel to help stop the automobile.

25. What is discbrake?

These brakes are different from drum brakes in that the drum is replaced by a circular plate and the brakeshoes are replaced by a calliper which supports a pairoffrictionpads,oneoneachsideofthedisc.Thesepadsareforcedinward by the operating force and so retard thedisc.

26. What is meant by electricbrake?

In an electric brake, the current from the battery is utilized to energize an electromagnet within the brake drum. This actuates a cam to expand thebrake shoes. When the current is not supplied, the cam and brake shoes are returned to the release position by retractorsprings.

27. What is regenerativebraking?

Aregenerativebrakeisanenergyrecoverymechanism,whichslowsavehicle by converting its kinetic energy into another form, which can be either used immediately or stored until needed. This contrasts with conventional braking systems,wheretheexcesskineticenergyisconvertedtoheatbyfrictioninthe brake linings and thereforewasted

What is disadvantages of having rigid axle suspension?

a) It does not allow each wheel to move independently in response to bumps (unsprungweight)

b) Cornering ability is poor. Because the wheels have zero camber angle gain during the body roll.

28. What do you understand by tractioncontrol?

Traction control helps limit tire slip in acceleration on slippery surfaces. In the past, drivers had to feather the gas pedal to prevent the drive wheels from spinning wildly on slippery pavement. Many of today's vehicles employ electronic controls to limit power delivery for the driver, eliminating wheel slip and helping the driver accelerate undercontrol.

29.Name the classification of the brakesystem?

- ♥ According to the construction
- ♥ According to method of braking contact
- ♥ According to the power unit
- ♥ According to method of applying brake force
- ♥ According to power employed

30. Why slip joint isimportant?

Slipjointscanbedesignedtoallowcontinuousrelativemotionoftwocomponents or it can allow an adjustment from one temporarily fixed position to another. Examples of the latter are tripods, hiking poles, or similar telescoping device. The position is fixed using a clamping mechanism based on a cam, a set screwor similar locking mechanism. Slip joints can also be non-telescoping, such as the jointsonsomeolderwoodensurveyor'slevelingrods.Theseuseajointthatkeeps thesectionsoffsetfromeachotherbutabletobeslidtogetherfortransport.

31. Name the type of frontaxles.

Live axle and dead front axle

32. What is meant by tractioncontrol?

Traction control is an active vehicle safety feature designed to help vehicles make effective use of all the traction available on the road when accelerating on low-friction road surfaces.

33. Mention the type of steering gear commonly used in light motor vehicles.(Apr/May 2018)

1. The pitman-arm type and
2. The rack and pinion type

34. What is traction control? Mention its significant. (Apr/May 2018)

The control system which maintains the traction and stability of the vehicle regardless of the road surface condition is known as traction control. The primary function of the traction control system is to maintain the traction and stability of the vehicle regardless of the road surface condition. It is achieved by reducing the drive torque applied to rear wheels or pulsing the rear wheel breaks to eliminate the wheel slip depending on the version of traction control installed.

35. Differentiate between passive and semi active suspension systems. (Nov/Dec 2018)

Passive suspension	Semi active suspension
Passive suspension system to control the dynamics of a vehicle vertical motion as well as spinning (pitch) and tilting (roll) . Passive indicate that the suspension elements cannot provide energy to the suspension system	Semi active suspension system can only change the viscous damping co-efficient of shock absorber and do not add energy to the suspension system.

36. Enumerate any two merits of using full floating front axle. (Nov/Dec 2018)

1. The load capacity of a full floater axle is higher than a semi floater axle.
2. A full floater axle that breaks would not causes the wheel to come out off because the wheels are attached to the wheel hub and not the axle. So it is safer.

37. Mention any two steering geometry parameter and their significance. (Apr/May 2019).

Camber: It is the tilt of the car wheels from the vertical. Camber is positive if the tilt is outward at the top. Camber is also called wheel rake. The tyre should roll on the ground vertically so that the wear is uniform. If while running the tyre are inclined from the vertical either inward or outward they will wear more on one side then on the other.

Castor:

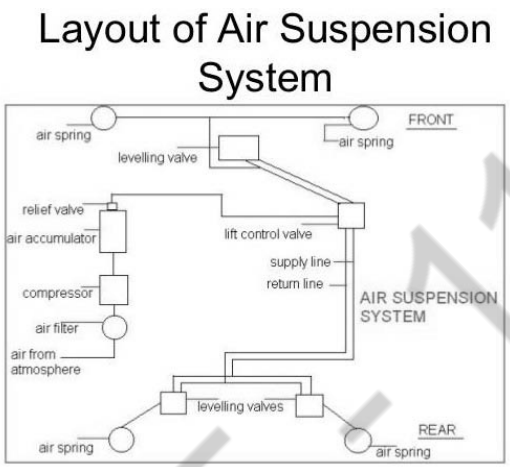
Tilting the kingpin axis either forward or backward from the vertical line ia known as castor. When the top of the kingpin is inclined backward direction the castor angle is positive. The castor angle is negative when the top of the king pin is inclined backward. The positive castor gives directional stability and it keeps the vehicle to straight ahead after completing a turn, similarly negative castor provides easy steering.

38. List the function of suspension system. (Apr/May 2019)

1. \To eliminate road shocks from transmission to vehicle components.
2. To maintain stability of the vehicle in pitching or rolling motion.
3. \to safe guard occupants from road shocks.
4. To keep proper steering geometry.
5. To resist torque and braking reaction.
6. To obtain particular height to body structure.

PART-B

1. With an aid of an neat sketch, explain the working principles of pneumatic suspensionsystem.



Air Springs

The bags come in three basic shapes:

- **Double-convolutedbag.** Thisbagisshapedlikeanhourglass.The design allows for a little more lateral flexibility than theotherdesigns.
- **Taperedsleeve.** Thisairbagperformsthesameasanyotherbutis designed to fit in a tighter area and offers a little more adjustabilityon ride height.
- **Rollingsleeve.** Thisisalsoaspecific-applicationairbag.Thepertinent differences between the two sleeves are really about ride height and spring control, and what's best for the vehicle and theapplication.

Most air suspension systems now come with an **on-board compressor**. The compressor is an electric pump feeding air to the bags through a series of compressed air lines. The compressor is generally mounted on the vehicle's frame,orinthetrunk.Thevastmajorityofcompressorscomewithanattached drier.Thecompressorworksbydrawingoutsideairintothepump,compressing it and moving it to the bags. Outside air is often laden with moisture, and moisture can wreak havoc in a closed system. The drier uses a substance known as a **desiccant** to absorb as much moisture from the air as possible before the air is sent through thesystem.

Simpler compressor systems rely on the compressor itself to maintain, increaseordecreasepressure.Moreadvancedsystemsaddanairtanktomaintain pressureandprovideaneventransitionbetweenpressures.Compressorscan

be activated manually or automatically, and controlled solely by the driver, automatically through an electronic system, or a combination of both.

Valves are the gateways for the air to enter various parts of the system. In today's air suspension system, valvesplay a critical roll in isolating and controlling where air is directed and how. Early generation air suspension systems were two-way setups. Essentially, each left and right air bag was connected by a line and shared air. As the vehicle cornered, one air bag compressed its air and pushed it through the line to the other air bag, which was expanding. This resulted in severe body roll and accounted for part of the reputationairsuspensionsystemshadforcausingaterribleride.Now,systems use a series of valves that control this tendency and offer betteringhandling.

Solenoids are used in electronically-controlled systems to fill and vent each air bag. As the system adjusts for different conditions, it commandseach solenoid to open or close, changing the amount of air in each of thebags.

Electronic systems are managed through an **electronic control module**. The controlling software can be very basic, almost a digital version of analog on/off controls, or it might run a more sophisticated software, monitoring pressureandrideheightinrealtime.Themodulesreceiveinformationthrough avarietyofinputs,includingride-heightsensors,andtogglethecompressoron and off as needed. The electronic side of the system is where most innovation has occurred, and where changes will likely happen in the future. These systems generally remain separate from the vehicle's on-board modules and communications.

Air springs have elasticity or "springiness" when it is compressed.

Characteristics of air springs:

1. Theyaresofterifthevehicleisnotloaded.Atthesametime,spring constant increases when the load is increased by increasing the air pressureinsidethechamber.So,itgivesoptimumridingcomfortwhen the vehicle is lightly loaded and fully loaded conditions.
2. The height of the vehicle is kept constant though the load variation by varying the air pressure.

Devices for controlling the air pressure and compressors for compressing air, etc.,arerequiredinairsuspensionsusingairsprings.Butthesuspensionsystem is more complex. The electronically modulated air suspension is incorporated along with air spring in modernvehicles.

2. With an aid of neat sketch, explain the working principles of antilock brakingsystem.

Antilock Braking System (ABS)

Stopping safely is one of the most important functions a motor vehicle canperform.Failureofthebrakesystemwillalmostinvariablyresultin

property damage, personal injury, or even death. Consequently, a great deal of consideration has been given to improving the brake system in trucks and passenger cars over the last nine decades.

One of the latest improvements is an antilock brake system which, as the name suggests, prevents a vehicle's brakes from locking up and skidding during hard stops on wet or icy roads.

The problem of skidding reveals the one overwhelming weakness of all motorvehiclebrakingsystems.Theydependstronglyonthecoefficientofstatic friction between the tire and the road. If for any reason the tire momentarily loses its adhesion to the road while the brakes are applied, the friction of the brakes against the drums or rotors locks the wheel solidly and the tire begins skidding across the road. In this condition, the braking force of that wheel is dependent on the sliding friction between the tire and the road, which is much less than the static friction. Under wet or icy conditions, the sliding friction is reduced even further, resulting in significantly longer stoppingdistances.

Inaddition,whenthefrontwheelsareinthiscondition,theycannotbeused to steer the vehicle; regardless of the angle of the front wheels, the vehicle continues to skid in whatever direction it momentum sends it until either the driver release the brakes or the vehicle collides with something solid enough to bring it to a halt. Antilock Braking Systems (ABS) is a form of electronic braking which was invented to help a driver control a vehicle under heavy braking by preventing the wheels from lockingup.

Need of ABS in Automobile

Braking systems take the force applied to the foot pedal by the driver and transferitviaamechanicalsystemtothebrakesonthewheel.Themechanism works by increasing the input force via a servo to the master cylinder which convertstheforceintothepressureappliedbybrakes.Themastercylinderhas two pressure chambers both of which are responsible for the braking pressure ontwoofthewheelsandthisistoprovideanextralevelofsafetyshouldthere be a failure.

During this process, there is a chance that the wheels stop rotating before the car comes to a halt. This process is known as 'locking up' and means that the braking force on the wheel is not being transferred efficiently to stop the vehicle due to the fact that the tyre is sliding upon the road.

This leads to a longer stopping distance than if the wheel had not locked because there is reduced grip between the car and the road, which in turn leads to an increased chance of losing control of the vehicle and skidding. On vehicles without ABS the best method to regain control of the vehicle is to 'pump' the brakes by taking your foot off the pedal and reapplying it. This allows the tyres to regain traction upon the road, rather than skid over the surfaceofit.ABSworksinasimilarbutmuchmoreeffectivemanner.Electric sensorsmonitorthespeedofthewheelasitrotatesanddetectifitissensors

monitor the speed of the wheel as it rotates and detect if it is about to lock up under braking. When this happens the brakes are automatically released and then rapidly reapplied.

1. Wheel speed sensors:

The wheel speed sensors (WSS) consist of a magnetic pickup and a toothed sensor ring which may be mounted in the steering knuckles, wheel hubs, brake backing plates, transmission tail shaft or differential housing. On some applications, the sensor is an integral part of the wheel bearing and hub assembly.

The wheel speed sensor pickup has a magnetic core surrounded by coil windings.Asthewheelturns,teethonthesensorringmovethroughthepickup magnetic field. This reverses the polarity of the magnetic field and induces an AC voltage pulses per second that are induced in the pickup changes in direct proportion to wheel speed. Mounted close to, but not touching this toothed wheel, is a permanent magnet wrapped with a coil of wire, called the pick-up coil .As each tooth rotates past the permanent magnet, it causes the magnetic fieldtoconcentrateandincreaseslightly.This,inturn,inducesasmallpulseof current in the coil ofwire.

Thenumberofpulsespersecondisdirectlyproportionaltothespeedofthe wheel. The faster the wheel turns, the faster the teeth pass the magnet and the higher the pulse rate.

The pulsed output from the wheel speed sensors goes to an electronic controller,whichmonitorseachwheel'sspeedrelativetothespeedoftheother wheels. As long as the brakes are not being applied and all of the monitored wheels are rotating at roughly the same speed, the system takes no action. If, however, the brakes are being applied and one or more of the monitored wheels suddenly begins to reduce speed at a higher rate than the others (i.e. indicating a loss of traction with the road and an imminent wheel lockup and skid) the controller then activates the antilocksystem.

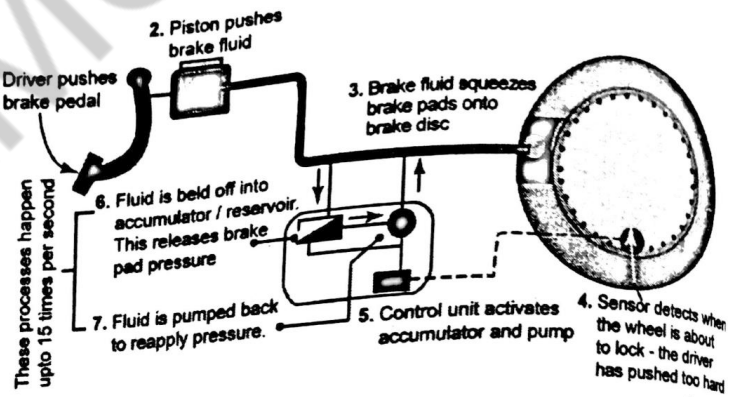


Figure 4.77 Steps in antilock braking systems

ABS controller operates solenoid valves built into the high pressure side of the master brake cylinder. These valves are normally open and do not interfere with braking, when the controller senses that a wheel is locking up while braking, it first activates a solenoid to close a valve in the affected wheel's brake line which prevents the pressure from increasing any further. If the locked wheel continues to lose speed, the controller activates a second solenoid which bleeds pressure off the affected brake line, in effect releasing thebrakeforthatwheelregardlessofwhetherthedriverisstillpushingonthe brake pedal. As soon as the wheel regains traction and its speed increases, the solenoids are de-activated, and normal brakingresumes.

Of course, if the conditions are such that the wheel starts to skid again, the brake will promptly begin to lock up and the ABS will take over. This cycleis repeated 12 to 15 times per second until either the roadcondition

3. List the types of suspension spring used in automobile.

Types of SuspensionSprings

Springs are the main important parts of any suspension system which are classified as follows:

1. Steelsprings
   a. Leafsprings
   b. Tapered leafsprings
   c. Coilsprings
   d. Torsionbar
2. Rubbersprings
   a. Compressionsprings
   b. Compression-shearsprings
   c. Steel reinforcedsprings
   d. Progressivespring
   e. Face shearspring
3. Airsprings
   a. Bellow typesprings
   b. Piston typesprings
4. Plasticsprings
5. Airsprings

Leaf spring suspension

Fig 4.35 shows the construction of the laminated leaf spring. It has a number ofleavesofincreasinglengthsmadeofsteelplates.Thespringeyeismounted to frame by a pin called as shackle pin. The centre portion of the spring is attached to the front axle by V-bolt. One end of the spring is mounted on the framewithasimplepin.Theotherendismountedbyashacklewiththeframe.

The spring eye is mounted to the frame by a pin called as shackle pin. The centre portion of the spring is attached to the front axle by V-bolt. One end of thespringismountedontheframewithasimplepin.Theotherendismounted by a shackle with theframe.

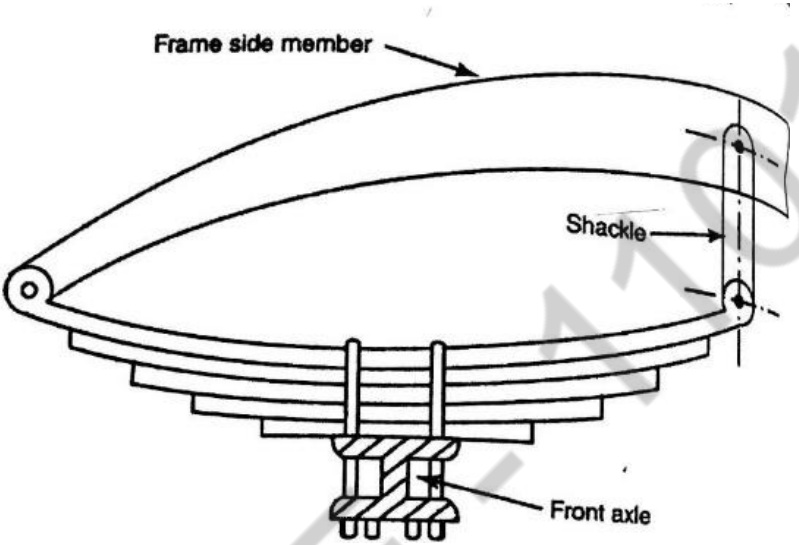


Figure 4.35 Leaf spring suspension

Types of Leaf springs:

1. Semi ellipticalspring
2. Quarter ellipticalspring
3. Three quarter ellipticalspring
4. Transversespring
5. Full ellipticalspring
6. Platform typespring

Helper springs:

Where there are fluctuations in their loads, helper springs are used to trucks and many other vehicles. It is mounted above the mainspring. If the load is less,themainspringisoperated.Boththemainandhelperspringsareoperated but if the load exceeds a certain value.

Helper springs are used along with the main leaf springs on manycommercial vehicles. It is more suitable for a wide range of loading. When the load on vehicle is only low, helper springs are not operated. When the load increases, the helper springs will share the load. Helper springs are mainly provided on rear suspension only as shown in fig. 4.36. When the load on the road wheel increases, on that time, the helper spring is just made to the ends of the helper spring touch the special brackets fitted to the side member thereby operating the helperspring.

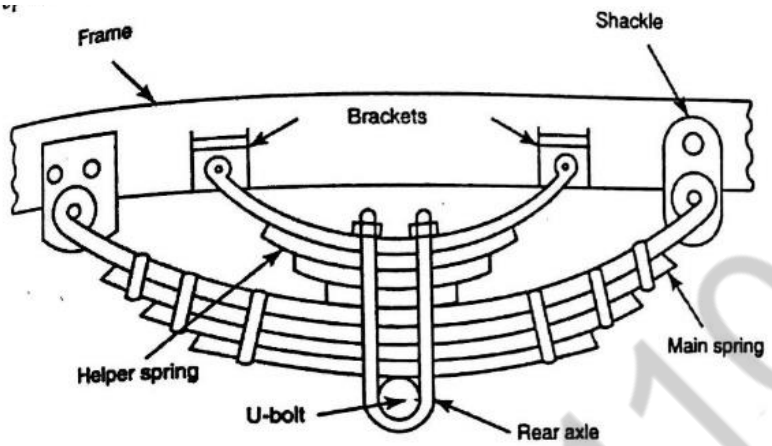


Figure 4.36 Helper springs

Characteristics of helper springs:

1. Due to the springs having enough rigidity to hold the axis in the proper position they are required.
2. Controllingofownoscillationthroughinter-leaffrictionisperformed.
3. These springs have durability in heavy-dutyapplications.
4. Due to inter-leaf friction, it is very difficult to absorb the minute vibrationsfromtheroadsurface.Hence,leafspringsaremoresuitable forlargecommercialvehiclesthatcancarryheavyloadswithrespect to highdurability.

Coil Spring

A coil spring is nothing but a steel wire. The coil springs are used in both the rear and also from independent suspension. The energy stored per unit volume is approximately twice the coil springs when compared to leaf spring. The coil spring carries both the shear and bending stresses. At the same time, boththetorquereactionandsidethrustcannotbecarriesout.So,somespecial arrangement has to be made to position the axle relative to the frame. Both the driving and braking torque reaction are also considered in arranging coil spring. A helper spring can also be used additionally to give progressive stiffnessagainsttheincreasingloadasshowninfigure4.37.So,theyareagain classifiedinto:

1. Tension,and
2. Compressionsprings

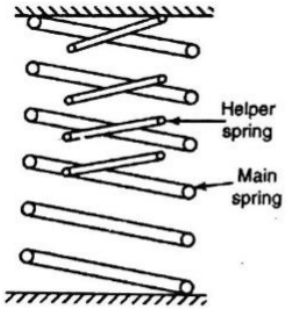


Figure 4.37

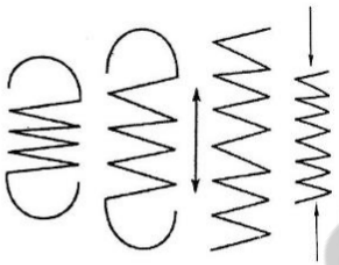


Figure 4.38

Characteristics of coil spring:

1. The energy absorption rate per unit of weight is greater when compared to leafsprings.
2. Soft springs can becoiled.
3. Duetonointer-leaffrictionwithleafsprings,nocontrolofoscillation is necessary by the spring itself but shock absorbers arenecessary.
4. Due to no resistance to lateral forces, linkage mechanisms to support the axle such as suspension arm, lateral control rod, etc., isrequired.

Torsion Bar

A torsion bar is a steel bar which is operated by both twisting and absorbing shearstressonly.Twolongsteelbarsformthesprings.Torsionbarcanbeused with independentsuspensions.

It is a simple bar in which one end is fitted to the frame whereas the other end is fitted to the end of a wheel arm. The structure with a bearing supports the projection of the second end of the bar. The other end of the wheel arm is attached with the spindle of the wheel usingkingpin.

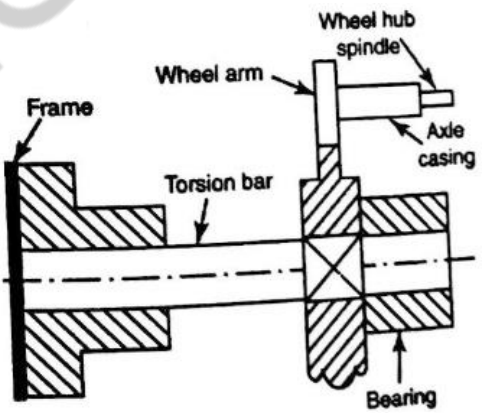
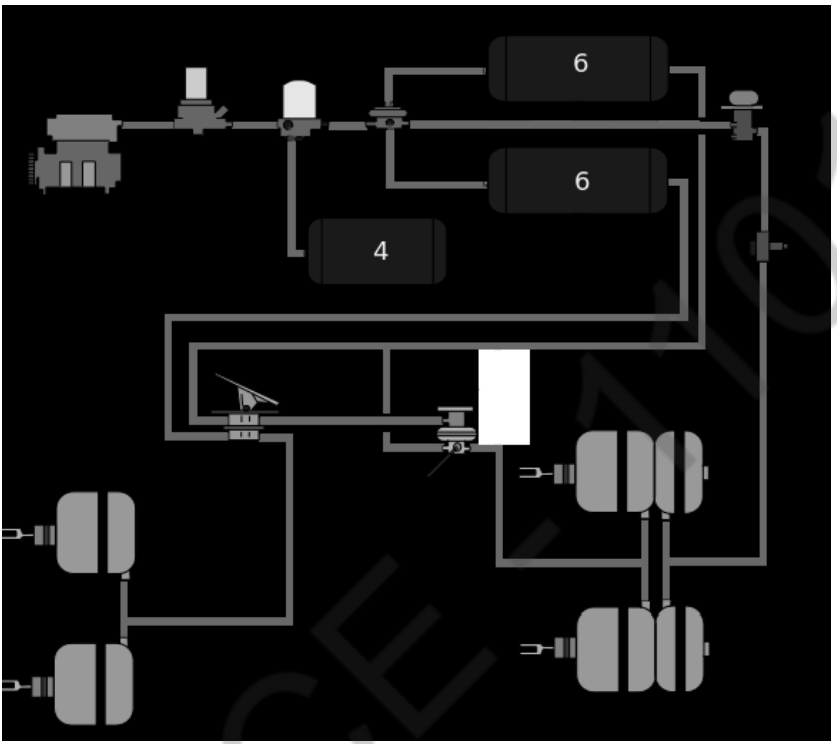


Figure 4.39 Torsion bar

4. Draw the schematic diagram of pneumatic braking system and explain it.



An air brake or, more formally, a compressed air brake system, is a type of frictionbrakeforvehiclesinwhichcompressedairpressingonapistonisused toapplythepressuretothebrakepadneededtostopthevehicle.Airbrakesare used in large heavy vehicles, particularly those having multiple trailers which must be linked into the brake system, such as trucks, buses, trailers, and semi-trailers in addition to their use in railroad trains. George Westinghouse first developed air brakes for use in railway service. He patented a safer air brake onMarch5,1872.Westinghousemadenumerousalterationstoimprovehisair pressured brake invention, which led to various forms of the automatic brake. In the early 20th century, after its advantages were proven in railway use, it was adopted by manufacturers of trucks and heavy roadvehicles.

Design and function

Air brake systems are typically used on heavy trucks and buses. The system consists of service brakes, parking brakes, a control pedal, and an air storage tank.Fortheparkingbrake,there'sadiscordrumbrakearrangementwhichis designed to be held in the 'applied' position by spring pressure. Air pressure mustbeproducedtoreleasethese"springbrake"parkingbrakes.Forthe

service brakes (the ones used while driving for slowing or stopping) to be applied,thebrakepedalispushed,routingtheairunderpressure(approx100– 120 psi or 690–830 kPa or 6.89-8.27 bar) to the brake chamber, causing the brake to be engaged. Most types of truck air brakes are drum brakes, though there is an increasing trend towards the use of disc brakes in this application. The air compressor draws filtered air from the atmosphere and forces it into high-pressure reservoirs at around 120 psi (830 kPa; 8.3 bar). Most heavy vehicles have a gauge within the driver's view, indicating the availability of airpressureforsafevehicleoperation,oftenincludingwarningtonesorlights. A mechanical "wig wag" that automatically drops down into the driver's field of vision when the pressure drops below a certain point is also common. Settingoftheparking/emergencybrakereleasesthepressurizedairinthelines between the compressed air storage tank and the brakes, thus allowing the spring actuated parking brake to engage. A sudden loss of air pressure would result in full spring brake pressureimmediately.

Acompressedairbrakesystemisdividedintoasupplysystemandacontrol system. The supply system compresses, stores and supplies high-pressure air to the control system as well as to additional air operated auxiliary truck systems (gearbox shift control, clutch pedal air assistance servo, etc.).Highly simplified air brake diagram on a commercial road vehicle (does not show all air reservoirs and all applicable air valves).

Theaircompressorisdrivenbytheengineeitherbycrankshaftpulleyviaa belt or directly from the engine timing gears. It is lubricated and cooled bythe enginelubricationandcoolingsystems.Compressedairisfirstroutedthrough a cooling coil and into an air dryer which removes moisture and oilimpurities and also may include a pressure regulator, safety valve and smaller purge reservoir.Asanalternativetotheairdryer,thesupplysystemcanbeequipped with an anti-freeze device and oil separator. The compressed air is then stored in a reservoir (also called a wet tank) from which it is then distributed via a four way protection valve into the front and rear brake circuit air reservoir, a parking brake reservoir and an auxiliary air supply distribution point. The system also includes various check, pressure limiting, drain and safetyvalves. Air brake systems may include a wig wag device which deploys to warn the driver if the system air pressure drops toolow.

Control system

Thecontrolsystemisfurtherdividedintotwoservicebrakecircuits:theparking brake circuit and the trailer brake circuit. This dual brake circuit is further splitintofrontandrearwheelcircuitswhichreceivecompressedairfromtheir individualreservoirsforaddedsafetyincaseofanairleak.Theservicebrakes are applied by means of a brake pedal air valve which regulates both circuits. The parking brake is the air operated spring brake type where its applied by spring force in the spring brake cylinder and released by compressed air via hand control valve. The trailer brake consists of a direct two line system: the supplyline(markedred)andtheseparatecontrolorserviceline(markedblue).

The supply line receives air from the prime mover park brake air tank via a park brake relay valve and the control line is regulated via the trailer brake relay valve. The operating signals for the relay are provided by the prime moverbrakepedalairvalve,trailerservicebrakehandcontrol(subjecttolocal heavy vehicle legislation) and the prime mover park brake hand control.

Synchronising system is used or smooth meshing. A synchromesh works like a friction clutch.

5. Explain the steering principle, it need, function in detail with proper sketches and mention the parts steeringsystems.

Purpose of a steering system

The steering system allows the driver to guide the car along road and left or right as desired.

The system includes the following

(i) Thesteeringwheel------ which the drivercontrol

(ii) Thesteeringgear------- whichchangestherotarymotionofthewheelinto straight line motion, and

(iii) Thesteeringlinkage -----which transmit the steering gear movement tothe front wheels.

The steering system configuration depends on vehicle design (the drive train and suspension system used, whether it is a passenger car or a commercial vehicleetc).Atpresent,therock–and–piniontypeandtherecirculating–ball types are in use.

Moststeeringsystemweremanualuntilafewyearback.Thenpowersteering because popular. It is now installed on almost all costlycars.

Functions of a steering system

Following are the function of a steeringsystem:

1. The primary function of steering system is to achieve angular motion of the front wheels to negative aturn.
2. To provide directional stability of the vehicle when going straightahead.
3. To facilitate straight ahead recovery after completing aturn.
4. To minimise wear and tear oftyres.
5. To absorb a major part of the road shocks thereby preventing them to get transmitted to the hands of thedriver.

Requirements of a good steering system

Following are the requirement of good steering system:

1. Very accurate
2. Easy to handle
3. Providedirectional
4. Multiplytheturningeffortappliedonthesteeringwheelbythedriver

5. Irreversible to a certain degree, so that the blocks of the read surface encounteredbythewholearenotwheelarenottransmittedtodriver's hands.

General arrangement of a steering system

Fig 8.1. shows the general arrangement of a steering system. The layout of steering system is shown. Fig 8.2

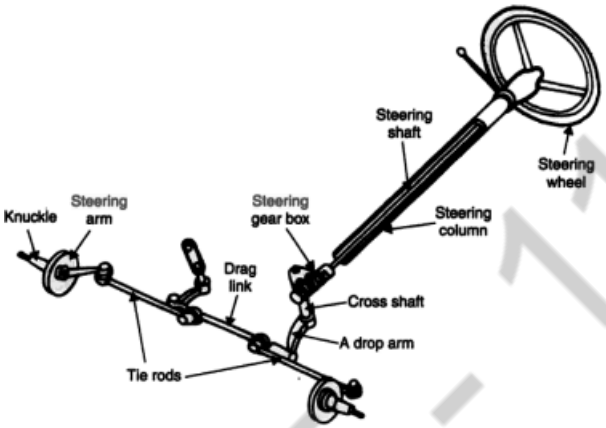


Fig. 8.1. General arrangement of a steering system.

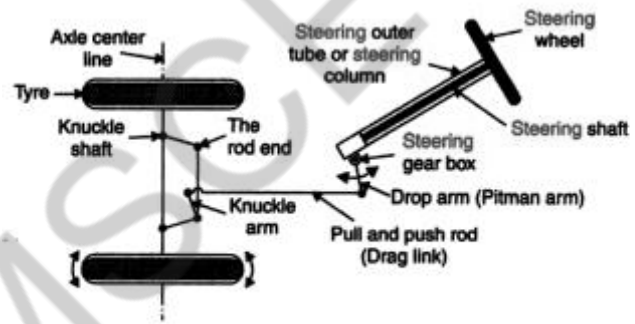


Fig. 8.2. Layout of steering system.

The main parts of a steering system are:

1. Steeringwheel
2. Steeringcolumn
3. Steeringshaft
4. Steering gearbox
5. Steering drop arm (pitmanarm)
6. Pull and push rod (Draglink)
7. Knucklearm
8. Tie rod and tie rodend

Working of steering mechanisms:

Thesteeringwheelrotatesthesteeringcolumn.Thesteeringboxisfittedtothe end of the column. Therefore, when the wheel is rotate, the cross shaft in the gear box oscillates. The cross shaft is connected to the drop arm. This arm is linked by means of a drag link to the steering arms. The steering arms onboth wheels are connected by the tie rods to the draglink.

When the steering wheel is operated, the knucks moves to and fro, moving the wheels to the right or left. The ends of the tie rod and steering kuuckls are connected to each other. One end of the drag link is connected to the tie rod. Theotherendisconnectedtotheendofdroparm.Aballandsocketjointgives the required movement to the joints between the tie rod, drag link and drop arm. When the vehicle is moving, the drop arm developers vibration. Shock springs are used in ball and socket system to absorb thisvibration.

Brief description of steering parts:

1. Steeringwheel:

It is made of steel ring welded together on a hub with the help of two, there or four spokes. After welding rings with the spokesis ebonite moulded on it.

- In certain vehicle centre hub has splines cut on it while in othercases a key groove is given to secure the steering shaft firmly in it.

Thesteeringwheels,inovercountry,haveafixedposition.However,inforeign countries, these wheels, in some vehicle can be tilted and located in position to suit thedriver.

Steering wheel is pulled out with the help of puller

2. Steering outer tube or steeringcolumn:

This is a hollow steel pipe in with steering is housed.

One end of the pipe is fixed on steering box, the other end is usually held with the help of bracket under the instrument panel.

3. Steeringshaft:

The steering shaft is made out of good quality steel.

One end of is fixed in the steering wheel with the help of splines or key and kepttightbynut.Theotherendwithwormissecuredfirmlyinthesteeringbox with the help of bearing placed both on top and bottom. Sometimes, instead of one shaft, two pieces of shafts are also used (in those cases where steering wheel and steering box are not in oneline)

4. Steering gearbox:

Its function is to convert rotary motion of wheel into – to – and – fro motion of drop arm so that the drag link up with drop arm can be pushed or pulled resulting into moving stub axle to right or left as desired by the driver.

5. Droparm:

It is forged out of good quality steel.

6. Explain the independent suspension with neatsketches.

Independent suspension

"Independentsuspension"isatermusedtodescribeanyarrangementbywhich the wheels are connected to the carriage unit in manner such that the rise and fullofonewheelhasnoeffectontheothers.Almostallthepassengercarsnow the independent front suspension, in which the coil spring arrangement is the common.

Whenavehiclewithrigidaxlesuspensionencountersroadirregularities,the axletitleandthewheelsnolongerremainvertical.Thiscausesthewholeofthe vehicletotilttooneside.Suchastateofaffairisnotdesirable.Besidescausing rough ride, it causes 'wheel wobble'. The road adhesion is also decreased. In order to avoid this the wheels are spring independent of each other, so that tilting of one does not affect theother.

Advantage

The independent suspension claims the following advantage over the rigid axle type suspension.

1. Inindependentsystemsincethewheelsmoreorlesstravelwiththeirplanes perpendicular to the road surface, the gyroscopic effects are reduced to a minimum.
2. The engine and chassis frame can be placed relatively lower which means engine position can be moved forward resulting in more space for passengers.
3. Provides a greater degree of vertical/ springingmovement
4. Diminished wheel wobble and steeringmovement
5. Provides scope for use of springs of greater resilience giving much better springing action than most ride axlevehicles.
6. Reduced unsprung weight and hence improved ride and better road holding while cornering andbraking
7. The frame and body do not tilt but remains horizontal and the wheels vertical when the wheel encounters a roadbump.
8. Variations in caster angle arereduced.
9. Itusescoilspringswhichcanbeplacedclosertothewheel.Thisisdefinite advantage vis – vis leaf springs for a wheel to be steered.

Disadvantages:

Apart from the distinct advantages which the independent suspension possesses, it has the following disadvantages:

1. High initialcost.
2. Owing to larger number of bearings greater maintenance isrequired
3. More rigid sub – frame or chassis framerequired.
4. Forces due to unbalanced wheels are more pronounced and transmitted easily to the steeringwheel.
5. In the event of body roll, the wheel chambers tilt outwards in case of wishbone type and inwards in case of Macpherson structure type , due to which cornering power isreduced.

Front wheel (dead axle) Independent suspension.

The front suspension is more complicated than the rear suspension, because thefrontwheelsnotonlymoveupanddownwithrespectstothecarframe,but also swing at various angles to the car frame foe steering. In order to permit the front wheels to swing on one side or the other for steering, each wheel is supportedonaspindlewhichispartofasteeringknuckls.Thesteeringknuckls is then supported through ball joints, by upper and lower control arms which are attached to the car frame.

Sincethefrontsuspensioninacarhastobearalotofforcesparticularlydueto acceleration, braking and cornering, therefore, it must adhere to the following conditions:

(i) Not to allow the system to alter the tilt of the wheels to any serious degree

(ii) Not to permit the various forces coming from road irregularities and cornering to deflect the car from its course of movement decided by thedriver.

(iii) Not to allow the wheels to wobble, move any significantdistance backwards or forwards or sideways.

The following types of independent suspension systems are applicable to automobiles:

1. Wishbone armsystem
2. Trailing linksystem
3. Sliding pillarsystem

Fig . 6.27 shows the double wish bone suspension system. This is the most popular type of independent suspension system in which coil springs are mostly used. In European cars, torsion bars are quite popular in lieu of coil springs. In some automobiles, transverse leaf spring in the front independent suspension system.

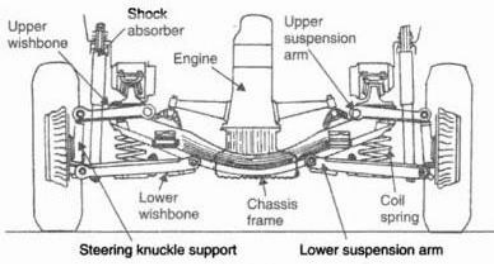


Fig. 6.27. Double wishbone suspension.

In this type of suspension, there are two suspension or control arms on each side of the vehicle. These arms are like the two legs of chicken wishbone or letter V. These wishbone arms are connected with chassis frame on the open end. One arm is below whereas other is above the frame. The closed ends of bothupperandlowersuspensionarmsareconnectedwiththesteeringknuckle to support to which is attached steering knuckle by means of a king pin. A coil spring is placed between the frame and lower wishbone suspension arm. Mostlytheopenendofuppercontrolarmisconnectedwiththedamper/shock absorber which is fitted at the frame. The upper and lower arms are connected in positions, for the cradle.

When there is bump and the wheel tended to go up, the control arms move up and coil spring is compressed. Since the damper / shock absorber is fitted with the upper control arm, so it damps the vibration set up in the coil spring due to road irregularities.

Macpherson strut assembly:

It is a single wishbone with a telescopic strut type system as a shown in fig.6.28. the Macpherson system consists of a telescopic strut, a single arm a diagonal stay. The strut is fixed to the body structure at the upper end through a flexible mounting and the lower part of the strut is connected at the bottom byajointtothelowerpartofthestrutalsocarriesthestubaxle,whichinterm carriesthewheel.Thesteeringmotionissuppliedtothelowerpartofthestrut and it turns the whole strut. A coil and a hydraulic damper/ shock absorber surround the upper part of the strut which takes care of the rod irregularity shocks andvibrations.

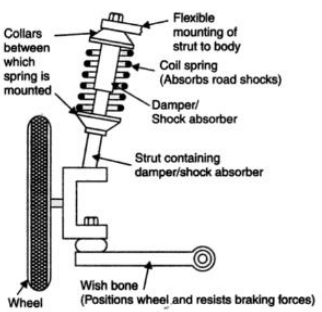


Fig. 6.28. MacPherson strut assembly.

Advantages of Macpherson system:

(i) Very easymaintenance
(ii) Simple in mechanicalconstruction
(iii) Less variation in wheelcamber
(iv) Its light moving parts help the wheels to follow the roadirregularities
(v) Distinctadvantagesincaseoftransverseengines,sinceinthecase there is no space or very little space for upper links to fit.

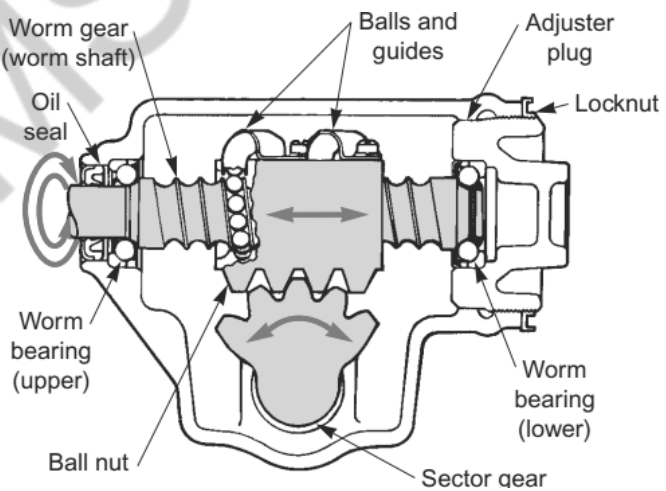
Disadvantages:

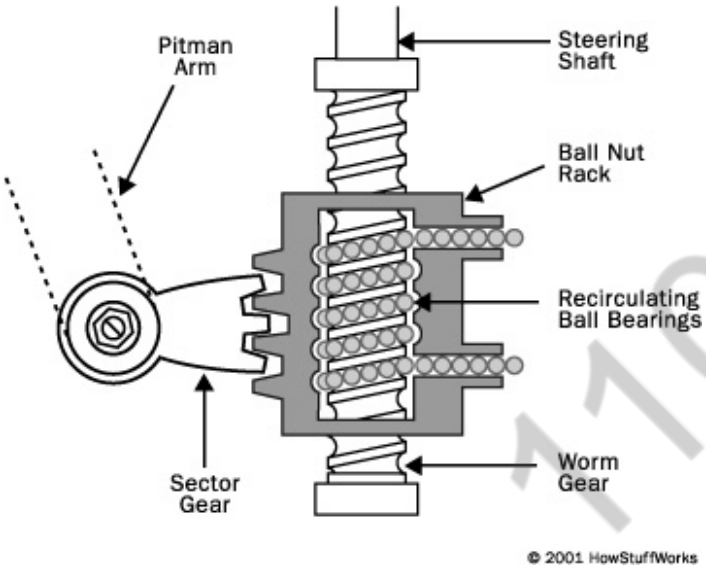
(i) Duringcorneringandbraketorquetheradialloadingcomeonthedue to the lateral forces

(ii) In order to absorb the full suspension loads the body structure has to be really strong above the wheel arches the struts areattached.

7. Sketch a recirculating ball type steering gear and explain its working principle.

Recirculating-Ball Steering Gear The recirculating-ball steering gear is commonly used on modern vehicles. This steering gear is known by many names,dependingonthemanufacturer.Commonnamesforthistypeofsteering gear include worm and nut, worm and ball, and recirculating nut and worm. No matter what the name, the basic design is the same. The basic principle of thistypeofsteeringgearisshowninFigure9-27.Thewormgearisthescrew, and the ball nut rides up and down as the screw turns. Teeth on one side of the ball nut contact matching teeth on the sector gear. When the steering shaft turns the worm gear, the ball nut moves on the worm gear shaft. Teeth on the ball nut cause the sector gear to turn. The ball bearings between the threads of the worm gear and ball nut reduce friction between the worm and the nut.The steering gear is called arecirculating-ball





Steeringgearbecausetheballbearingsmoveinaloop,orcircuit,astheworm gear moves the ball nut. The ball bearings can recirculate because of ball guides installed on top of the ball nut assembly. The worm and sector gears ride on ball or roller bearings to reduce friction. The steering gear may be lubricatedby90–140weightgearoil,oritmayrequireautomatictransmission fluid. Seals at the input shaft and sector shaft keep lubricant from leaking out of the steering gear. The worm and sector gears contain thrust washers and spacers for properclearance.

8. With the aid of a diagram explain the function of the main parts of the mastercylinder.

Brake Master Cylinder (BMC) is nothing but a highly advanced piston and cylinder assembly.The purpose of BMC is to **build hydraulic pressure** and it works on the basic principle of Pascal's Law.So how does a BMC build hydraulic pressure, it does using some complicated piston, seals and spring set-up.

Brake Master cylinders is simply a hydraulic piston. The force of the foot is transferred to the piston through the pedal lever which in-turn compresses thefluidinsidethemastercylinder.Thisbuildshydraulicpressureinthebrake lines which causes the brakingaction.

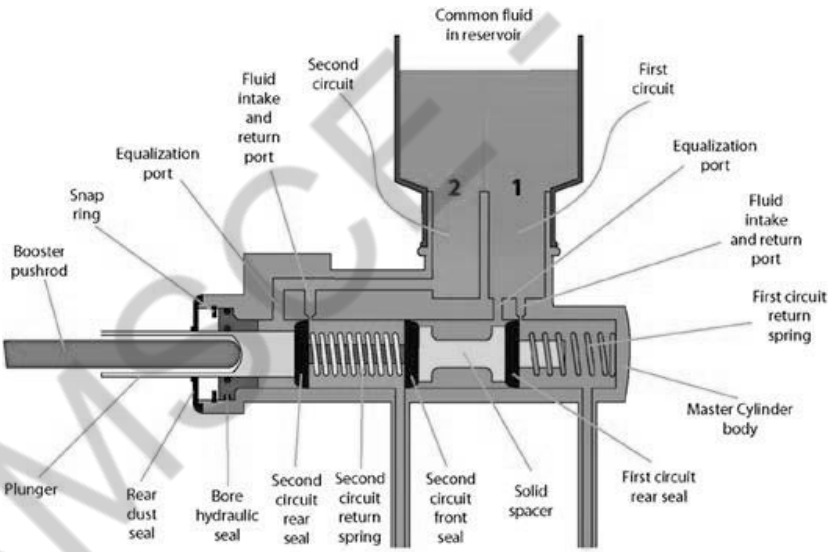
Thereservoirisconnectedtothecylindertoensurethatanybrakefluidlost (through evaporation, boiling or minor leaks) will be topped up by more fluid Thebelowpictureisacutsectionofa BMC.Themainpartswewilldealwith and which is sufficient for understanding the function of the BMC are

1) **Reservoir** - which holds the brakefluid

2) **Primary & Secondary Piston** - which acts aspiston

3) **Seals** - seals the port and also seals thechambers.

The force on the brake pedal is shifted to a Booster [2] which multiplies the forceandtheforceisappliedtotheBMCviatheBoosterpushrod.Thebooster push rod transfers the force to the primary piston (**Plunger**) which pushes the rod forward and this leads to the seal (**Second Circuit Rear Seal**) closing the port (**Fluid Intake and Return Port**), so now the fluid as nowhere to go, so as per Pascal's law the hydraulic pressure increases in the brake lines which are connected to the brakes. Simultaneously the secondary piston (**Solid Spacer**) does the same in the second chamber. As and when the fluid reduces in the chamber (because of wear and tear, chemical changes etc.,) the **Reservoir** refillsit.



The outlet of both the chambers are connected to the brakes generally one opposite another i.e., primary chamber may serve one front and one back and samewiththesecondarychamber-thisistoallowforthebrakestohaveatthe least minimal function in the event of failure in anychamber.

9. List down the advantages and disadvantages of using Anti-Locking Brakingsystem.

Anti-lock brakes help drivers have better control of a vehicle in some road conditions where hard braking may be necessary. In vehicles without anti-lock brake systems, drivers who encounter slippery conditions have to pump their brakes to make sure they do not spin out of control because of locked up wheels. Anti-lock braking systems coordinate wheel activity with a sensor on each wheel that regulates brake pressure as necessary, so that all wheels are operating in a similar speed range.

The advantages of ABS brakes (anti-lock braking system), are just as the meaning of their acronym implies, they eliminate or greatly reduce the possibility of brake lock up and therefore provide a better chance of steering out of trouble.

Conventional hydraulic brakes work by using a cylinder (actuator), which squeezesbrakecaliperstogetheraroundthewheel'srotorwhenthebrakepetal is depressed. Difficulties arise with these conventional brakes if the road is slick and the driver executes a panic stop. Under these conditions the wheels maylockupandthetiresruntheriskoflosingtheirgrip.Whentireslose their gripoftheroad,thereisagoodchancethatthecarmaygointoanuncontrolled spin.Thisiswhydriversinoldervehicleshavebeentaughtinthepasttopump brakes when on icyroads.

ABS brakes were designed to combat the problem of tire lock up and uncontrolledspins.Sincebrakesaremosteffectiveatslowingthecaratapoint just before wheel lock up, a system that provides for wheel braking while preventing wheel lock up is verydesirable.

Anti-lock brakes do just this by using a computer processor to monitor and control the application of the brakes. At braking, the processor monitors rpm and braking pressure on each of the vehicle's wheels. With this information, measured amounts of pressure are sent to each wheel in the form of hydraulic pulses of pressure to the calipers. These pulses achieve the desired braking pressure without allowing the wheels to lock up.

Advantages of Anti-Lock Brakes

The main benefits of an anti-lock brake system (ABS) include.

- **Stopping on ice.** As mentioned above, an ABS prevents lock-ups and skidding, even in slippery conditions. Anti-lock brakes have been proven to save lives in some situations by helping drivers keepcontrol of a vehicle.
- **Traction control.** An ABS shares some of the infrastructure of a traction control system, where new technology helps ensure that each wheelhastractionontheroad.Thatmakesiteasyformanufacturersto install both of these features at thefactory.

Disadvantages of Anti-Lock Brakes

Despite the fact that anti-lock brakes are proven to be a safety feature in most situations, and insurers consider them to significantly lower risk for a vehicle, not all drivers are sold on this option for a car or truck. Here are some of the down sides that drivers find in this kind of brake system.

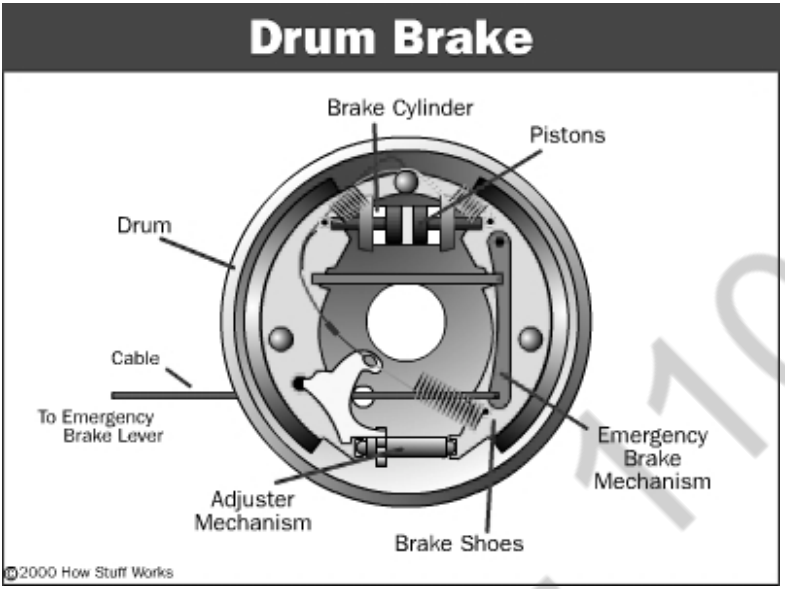
- **Inconsistentstoptimes.**Anti-lockbrakesaremadetoprovideforsurer braking in slippery conditions. However, some drivers report that they find stopping distances for regular conditions are lengthened by their ABS, either because there may be errors in the system, or because the clunking or noise of the ABS may contribute to the driver not braking at the samerate.
- **Expense.** An ABS can be expensive to maintain. Expensive sensors on each wheel can cost hundreds of dollars to fix if they get out of calibration or develop other problems. For some, this is a big reasonto decline an ABS in avehicle.
- **Delicate systems.** It's easy to cause a problem in an ABS by messing around with the brakes. Problems include disorientation of the ABS, where a compensating brake sensor causes the vehicle to shudder, make loud noise or generally brake worse.

10. With a neat sketch describe the advantages and disadvantages of the drum and disc brakesystems.

For most cars, **drum brakes** work in conjunction with disc brakes to stop a car. Although disc brakes are a more efficient means of braking, drum brakes are less expensive to manufacture. Car makers install drum brakes in the rear of most cars due in part because of their low cost relative to disc brakes, but also because they work well as a parking brake. High end cars may come with stock disc brakes in the rear, but they are usually added as anaftermarket part. Comparing the two types of brakes, both has its own advantage and disadvantages.

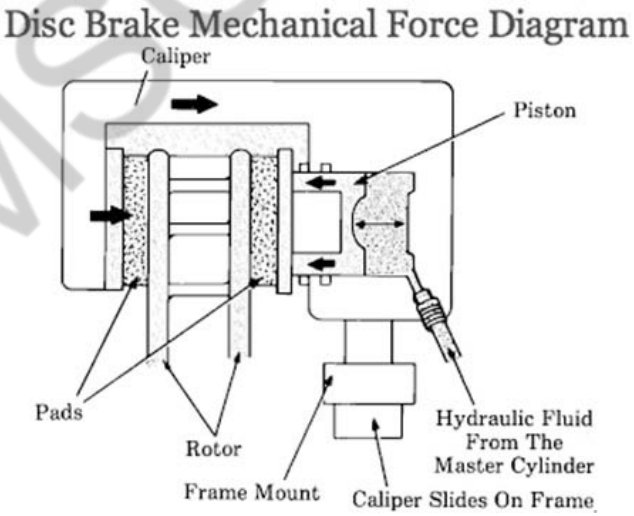
Drum brakes

Drum brakes are named because of the round drum that comprises part of the wheel housing. Although open from the backside, from the front the large cylinder resembles a drum. The way they work is as follows: When the brake pedal is applied, pressurized brake fluid enters into the individual wheel cylinder in each of the two drums. This fluid pushes two brake pistons out which in turn push two brake shoes. The shoes are pushed up against the interiorofthedrum.Anadjusterarmoppositethewheelcylinderletstheshoes rotateaspressureisexerted.Thiscreatesbetterstoppingpowerandallowsthe shoes to wear evenly on the inside of thedrum



Disc Brakes

Discbrakes,bycomparison,consistofflatmetalrotorthatsurroundsthewheel housing and rotates with the wheel. When the brakes are applied, the pressure forces brake calipers to clamp down on two brake pads, one on either side of the disc.



Advantages and disadvantages

- In general, it is thought that disc brakes are a better means of stopping the car than drum brakes. This is due to three primary reasons. The heatenergythatistransferredtothebrakesbetterdissipateswithdiscs, brake fade occurs more slowly with disc brakes and they tend to stay drier in wetweather.
- Drum brakes tend to get hotter with use, they lose their effective abilitytostopthecarfasterandwatercangatheronthedrum'sinterior between the lining and theshoes.
- Drum brakes, on the other hand, function well as a parking brake. A mechanismisbuiltrightintodrumbrakesthatactivatesthemwhenthe parkingbrakeleverispulled.Ondiscbrakes,anadditionaldevicemust be installed to accommodate a parking brake.
- The other benefit is the low cost of drum brakes.
- Carsfittedwithdiscbrakesonalltireswillcostmoreoffthelot,sotheuseofdrumbrakesintherearequalssavingsconferredtotheconsumer.
- When having brake work done, the replacement of drums or shoes is less expensive than that of calipers or discs.

11. What is the need for a suspension system? Draw a schematic of a front suspension system. Indicate the parts and their function. (Apr/May 2018)

1. To eliminate roadshocks from transmission to vehicle components.
2. To maintain stability of the vehicle in pitching or rolling while in motion.
3. To safe guard occupant from road shocks.
4. To obtain good road holding while driving, cornering and breaking.
5. To keep proper steering geometry.
6. To obtain particular height to body structure.
7. To resist torque and breaking reactions.
8. To keep the body of the motor vehicle on even keel while travelling over a rough round or when turning in order to minimize rolling. Pitching or

vertical movements tendency.

Front wheel (dead axle) Independent suspension.

The front suspension is more complicated than the rear suspension, because the front wheels not only move up and down with respects to the car frame, but also swing at various angles to the car frame foe steering. In order to permit the front wheels to swing on one side or the other for steering, each wheel is supported on a spindle which is part of a steering knuckle. The steering knuckle is then supported through ball joints, by upper and lower control arms which are attached to the carframe.

Sincethefrontsuspensioninacarhastobearalotofforcesparticularly due to acceleration, braking and cornering, therefore, it must adhere to the following conditions:

(i) Nottoallowthesystemtoalterthetiltofthewheelstoanyserious degree

(ii) Not to permit the various forces coming from road irregularities and cornering to deflect the car from its course of movement decided by thedriver.

(iii) Not to allow the wheels to wobble, move any significantdistance backwards or forwards or sideways.

The following types of independent suspension systems are applicable to automobiles:

1. Wishbone armsystem
2. Trailing linksystem
3. Sliding pillarsystem

This is the most popular type of independent suspension system in whichcoilspringsaremostlyused.InEuropeancars,torsionbarsarequite popular in lieu of coil springs. In some automobiles, transverse leaf spring in the front independent suspensionsystem.

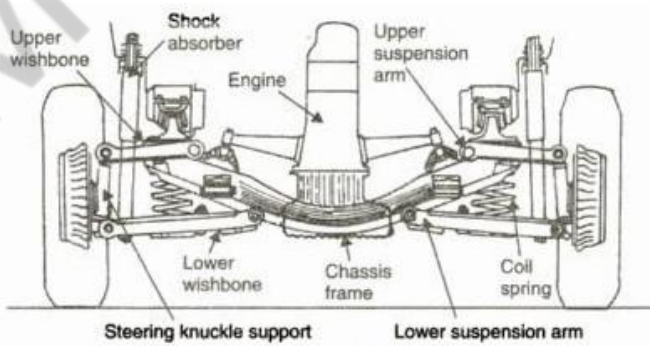


Fig. 6.27. Double wishbone suspension

In this type of suspension, there are two suspension or control arms on each side of the vehicle. These arms are like the two legs of chicken wishbone or letter V. These wishbone arms are connected with chassis frameontheopenend.Onearmisbelowwhereasotherisabovetheframe. The closed ends of both upper and lower suspension arms are connected with the steering knuckle to support to which is attached steering knuckle by means of a king pin. A coil spring is placed between the frame and lowerwishbonesuspensionarm.Mostlytheopenendofuppercontrolarm isconnectedwiththedamper/shockabsorberwhichisfittedattheframe. The upper and lower arms are connected in positions, for the cradle.

When there is bump and the wheel tended to go up, the control arms moveupandcoilspringiscompressed.Sincethedamper/shockabsorber is fitted with the upper control arm, so it damps the vibration set up in the coil spring due to roadirregularities.

Macpherson strut assembly:

It is a single wishbone with a telescopic strut type system as a shown in fig.6.28. The Macpherson system consists of a telescopic strut, a single arm a diagonal stay. The strut is fixed to the body structure at the upper endthroughaflexiblemountingandthelowerpartofthestrutisconnected at the bottom by a joint to the lower part of the strut also carries the stub axle, which in term carries the wheel. The steering motion is supplied to thelowerpartofthestrutanditturnsthewholestrut.Acoilandahydraulic damper/ shock absorber surround the upper part of the strut which takes care of the rod irregularity shocks andvibrations.

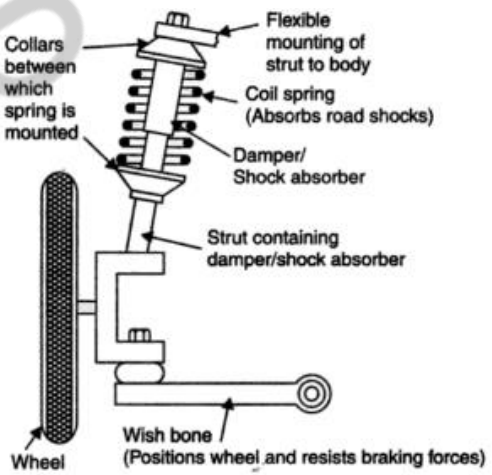


Fig. 6.28. Mac Pherson strut assembly.

Advantages of Macpherson system:

(i) Very easymaintenance

(ii) Simple in mechanicalconstruction

(iii) Less variation in wheelcamber

(iv) Its light moving parts help the wheels to follow the road irregularities

(v) Distinctadvantagesincaseoftransverseengines,sinceinthecase there is no space or very little space for upper links tofit.

Disadvantages:

(i) During cornering and brake torque the radial loading come on the due to the lateral forces

(ii) In order to absorb the full suspension loads the body structurehas to be really strong above the wheel arches the struts areattached.

12. Describe with an illustration the steering geometry and how it affects motion of an automobile. Mention the difference between manual and power assisted steering. (Apr/May 2018)

Steering Geometry:

Since the steering linkage consists of different mechanisms such as support arms, tie rod, pitman arm, drag link etc connected together they form angles in relation to each other. Steering geometry is the angular representation and obtaining relationship between these linkages and front wheels. It is essential to know the name of various angles which is produced in steering geometry.

The important angles pertaining to steering geometry are as follows:

1. Castor
2. Camber
3. Kingpin Inclination
4. Toe-in
5. Toe-out

(i) Camber:

When the front of the vehicle is viewed, the angle between centre line of tyre and vertical line is called camber. Figure 4.8 shows the camber angle. The camber is also named as wheel rake. When the wheels are titled inwards at the top, it is negative. It is private when it tilts outward at the top. The camber is referred in

degrees. The front wheels are come to vertical position when the vehicle loads are with a positive camber. At that time, the camber should not exceed to 2^0

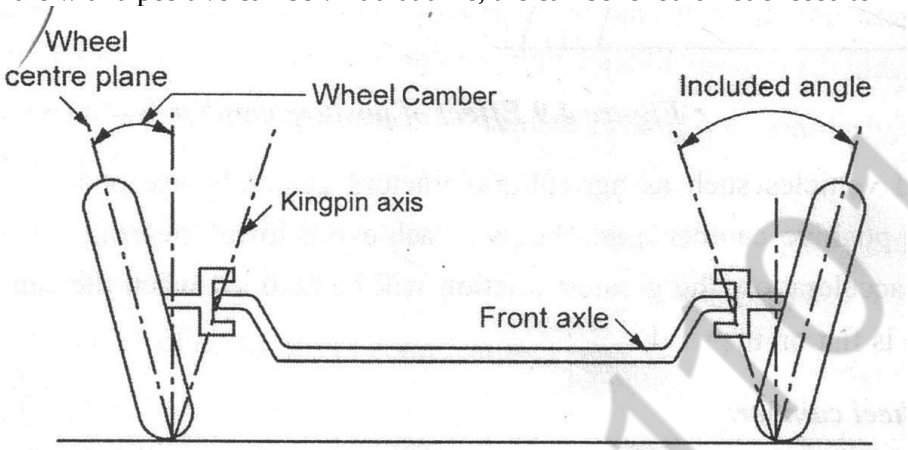


Figure 4.8 Camber

Reason of Camber angle provided in steering system:

Camber angle alters the handling qualities of a particular suspension design. Particularly, a negative camber improves grip when concerning because it places the tyre at a better angle to the road, transmitting the forces through the vertical plane of the tyre rather than through a shear force across it.

Effects of Wheel Camber:

1. Bending stresses in the kingpin and stub axle are reduced.
2. Steering effort is drastically reduced.
3. Shock loads are not permitted to transmit to the steering wheel at high speeds.
4. It imparts the directional stability.

(ii) Castor:

Tilting the kingpin axis either forward or backward from the vertical line is known as castor. The angle between the vertical line and kingpin centre line in the plane of the wheel when it is viewed the side is known as castor angle.

When the top the kingpin is inclined in backward direction, the castor angle is positive. The caster angle is negative, when the top of the kingpin is inclined in forward direction. It ranges from 2^0 to 7^0 in modern vehicles. Excessive castor causes excessive wobbling on front wheels.

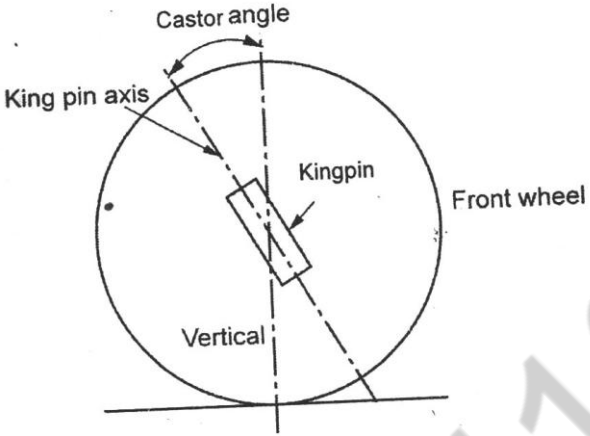


Figure 4.10 Castor

Effects of Castor:

1. The positive castor gives the directional stability and it keeps the wheels to straight ahead after completing its turns. Similarly, the negative castor provides easy steering.

2. The excessive positive castor tends the vehicle rolling out. Similarly, the excessive negative castor makes the wheel to toe-out.

3. If castor angle on both wheels is same, both wheels will be equally balanced. If it is greater on one side, wheels are pulled towards the wheel having lesser castor angle.

(iii) Kingpin Inclination:

The angle between vertical lien and centre of the kingpin or steering axle when viewing from the front of the vehicle is called kingpin inclination. It usually varies from 3.5^0 to 7.5^0.

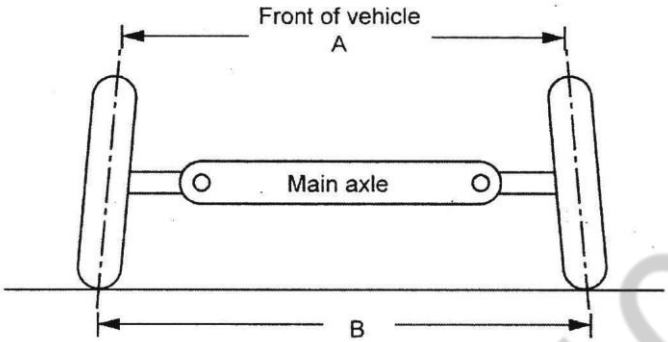


Figure 4.11 Toe-in

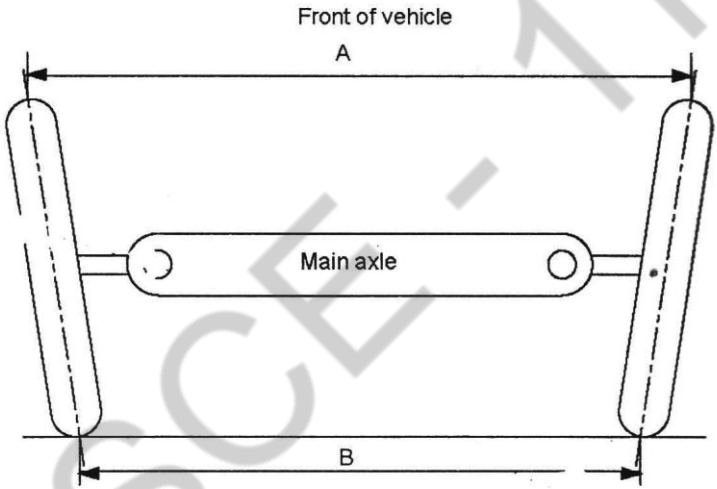


Figure 4.12 Toe-out

Effects of Kingpin inclination:

1. Both kingpin inclination and castor give directional stability.
2. Particularly steering effort is reduced when the vehicle is stationary.
3. Tyre wear also is greatly reduced.

(iii) Toe-in and Toe-out:

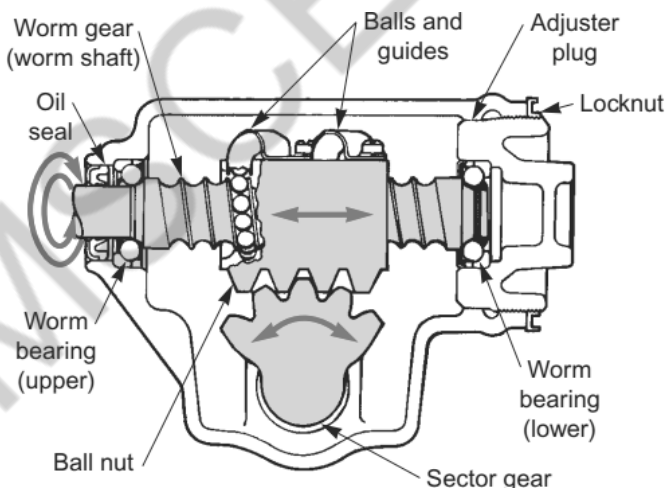
Usually, front wheels are slightly turned to the front side. It means, the distance (A) between front ends is slightly less than distance (B) between back ends when it is viewed from top as shown in figure 4.11. Then the wheels are said to be toe-in.

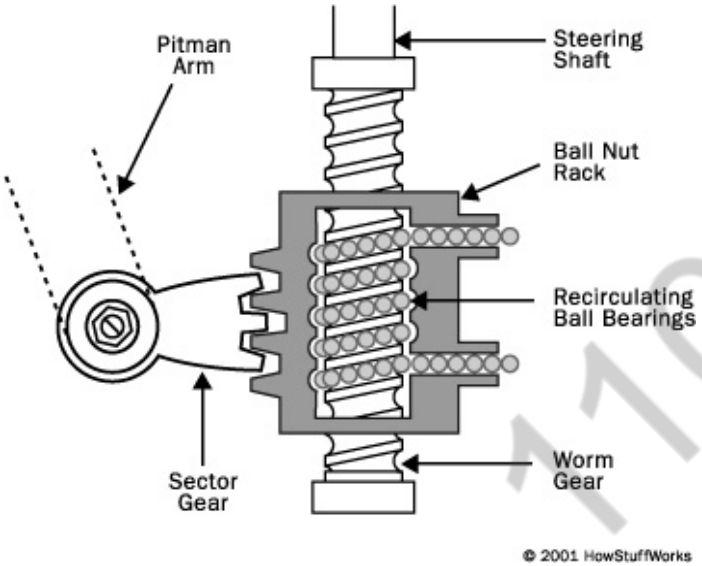
Effects of toe-in:

The toe-in is given to ensure the parallel rolling of front wheels, stabilized steering and no side slipping and less tyre wear

13. **. With relevant sketches brief about the construction of the following steering gear boxes.(Nov/Dec 2018)**
    1. **Recirculating Ball type**
    2. **Rack and pinion type**

Recirculating-Ball Steering Gear The recirculating-ball steering gear is commonly used on modern vehicles. This steering gear is known by many names,dependingonthemanufacturer.Commonnamesforthistypeofsteering gear include worm and nut, worm and ball, and recirculating nut and worm. No matter what the name, the basic design is the same. The basic principle of thistypeofsteeringgearisshowninFigure9-27.Thewormgearisthescrew, and the ball nut rides up and down as the screw turns. Teeth on one side of the ball nut contact matching teeth on the sector gear. When the steering shaft turns the worm gear, the ball nut moves on the worm gear shaft.Teeth on the ball nut cause the sector gear to turn. The ball bearings between the threads of the worm gear and ball nut reduce friction between the worm and the nut.The steering gear is called arecirculating-ball





Steeringgearbecausetheballbearingsmoveinaloop,orcircuit,astheworm gear moves the ball nut. The ball bearings can recirculate because of ball guides installed on top of the ball nut assembly. The worm and sector gears ride on ball or roller bearings to reduce friction. The steering gear may be lubricatedby90–140weightgearoil,oritmayrequireautomatictransmission fluid. Seals at the input shaft and sector shaft keep lubricant from leaking out of the steering gear. The worm and sector gears contain thrust washers and spacers for properclearance.

14. Discuss with an illustration the hydraulic breaking system used in four wheeler. Mention the difference between hydraulic and pneumatic breaking system. (Apr/May 2019)

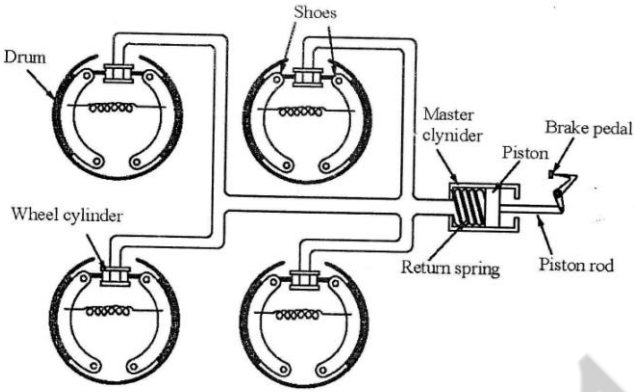


Figure 4.81 Hydraulic brake system

Hydraulic braking system consists of two main components which are master cylinder and wheel cylinder. The master cylinder is attached to the wheel cylinder by tunes on each of our wheels. The system has liquid pressure which acts as a brake fluid. This brake fluid is a mixture of glycerin and alcohol or castor oil, denatured alcohol and some additives.

Construction:

A wheel brake has a cylinder brake drum connected on the inner side of the wheel as shown in fig 4.81.. Two brake shoes are connected inside the brake drums. The shoes are fixed with heat and wear resisting brake lining on their surface. The brake pedal is fitted to the master cylinder piston by a piston rod.

When the brake is applied, the driver depresses the pedal to force the piston into the master cylinder. It will increase the pressure of the fluid in the master cylinder. So, the entry hydraulic system pressure is increased. This pressure is transmitted equally to the wheel cylinder on each of four brakes. Then, it forces the wheel cylinder piston outwards. Due to this, the brake shoes are forced out against the brake drums. Hence, the brake is applied.

15. **List some commonly used rear suspension system. Draw a schematic of any one rear suspension system indicate the parts and their function.(Apr/May 2019)**

For answer refer page No,82 question No, 3

16. **Explain the working of a typical traction control system used in passenger car. (Nov/Dec 2018)**

Traction Control

A traction control system also known as Anti-Slip regulation is typically a secondary function of ABS. A primary function of the traction control system is to maintain the traction and stability of the vehicle regardless of the road surface condition. It is achieved by reducing the drive torque applied to rear wheels to eliminate the wheel slip depending on the version of traction control installed.

When the traction control system determines one wheel spending more quickly than other, it automatically pumps the brake fluid to the particular wheel to reduce its speed and lesson wheel slip. If one of the driven wheels tends to spin, traction control is activated. The TCS reduces the drive torque supplied by the engine. If necessary brakes are applied to individual wheels in order to regulate the slip of driven wheels as quickly as possible to the optimum level.

The main components are an electronic control unit, one or more hydraulic modulator assemblies, one or more wheel speed sensor and a wiring harness.

TCS hydraulic control unit contains pumps, valves, accumulator and motor which perform ECU commanded functions for the system operations. In some traction control system, a special type of traction control reduces engine power to slipping wheels. On a few of these vehicles driver may sense a pulsation of the gas pedal when the system is reducing the engine power similar to the brake pedal pulsates and when the antilog braking system is working.

5 ALTERNATIVE ENERGY SOURCES

PART-A

1. List the advantages of hydrogen fuel used inautomobiles.

- It can be manufactured from water through electrolysis process.
- It does not contain carbon. Hence, CO and unburned HC emissions are not present.
- The flame speed is highest. Hence it results in high thermal efficiency.
- It has wide ignition limits.

2. What is a hybridvehicle?

A hybrid vehicle is a vehicle that uses two or more distinct power sources to move the vehicle. The term most commonly refers to hybrid electric vehicles (HEVs), which combine an internal combustion engine and one or more electric motors.

3. What is a fuel cell?

A fuel cell is an electrochemical device that converts a source fuel into an electrical current and water. It generates electricity inside a cell through reactions between a fuel and an oxidant, triggered in the presence of an electrolyte.

4. Write the composition of LPG and CNG.

Composition ofCNG

CH_4 = 70.9%, C_2H_6 = 5.10%, H_2 = 3%, CO + CO_2 = 22%

Composition of LPG:

Propane= 30 % and Butane = 70 %

5. Define detonation andpre-ignition.

TheabnormalcombustionoccurringinICenginesiscalledasdetonation.This results in sudden rate of pressure rise, abnormal heat release, heavy vibrations of the engine and loud noise operation.

The ignition of the air-fuel mixture before the introduction of the spark in the combustion chamber is called as pre-ignition.

6. What are the advantages of an electriccar?

- No emissions from an electric car
- It does not depend upon the availability fossil fuels

7. State the advantages of fuelcell.

- Higher efficiency than diesel or gas engines.
- Quiet operation.
- Fuel cells can eliminate pollution problems.
- Don't need conventional fuels such as oil or gas and can therefore reduce economic dependence on oil producing countries, creating greater energy security for the user nation.
- The maintenance of fuel cells is simple since there are few moving parts in the system.

8. What are the types of fuelcell?

- Proton exchange membrane fuel cell
- Alkaline fuel cell
- Phosphoric acid fuel cell
- Direct methanol fuel cell
- Solid oxide fuel cell
- Molten carbonate fuel cell

9. What are the alternativefuels?

Alcohols, Hydrogen, Natural Gas, CNG, LNG, LPG, Bio Gas, Producer Gas, Coke oven Gas, Water Gas, Gasohol, Biodiesel.

10. What are the various properties of gaseous fuel?

Advantages

Gaseous fuels due to erase and flexibility of their applications possess the following advantages over solid or liquid fuels:

- They can be conveyed easily through pipelines to the actual place of need, thereby eliminating manual labour in transportation.
- They can be lighted at ease.
- They have high heat contents and hence help us in having higher temperatures.
- Theycanbepre-heatedbytheheatofhotwastegases,therebyaffecting economy in heat.
- Their combustion can readily by controlled for change in demand like oxidizing or reducing atmosphere, length flame, temperature, etc.

- They are clean in use.
- They do not require any special burner.
- They burn without any shoot, or smoke and ashes.
- They are free from impurities found in solid and liquid fuels.

Disadvantages

- Very large storage tanks are needed.
- They are highly inflammable, so chances of fire hazards in their use is high.

11. What isCNG?

Compressed Natural Gas: It is typically stored in a tank at a pressure of 3,000 to 3,600 pounds per square inch.

12. What is BIO- DIESEL? State itsadvantages.

Biodiesel is a non-petroleum based diesel fuel which consists of the mono alkyl esters of long chain fatty acids derived from vegetable oil and animal fats.

Advantages

- Domestically produced from non-petroleum, renewable resources
- Can be used in most diesel engines, especially newer ones
- Less air pollutants (other than nitrogen oxides)
- Less greenhouse gas emissions (e.g., B20 reduces CO2 by 15%)
- Biodegradable
- Non-toxic
- Safer to handle

13. What are advantages of LPG over conventionalfuels?

- LPG contains less carbon than petrol
- LPG mixes with air at all temperatures
- In multi cylinder engines, a uniform mixture can be supplied to all cylinders
- Since the vapour in the form of vapour, no crankcase dilution
- Automobile engines can use propane if they use high compression ratio
- LPG has better antiknock characteristics
- Running on LPG produces fuel saving cost of about 50%
- The engine will have 50% longer life.

14. What are the disadvantages of using alcohol as an alternativefuel?

- A larger quantity of fuel is required to produce a specified power output. For example, in an automobile, more fuel is required for each mile driven.

- Low boiling points and high vapour pressures of methyl and ethyl alcohol indicate that vapour lock could be a serious problem, particularly at high altitudes on warm summer days.
- The relatively high latent heats of methyl and ethyl alcohol cause problems in mixing these alcohols with air and transporting them through the intake manifold of the engine. Heating the intakemanifold maybenecessaryincoldweatherorbeforetheenginereachesoperating temperatures.
- Without external heat to more completely vaporize the fuel, the engine may be difficult to start and sluggish for a considerable time after starting.
- All of the alcohols are soluble in water, but butyl alcohol is relatively insoluble compared to methyl and ethyl alcohol. Less engine power is produced as the water content of an alcohol increases. Further, vapour lock, fuel mixing and starting problems increase with water.

15. Define flamespeed.

The speed at which flame travels inside the combustion chamber is called as flame speed. The unit is m/s

16. List out the various forms of naturalgas.

- Natural Gas (NG)
- Compressed Natural Gas (CNG)
- Liquefied Natural Gas (LNG)

17. Write down the components of LPGequipment.

- Converter
- Mixer
- Gas Injector

18. Write down the parts of a fuelcell.

- Anode
- Cathode
- Electrolyte
- Fuel

19. What are the properties ofCNG?

- Colourless
- Odourless
- Lighter than air
- Non - toxic

20. What are the two types of LPG used for automotive-enginefuel?

- Propane based LPG
- Butane based LPG

21. What are the main components of electric and hybridvehicles?

- Gasoline engine
- Fuel tank
- Generator
- Electric motor
- Battery
- Transmission elements

22. What are the advantages of fuelcell?

- The only by product from the fuel cell is either water or CO2, which can be safely disposed.
- It is compact in size.
- As long as there is a supply of fuel, there will be generation of electricity.

23. What are the advantages ofGasohol?

Gasohol – It is the mixture of 10 % Ethanol + 90 % unleaded gasoline.

- 10 % fuel savings in terms of consumption of petrol.

Write down the advantages and disadvantages of bio diesel.

Advantages:

- Produced from Renewable Resources
- Can be Used in existing Diesel Engines
- Less Greenhouse Gas Emissions

Disadvantages:

- Variation in Quality of Biodiesel
- Not Suitable for use in Low Temperatures

24. Write a short notes on"LPG"

LPGistheabbreviationorshortformforliquefiedpetroleumgas.Itisextracted fromcrudeoilandnaturalgas.ThemaincompositionofLPGarehydrocarbons containing three or four carbon atoms. The normal components of LPG thus, arepropane(C3H8)andbutane(C4H10).LPGisagasatatmosphericpressure and normal ambient temperatures, but it can be liquefied when moderate pressure is applied or when the temperature is sufficiently reduced. It can be easily condensed, packaged, stored and utilized, which makes it an ideal energy source for a wide range ofapplications.

25. Why alcohol is an alternate fuel for S.Iengine?

Ethanolhasahigherantiknockingpropertyastheoctanenumberofethanolis over100whichishigherthanthegasolinefuel'soctanenumberof91,93.And so the alcohol can be used as alternate fuel on SIengines.

26. List down the major constituents of natural gas andLPG.

Chemical Composition of Natural Gas. Natural gas is primarily composed of methane, but also contains ethane, propane and heavier hydrocarbons. It also contains small amounts of nitrogen, carbon dioxide, hydrogen sulphide and trace amounts of water.

Liquefied Petroleum Gas or LPG consists mainly of propane, propylene, butane, and butylene in various mixtures. It is produced as a by-product of natural gas processing and petroleum refining.

27. Indicate the difference between an electric vehicle and hybrid vehicle.

The primary difference between a hybrid car and an electric car is that the hybrid car derives some of its power from a conventional gasoline engine.On the other hand, a true electric car gets all of its power from electrical sources, and thereby is a completely non-polluting zero-emission vehicle.

28. Define energyintensity?

Theinverseof"energyefficiency"is"energyintensity",ortheamountofinput energy required for a unit of output. The ratio is usually depicted as E/GDP, where E stands for energy and GDP stands for economicoutput.

29. Why is hydrogen called as secondary energysource?

Asafuel,thehydrogenisusedintheformofgas.Sincehydrogendoesnotexist on Earth as a gas, it must be separated from other compounds. It isconsidered as a secondary source of energy because another form of energy is needed to producethehydrogenfuel.Theprimarysourcesofenergytoproducehydrogen are natural gas, water, coal, or oil. These sources go through different types of processes that allow hydrogen fuel to be made.

30. What is gasohol? (Ape/May 2018)

Gasohol is a mixture of one part of ethanol and nine parts of unleaded gasoline. Although automobiles could be designed to operate on alcohol alone for the foreseeable future , the most economic use of ethanol is as an octane booster in gasoline.

31. Mention atleast two merits of a hybrid electric vehicle.(Apr/May 2018)

1. Low emission and high efficiency
2. High fuel economy and low costs
3. Outstanding performance

32. Define Bio-fuel with any one example. (Nov/Dec 2018)

A bio fuel is any liquid fuel derived from biological material such as trees, agricultural wastes, crops or grass. They contains no Sulphur and produce low carbon monoxide emission. Bio fuel are substitutes for conventional fossil fuels such petroleum, coal and natural gas (eg) Ethanol

33. Sketch the layout of a parallel configuration electric vehicle. (Nov/Dec 2018)

34. What is gasohol. (Apr/May 2019)

Gasohol is a mixture of one part of ethanol and nine parts of unleaded gasoline. Although automobiles could be designed to operate on alcohol alone for the foreseeable future , the most economic use of ethanol is as an octane booster in gasoline.

35. Mention atleast two demerits of an electric vehicle. (Apr/May 2019)

1. It has less initial torque.
2. It is more expensive.
3. Frequent recharging of battery is needed.
4. The performance is poor.

PART-B

1. Discuss about hybrid vehicles.

HybridVehicles

The word hybrid means something that is mixed together from two things. Usually, it refers to plants or animals that are breed from different dissimilar parents. Hybrid electric vehicles (HEVs) typically combine the internal

combustion engine of a conventional vehicle with the battery and electric motor of an electric vehicle.

The combination offers low emissions, with the power, range, and convenient fueling of conventional (gasoline and diesel) vehicles, and they neverneedtobepluggedin.TheinherentflexibilityofHEVsmakesthemwell suited for fleet and personaltransportation.

Working of Hybrid Vehicles

Hybridelectricvehicles(HEVs)arepoweredbytwoenergysourcessuchasan energyconversionunit(suchasacombustionengineorfuelcell)andanenergy storage device (such as batteries or ultra-capacitors). The energy conversion unitmaybepoweredbygasoline,methanol,compressednaturalgas,hydrogen, or other alternative fuels. Hybrid electric vehicles have the potential to be two to three times more fuel-efficient than conventionalvehicles.

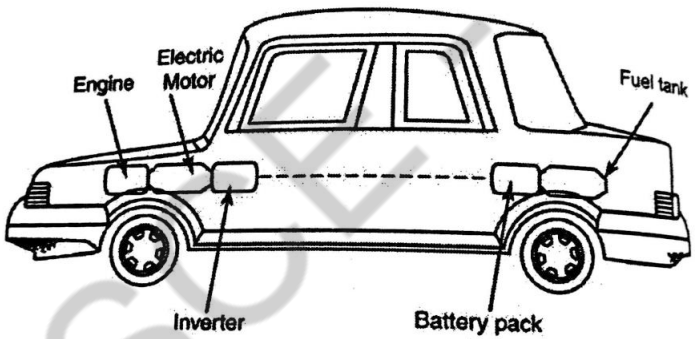


Figure 5.29 Hybrid vehicles

HEVs can have a parallel design, a series design, or a combination of the two. In a parallel design, the energy conversion unit and electric propulsionsystem are connected directly to the vehicle's wheels. The primary engine is used for highway driving. The electric motor provides added power during hill climbs, acceleration,andotherperiodsofhighdemand.Inaseriesdesign,theprimary engine is connected to a generator that produces electricity. There is also the inefficiency of converting the chemical energy to mechanical to electrical energy and back to mechanical energy.

Hybrid Electric VehicleComponents

A hybrid electric vehicle (HEV) is an optimized mix of various components. View a typical hybrid configuration in the fig 5.32.The following components are primarily used in the hybrid vehicles:

1. Electric traction motors/controllers.
2. Electricenergystoragesystems,suchasbatteriesandultra-capacitors.
3. Hybrid power units such as spark ignition engines, compression ignition direct injection (diesel) engines, gas turbines, and fuel cells.
4. Fuel systems for hybrid powerunits.
5. Transmissions.

To help reduce emissions and improve vehicle efficiencies, thefollowing systemsandcomponentsarebeingimprovedthroughresearchanddevelopment.

1. Emission controlsystems
2. Energy management and systemscontrol
3. Thermal management of components
4. Lightweight and aerodynamic body/chasis
5. Low rolling resistance (including body design and tires)
6. Reduction of accessory loads.

Hybrid electric vehicle motors/controllers:

Motorsarethe"workhorses"ofHybridElectricVehicle(HEV)drivesystems. In an HEV, an electric traction motor converts electrical energy from the energystorageunittomechanicalenergythatdrivesthewheelsofthevehicle.
Unlike a traditional vehicle, where the engine must "ramp up" before full torque can be provided, an electric motor provides full torque at low speeds. This characteristic gives the vehicle excellent "off the line"acceleration.

Hybrid electric vehicle batteries:

Battery is an essential component of HEVs. Although a few productionHEVs withadvancedbatterieshavebeenintroducedinthemarket,nocurrentbattery technology has demonstrated an economically acceptable combination of power, energy efficiency, and life cycle for high-volume production vehicles. The various types of batteries used in hybrid vehicles are explained below:

Lead-Acid batteries:

Lead-acidbatteriescanbedesignedtobehighpowerandareinexpensive,safe, and reliable. A recycling infrastructure is in place for them. But low specific energy, poor cold temperature performance, and short calendar and cycle life are still impediments to their use. Advance high-power lead-acid batteries are being developed for HEVapplications.

Nickel-Cadmium batteries:

Although nickel-cadmium batteries used in many electronic consumer products have higher specific energy and better life cycle.

2. Explain about electrically operated vehicles.

Working of ElectricVehicles

There are other types of electric vehicles, too. Many cities use electric-powered buses, trolleys, subways or light-rail. Even most trains are electric. Other places will use electric buses with batteries because they do not want wires over the roads.

Other people are using electric-powered bicycles. The motor is mounted just above the rear wheel and under the seat. The bag that is hanging from the middleholdsthebattery.Thebikecango20milesperhour,anditcantravel20 miles before needing a recharge. For people who have disabilities, anelectric-powered bike might allow them freedom to be outdoors.

Maintenance Considerations

Service requirements for EVs are fewer than those forgasoline-powered vehicles. EVs do not require tune-ups, oil changes, timing belts, waterpumps, radiators, fuel injectors, or tailpipes. They do, of course, require battery maintenance.

Electric batteries have a limited number of charging cycles (the number of times a battery can be charged and discharged) and will typically need to be replaced within 3-6 years. Different types of batteries (such as lead-acid, nickel-metal hydride, and lithium-ion) are available depending on the manufacturer and the vehicle.

Benefits of ElectricVehicles

EVs are zero emission vehicles, meaning they produce no tailpipe or evaporative emissions that contribute to air pollution and global warming (although electricity production is not pollution-free).

The cost of electricity per kilowatt-hour usually compares favorably to that of gasoline but varies depending on location. More than 95% of theelectricity used to charge EVs originates from domestic resources, so driving an EV reduces the nation's dependence on importedoil.

Asmentionedpreviously,EVsrequirelessservicebecausetheydonotneed oil and they have no timing belts, water pumps, radiators, fuel injectors, or tailpipes. Advantages of electric vehicles are summarizedbelow:

Advantages:

1. No pollution due to emission.(i.e)., zeroemission.
2. Smooth operation. i.e., vibration and noise isless.
3. Cost of operation is very less.
4. Less maintenance is required.
5. Easy to start thevehicle.
6. Takeuplessspaceontheroad,sotheyhelptoreducetrafficcongestion.

3. Explain the working principles of LPG fuelledengines.

Use of Liquefied Petroleum Gas (LPG) In Automobiles

Most people call liquefied petroleum gas (LPG) as "propane". That isbecause LPG is mostly made up of propane. Actually, LPG is made of a mixture of propane and other similar types of hydrocarbon gases. Different batches of LPG have slightly different amounts of the different kinds of hydrocarbon molecules. These hydrocarbons are gases at room temperature, but turn to liquid when they are compressed. LPG is stored in special tanks that keep it underpressure,soitstaysaliquid.Thepressureofthesetanksisusuallyabout 200 psi.

LPG is the name given to the mixture of petroleum gases released during theextractionofcrudeoilandnaturalgasorduringtherefiningofcrudeoil.It consists of a mixture of hydrocarbons including major components ofpropane and butane, minor components such as normal-butane, iso-butane, pentane, ethane, propane and butane, together with small quantities of additives including sulphur to give it an odour for safety reasons. Propane (C_3H_8) and butane (C_4H_{10}) are the main components but different mixing rations are used in different countries that reflect the local market prices, production facilities and climatic conditions. LPG is a gas which due to its low vapor tension can be stored in a liquid state under lowpressures.

The % age of passenger cars running worldwide on LPG is currently about 1% which includes some 2.5 millions in Europe. Countries with the most developed LPG markets are Italy, Poland, Netherlands, Czech Republic and France in Europe, South Korea Japan, Australia, and the USA and involve passenger cars, taxis, LDVs and HDVs. The varying LPG composition betweencountriesnotonlydictatestheOctanenumberbutalsoaffectsexhaust emissions,mainlyCO;ahigherbutanenumberleadstolowerNO_xlevelswhile a higher propane number reduces CO levels.

There are various types of vehicle running on LPG: converted (retrofitted) gasoline engines for passenger cars and LDVs operating as duel-fuel systems, as well as dedicated LPG engines; some converted diesel engines operating in the compression-ignition mode with diesel pilot injection. Most of LPG HDV engines are converted into diesel engines operating in the spark-ignitionmode withmodifiedcylinderheadsandcombustionchambers.Thelasttwotypesare intended for medium and heavy-duty applications and employ dedicated and retrofittedengines.

LPG Equipment

1. LPG fuel tank:

LPG tanks are constructed of heavy gauge steel, in compliance with the Boiler and Pressure Vessel Code of The American Society of Mechanical Engineers (ASME) to withstand a pressure of 1000 psi. Normal working

pressures within the tank vary depending upon the ambient temperatures and the quantity of fuel in the tank. Common operating pressures are in therangeof130-170psi.Propanetankslimittheliquidlevelto80%ofthe totaltankvolumebyusinganauto-stopfillvalve.Tanksareequippedwith a pressure relief valve that can release propane vapors to the atmosphere topreventtankruptureunderabnormallyhigh-pressureconditions.Under normal operating conditions the LPG system is essentially a closed fuel system without the typical vapor emissions associated with gasoline. Each tank also includes a manual shut-off valve. The propane fuel tank is installed along with a fueling port, fuel lines, and pressure safety valves. A filter removes particles and contaminants that may be present in the propane.

2. Vaporizer:

LPG system draws fuel from the bottom of the tank and sends liquid propane to the vaporizer. The vaporizer converts the liquid to a gas. The primary heat source for this vaporization is engine coolant flowing through specially designed water jackets cast into the vaporizer body. Many vaporizers include and internal pressure regulator to control the pressure of the fuel sent to theengine.

3. Fuel metering:

Early propane systems used a mixer which operated as a conventional venture device in a manner quite similar to a gasoline carburetor. Vaporized propane is drawn through a fixed orifice in response to engine airflow.Asintakeairenterstheengine,aventureeffectiscreatedthrough themixer.Thisslightpressuredropisactedonaspring-loadeddiaphragm inproportionwithairflow.Theresultwasasimpleyetfairlyaccurateflow meter which controlled the volume of fuel to the engine as function of air flow. Such as gasoline carburetors, the mixer was limited in accuracy. Changes in altitude, ambient weathers conditions, and even temperature cause significant variations in the fuel mixture.

LPG Fuel / Engine Interaction

DuetothelimitedLPGrefuelinginfrastructure,theautomotivemanufacturers whowerekeentopromotethe‘worldcar’conceptpthadnootheroptionbuttoopt forbi-fuelLPGspark-ignitionenginesthatarecapableofrunningeverywhere withgasoline,LPGorboth;atleastthiswasthetrendinthepassengercarand light-duty vehicle market.

Ontheotherhand,forthemediumandheavy-dutyLPGmarkets,theoptions are to convert diesel engines into bi-fuel diesel/LPG versions, with diesel actingasauto-ignitionimprover,ortoconvertthemintospark-ignitionengines burningLPGineitherstoichiometricorleanburnmode.Itisinterestingto

note that direct-injection gasoline engines, representing at present the best hopeforimprovingthefuelefficiencyofspark-ignitionengines,seemcapable of achieving the efficiency of indirect-injection diesel engines but not that of direct-injection diesels which is at least 10-15% higher, probably beyond reach.

4. Discuss the working of fuel cells.

Parts of a FuelCell

Polymer electrolyte membrane (PEM) fuel cells are the current focus of research for fuel cell vehicle applications. PEM fuel cells are made from several layers of different materials as shown in the diagram. The three key layers in a PEM fuel cell include:

- Membrane electrode assembly
- Catalyst
- Hardware

Other layers of materials are designed to draw fuel and air into the cell and to conduct electrical current through the cell.

1. Membrane electrodeassembly:

The electrodes (anode and cathode), catalyst, and polymer electrolyte membrane together form the membrane electrode assembly (MEA) of a PEM fuel cell.

a. Anode:

The anode, the negative side of the fuel cell, has several jobs. It conducts the electrons that are breed from the hydrogen molecules so that they can be used in an external circuit. Channels etched into the anode disperse the hydrogen gas equally over the surface of the catalyst.

b. Cathode:

The cathode, the positive side of the fuel cell, also contains channels that distribute the oxygen to the surface of the catalyst. It conducts the electrons back from the external circuit to the catalyst, where they can recombine with the hydrogen ions and oxygen to form water.

c. Polymer electrolytemembrane:

The polymer electrolyte membrane (PEM) is a specially treated material that looks something such as ordinary kitchen plastic wrap which conducts only positively charged ions and blocks the electrons. The PEM is the key to the fuel cell technology; it must permit only the necessary ions to pass between theanodeandcathode.Othersubstancespassingthroughtheelectrolytewould disrupt the chemical reaction.

The thickness of the membrane in a membrane electrode assembly can vary with the type of membrane. The thickness of the catalyst layers depends upon how much platinum (Pt) is used in each electrode. For catalyst layers containing about 0.15 milligrams (mg) Pt/cm^2, the thickness of the catalyst layeriscloserto10micrometerslessthanhalfthethicknessofasheetofpaper. This membrane/electrode assembly with a total thickness of about 200m (or 0.2mm) can generate more than half an ampere of current for every square centimeterofassemblyareaatavoltageof0.7volts,butonlywhenencasedin well-engineered components such as backing layers, flow fields, and current collectors.

2. Catalyst:

Allelectrochemicalreactionsinafuelcellconsistoftwoseparatereactions:an oxidationhalf-reactionattheanodeandareductionhalf-reactionatthecathode. Normally,thetwohalf-reactionswouldoccurveryslowlyatthelowoperating temperature of the PEM fuel cell. So, each of the electrodes is coated on one side with a catalyst layer that speeds up the reaction of oxygen and hydrogen. It is usually made of platinum powder very thinly coated onto carbon paperor cloth. The catalyst is rough and porous so that the maximum surface area of theplatinum-coatedsideofthecatalystfacesthePEM.Platinum-groupmetals are critical to catalyzing reactions in the fuel cell, but they are veryexpensive.

3. Chemistry of a Fuel Cell:

Anodeside:

$2H_2 => 4H^+ + 4e^-$

Cathode side:

$O_2 + 4H^+ + 4e^- => 2H_2O$

Net reaction:

$2H_2 + O_2 => 2H_2O$

The pressurized hydrogen gas (H_2) enters the fuel cell on the anode side. This gas is forced through the catalyst by the pressure. When and H_2 molecule comes in contact with the platinum on the catalyst, it splits into two H^+ ions and two electrons (e^-). The electrons are conducted through the anode, where they make their way through the external circuit (doing useful work such as turning a motor) and return to the cathode side of the fuelcell.

Meanwhile, on the cathode side of the fuel cell, oxygen gas (O_2) is being forced through the catalyst, where it forms two oxygenatoms.

Each of these atoms has a strong negative charge. This negative charge attracts the two H^+ ions through the membrane where they combine with an oxygenatomandtwooftheelectronsfromtheexternalcircuittoformawater molecule (H_20).

This reaction in a single fuel cell produces only about 0.7 volts. To get this voltage upto a reasonable level, many separate fuel cells must be combined to form a fuel-cell stack.

3. Hardware:

Thebackinglayers,flowfields,andcurrentcollectorsaredesignedtomaximize the current from a membrane/electrode assembly. The backing layers onenext totheanode,theothernexttothecathodeareusuallymadeofaporouscarbon paper or carbon cloth, about as thick as 4 to 12 sheets of paper. The backing layers have to be made of a material (such as carbon) that can conduct the electrons that leave the anode and enter the cathode. The porous nature of the backing material ensures effective diffusion (flow of gas molecules from a regionofhighconcentrationtoaregionoflowconcentration)ofeachreactant gastothecatalystonthemembrane/electrodeassembly.Thegasspreadsoutas it diffuses so that when it penetrates the backing, it will be in contact with the entire surface area of the catalyzedmembrane.

The backing layers also help in managing water in the fuel cell; too littleor too much water can cause the cell to stop operating. Water can build up in the flowchannelsoftheplatesorcanclogtheporesinthecarboncloth(orcarbon paper) preventing reactive gases from reaching the electrodes.

The correct backing material allows the right amount of water vapor to reach the membrane/electrode assembly and keep the membrane humidified. The backing layers are often coated with Teflon to ensure that at least some, and preferablymostoftheporesinthecarboncloth(orcarbonpaper)donotbecome clogged with water which would prevent the rapid gas diffusion necessary for a good rate of reaction at the electrodes.

Pressed against the outer surface of each backing layer is a piece of hardware calledbipolarplatethattypicallyservesasbothflowfieldandcurrentcollector. In a single fuel cell, these two plates are the last of the components making up the cell. The plates are made of a lightweight, strong, gas-impermeable, electron-conducting material. Graphite or metals are commonly usedalthough composite plates are now being developed.

The first task served by each plate is to provide a gas "flow field." Channels are etched into the side of the plate next to the backing layer. The channels carry the reactant gas from the place where it enters the fuel cell to the place whereitexits.Thepatternoftheflowfieldintheplate(aswellasthewidthand depth of the channels) has a large impact on how evenly the reactant gases are spread across the active area of the membrane/electrode assembly. Flow field design also affects water supply to the membrane and water removal from the cathode.

5. (i)**What are the merits and demerits of LPG as a motorfuel?**

Advantages ofLPG:

- It has very low sulphur levels giving rise to insignificant sulphate emissions
- It has low cold start emissions due to its gaseous state at ambient pressure and temperature
- It has relatively high Octane number with propane having the best antiknock properties relative to the other components
- It has lower peak pressure during combustion which generally reduces noise and improves durability; noise levels can be less than 50% of equivalent diesel engines
- It can be stored as liquid under very low pressure (~3minutes) i.e. similar to gasoline
- LPG fuel systems are sealed and evaporative losses are negligible
- It is easily transportable and offer 'stand-alone' storage capability withsimpleandself-containedLPGdispensingfacilitywithminimum supportinfrastructure
- LPG vehicle do not require special catalysts
- It contains negligible toxic components.
- Withproperdesignandpositioningoftheportfuelinjector,volumetric efficiency and thus power losses are very low; turbo-charging may not be necessary
- Although compositional variations of LPG exist across Europe, its high Octane number provides room for increase in the compression ration and fuel efficiency of dedicated engines
- LPG has lower particulate emissions and lower noise levels relative to diesels, making it more attractive in urban areas
- Its low emissions have low greenhouse gas effect and low NO_x precursors
- It has similar vehicle range to gasoline-fuelled cars
- It has higher calorific value than gasoline on a mass basis
- Relative to other alternative fuels, any increase in future demand for LPGcanbeeasilysatisfiedfrombothnaturalgasfieldsandoilrefinery sources.
- Concerningnon-regulatedpollutants,theperformanceofLPGvehicles can be summarized asfollows:
  - Their PAH and aldehyde (formaldehyde, acetaldehyde, acrolein) emissions are much lower than diesel-fuelled vehicles.
  - Their Benzene, Toluene, Xylene (BTX) emissions are lower than gasoline-fuelled vehicles.

- Their summer smog formation potential is lower than that of gasoline.
- Their winter smog formation potential is much lower than that of diesel.

Disadvantages of LPG:

- Although LPG has a relatively high energy content per mass, its energy content per unit volume is low which explains why LPG tanks take more space and weigh more than gasoline tanks.
- It is heavier than air which requires appropriate handling.
- It's vapor flammability limits in air (2-10% by volume) are wider than gasoline which makes LPG ignitable more easily.
- It has a high expansion coefficient which necessitates only partial filling of the tank to not more than 80% of its capacity.
- The filling system of the LPG tanks is not uniform across Europe, demanding different adaptors to connect service pump and vehicle; however new CEN standards are expected to be implemented in 2000.
- It can give rise to backfiring in the inlet manifold unless a multi-point fuel injection system is used; this is becoming now the standard.
- LPG in liquid form can cause cold burns to the skin in case of inappropriate use.

5.(ii) List the advantage of LNG.

Advantages of liquefied natural gas:

1. LNG has very low particle emissions because of its low carbon to hydrogen ration.
2. There are negligible evaporative emissions, requiring no relevant control.
3. Due to its low carbon-to-hydrogen ration, it produces less carbon dioxide per GJ of fuel than diesel.
4. It has low cold-start emissions due to its gaseous state.
5. It has extended flammability limits, allowing stable combustion at leaner mixtures.
6. It has a lower adiabatic flame temperature than diesel, leading to lower NO_x emissions.
7. It has much higher ignition temperature than diesel, making it more difficult to auto-ignite, thus safer.
8. It contains non-toxic components. The liquefaction process removes impurities.

9. LNG is pure methane which is a non-toxicgas.
10. It is much lighter than air and thus it is safer than spilleddiesel.
11. Methane is not a volatile organic compound(VOC).
12. Engines fueled with NG in heavy-duty vehicles offer more quiet operationthanequivalentdieselenginesmakingthemmoreattractive for use in urban areas.
13. It has nearly zero sulphur levels and thus, negligible sulphate emissions.
14. NGpricingisstableandpredictable,removinguncertaintytobusiness caused by fuel price fluctuations.
15. Whereonsiteliquefactionisused,NGisdistributedviaunderground pipe networks, removing the need for hazardous transportation and transfer processes.
16. Where on site liquefaction is used because of the pipeline delivery, retailers or fleet operators are not required to store large quantities of fuel, usually prepaid, onsite.
17. NG use does not give rise to issue with groundwater contamination such as those experienced through diesel/petrol spillage or leakage from underwaterstorage.

6. (i)What are merits and demerits of hydrogen fuel ?

Advantages of Hydrogen Fuel Cells

1. Available andRenewable

One of the biggest reasons that hydrogen is such a great choice for power is because of the abundance of it. There is no worry about running out of hydrogenanytimesoon,unlikefossilfuelsandothernonrenewableresources.

2. NonToxic

All of the energy sources that we are currently utilizing are harmful andtoxic. Not only for humans and animals, but for our environment as well. Hydrogen fuel cells are completely non toxic and pose no risk to our climate.

3. VeryPowerful

Along with being renewable and non toxic, hydrogen fuel cells are also incredibly powerful. They are so powerful in fact that they are used as fuel in rockets that go into space!

4. Doesn't Contribute To ClimateChange

There are no green house gas emissions that are associated with hydrogen fuel cells. These gasses, which are released by other types of non renewable resources, are the cause of global warming and a massive climatechange.

5. CheapMaintenance
Whiletheinitialcostsmaybeabithigh,oncetheyareinstalled,hydrogenfuel cells are very affordable to maintain. This same idea would go if cars began running on hydrogen energy. Costly car repairs would be a thing of thepast.

Disadvantages of Hydrogen Fuel Cells
1. Fossil Fuels Are StillNeeded
Inordertoseparatetheatomsofthehydrogenandoxygenandactuallygenerate hydrogen fuel, fossil fuels are needed. This completely defeats the purpose of an alternative energy source. If we ran out of fossil fuels we would no longer be able to produce hydrogen energy.

2. Costly ToProduce
Oneofthebiggestpitfallsofhydrogenfuelcellsisthesimplefactthatitisvery expensivetoproduce.Asof now, theenergyisnotefficientenoughtoproduce hydrogen energy in a cost effectiveway.

3. Flammable!
Whileitmaynotbetoxic,itsureisflammable.Thesourceofthehazardcomes from the hydrogen itself, which is very prone to catching on fire, or even exploding. This would add unnecessarily and new risks intosociety.

4. Much Work To BeDone
The use of fuel cells is very new, and quite a bit of advancement and research stillneedstobedonebeforeitcanbeusedonawidescalebasis.Theplausibility of it's use isn't even fully known yet, and many people believe it is just afairy tale.

5. Cells Can't HoldMuch
The actual cells that the hydrogen energy is stored in can store only a small amountofpower.Thismakestheprocessofmaintainingreliablepowersources with the use of hydrogen fuel cells veryunlikely.

6.(ii) Explain the merits of ethanol fuel.
ADVANTAGES OF ETHANOL
GreenFuelProduction–Theproductionofethanolonlycreatesfewgreenhouse emissionsascomparedtootherfuels.Andsinceethanolisproducedfromcorn, the greenhouse emissions are reduced by thirteen percent. This is accordingto thestudiesconductedbymanyresearchers.Asforthisreduction,itisincreased through the use of improved technology and sources such as switchgrass.
A Balance in Positive Energy – Although a lot of critics believed that there must be more energy needed in producing ethanol, the study has revealed that thefueloutsourcedfromcorngeneratesabalanceinpositiveenergy.Bymeans ofethanolproduction,therearemorevaluableproductsandby-productstoget such as cornoil.

Less Pollutants Being Produced – One of the major advantages of ethanol is that in burning the fuel, there are only less pollutants being produced.

ReducedNeedonDependingonOil–Anotherbigadvantageofethanolisthe reduced need to depend mostly on oil. Oil is mainly sourced out for running operated machinery and or for travel. This may be a better option other than spending too much onoil.

7. Discusstheadvantagesanddisadvantagesofusing LPG as an alternate fuel in engines.

Advantages of LPG:

- It has very low sulphur levels giving rise to insignificant sulphate emissions
- It has low cold start emissions due to its gaseous state at ambient pressure and temperature
- It has relatively high Octane number with propane having the best antiknock properties relative to the other components
- It has lower peak pressure during combustion which generally reduces noise and improves durability; noise levels can be less than 50% of equivalent diesel engines
- It can be stored as liquid under very low pressure (~3minutes) i.e. similar to gasoline
- LPG fuel systems are sealed and evaporative losses are negligible
- It is easily transportable and offer 'stand-alone' storage capability withsimpleandself-containedLPGdispensingfacilitywithminimum supportinfrastructure
- LPG vehicle do not require special catalysts
- It contains negligible toxic components.
- Withproperdesignandpositioningoftheportfuelinjector,volumetric efficiency and thus power losses are very low; turbo-charging may not be necessary
- Although compositional variations of LPG exist across Europe, its high Octane number provides room for increase in the compression ration and fuel efficiency of dedicated engines
- LPG has lower particulate emissions and lower noise levels relative to diesels, making it more attractive in urban areas
- Its low emissions have low greenhouse gas effect and low NO_x precursors
- It has similar vehicle range to gasoline-fuelled cars
- It has higher calorific value than gasoline on a mass basis
- Relative to other alternative fuels, any increase in future demand for LPGcanbeeasilysatisfiedfrombothnaturalgasfieldsandoilrefinery sources.

- Concerning non-regulated pollutants, the performance of LPG vehicles can be summarized as follows:
  - Their PAH and aldehyde (formaldehyde, acetaldehyde, acrolein) emissions are much lower than diesel-fuelled vehicles.
  - Their Benzene, Toluene, Xylene (BTX) emissions are lower than gasoline-fuelled vehicles.
  - Their summer smog formation potential is lower than that of gasoline.
  - Their winter smog formation potential is much lower than that of diesel.

Disadvantages of LPG:

- Although LPG has a relatively high energy content per mass, its energy content per unit volume is low which explains why LPG tanks take more space and weigh more than gasoline tanks.
- It is heavier than air which requires appropriate handling.
- It's vapor flammability limits in air (2-10% by volume) are wider than gasoline which makes LPG ignitable more easily.
- It has a high expansion coefficient which necessitates only partial filling of the tank to not more than 80% of its capacity.
- The filling system of the LPG tanks is not uniform across Europe, demanding different adaptors to connect service pump and vehicle; however new CEN standards are expected to be implemented in 2000.
- It can give rise to backfiring in the inlet manifold unless a multi-point fuel injection system is used; this is becoming now the standard.
- LPG in liquid form can cause cold burns to the skin in case of inappropriate use.

8. Enumerate the advantage and disadvantage of using alcohol as a fuel.

Alcohol:

Alcohol is an attractive alternatives fuel because it can be obtained from a number of sources, both natural and manufactured. Methanol (methyl alcohol) and ethanol (ethyl alcohol) are two kinds of alcohol that seem most promising and have had the most development as engine fuel.

Advantage:

1. It is high octane fuel with anti – knock index numbers (octane number on fuel pump) of over 100. High octane numbers results, at least part, from the high flame speed of alcohol

- Engines using high – octane fuel can run more efficiently by using higher compression ratios.

2. Itcanbeobtainedfromanumberofsources,bothnaturalsandmanufactured.
3. It has high evaporation cooling (h_{fg}) which results in cooler intake process and compression stroke. This raises the volumetric efficiency of the engine and reduces the required work input in the compressionstroke.
4. Generally less overall emissions when compared withgasoline.
5. Low sulphur content in thefuel.
6. When burned, it forms more moles of exhaust which gives higher pressure and because and more power in the expansionstroke.
7. Thecontaminationofnatterinalcoholofmatterinalcoholislessdangerous than petrol or diesel because alcohol are less toxie to humans and has recognized taste.

Disadvantage:

1. Low energy content of the fuel (almost twice as much alcohol as gasoline must be burned to give the same energy input to theengine)
2. Theexhaustcontainsmorealdehydes.Ifasmuchalcoholfuelwasconsumed as gasoline, aldehyde emissions would be a serious exhaustpollutions problems.
3. as compared to gasoline, alcohol is much more corrosive on copper, brass, aluminium, rubber and many plastics. This puts some restriction on the design and manufacturing of engine to be used with thisfuel.
   - Methanol is very corrosive on metals
4. In general, the ignition characteristics are poor
5. Vapour lock in fuel deliverysystem
6. Owingtolowvapourpressureandevaporation,thecoldweatheringstarting characteristics are poor.
7. duetolowvapourpressure,thereisadangerofstoragetankflammability. Air can leak into storage tanks and create a combustible mixture.
8. alcohol have almost invisible flames, which is considered dangerouswhen handling fuel. Again a small amount of gasoline remove this danger.
9. Low flames temperature generate less NO_x,but the resulting lower exhaust temperature tures take longer to heat the catalytic convertor to an efficient operating temperature.
10. When refuelling an automobile, headaches and dizziness have been experienced (due to the strong odour ofalcohol).

Alcohol are considered as clean burning renewable alternatives fuels which can come to our rescue to meet the challenge of vehicular fuel oil scarcityand fouling of environment by exhaust emissions.

Alcohols make very poor diesel engine fuels as their ‘cetane number’ is considerably lower.

- Alcohol can be used in dual engine fuels engines or with assisted ignitionindieselengine.Inadualfuelmode,alcoholisinducedalong withtheair,compressedandthenignitedbyapilotsprayofdieseloil.

Methanol

Of all the fuel being considered as an alternate to gasoline, methanol is one of the more promising and has experienced major research and development. Methanolcanbefrommanysources,bothfossilandrenewable.Theseinclude coal, petroleum, natural gas, biomass, wood, landfills, and even ocean. However, any source that requires extensive manufacturing or processing raises the price of the fuel and requires an energy input back into the overall environmental picture, both unactractive.

Methanol behaves much like petroleum and so, it can be stroed and shifted in the same manner.

Some important features of methanol as fuel:

1. The specific heat consumption with methanol as fuel is 50 percent lessthan petrol engine.

2. Exhaust Co and HC are decreased continuously with blends containing higherandhigherpercentageofmethanol.Butexhaustaldehydeconcentration shows a reversedtrend.

3. Methanolcanbeusedassupplementaryfuelinheavyvehiclepoweredby C.I engines with consequent

9. **Explain briefly about the history, currents uses, process of utilization and advantages of biomass, as a fuel.**

Biomass is fuel is developed from organic materials, a renewable and sustainablesourceofenergyusedtocreateelectricityorotherformsofpower. Some examples of materials that make up biomass fuelsare:

- Scarp lumber
- Forest debris
- Certain crops
- Manure and
- Some types of waste residues

Withaconstantofwaste–fromconstructionanddemolitionactivities,towood not used in papermaking to municipal solid waste – green energy production can continueindefinitely.

Biomass is a renewable source of fuel to produce energy because

- Wasteresidueswillalwaysexist–intermsofscrapwood,millresiduals and forest resource, and
- Property managed forests will always have more tress, and we will

always have crops and the residual biological matter from those crops. Re energy holdings is an integrated waste fuel/biomass renewable energy company. Our facilities collect, process and recycle items for use as fuel, as well as green energy facilities that create power from that waste.

Biomass power is carbon neutral electricity generated from renewable organic waste that would otherwise be dumped in landfills, openly burned, or left as fodder for forest fires.

When the energy burned in biomass is released as heat. If you have a fireplace, you already are participating in the use of biomass as the wood you burn in it's a biomass fuel.

In biomass power plants, wood waste or other waste is burned to produce steamthatrunsaturbinetomakeelectricity,orthatprovidesheattoindustries and homes. Fortunately, new technologies including pollution controls and combustion engineering – have advanced to the point that any emissions from burning biomass in industrial facilities are generally less than emissions produced when using fossil fuels (coal, naturals gas, oil). Re energy has included these technologies in our facilities.

Advantages:

1. Biomass used as a fuel reduces need for fossil fuels for the production of heat steam, and electricity for residential, industrial and agricultureuse.
2. Biomass is always available and can be produced as a renewable resource
3. Biomass fuel from agriculture wastes may be secondary product that adds value to agriculture crop.
4. Growing Biomass crops produce oxygen and use up carbondioxide.
5. The use of waste materials reduces landfill disposal and makes morespace for everything else.
6. Carbon Dioxide which is released when Biomass fuel is burned, is taken in by plants.
7. Less money spent on foreignoil.

10. Discuss the principle of operation of a fuel cell with a neat sketch.

A fuel cell is a device that generates electricity by a chemical reaction. Every fuelcellhastwoelectrodes,onepositiveandonenegative,called,respectively, the anode and cathode. The reactions that produce electricity take place at the electrodes.

Every fuel cell also has an electrolyte, which carries electrically charged particles from one electrode to the other, and a catalyst, which speeds the reactions at the electrodes.

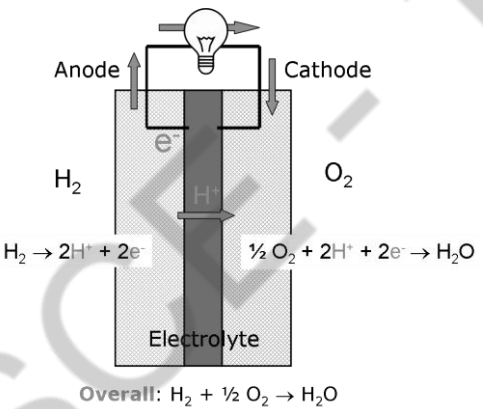
Hydrogen is the basic fuel, but fuel cells also require oxygen. One great appeal of fuel cells is that they generate electricity with very little pollution–

much of the hydrogen and oxygen used in generating electricity ultimately combine to form a harmless byproduct, namely water.

One detail of terminology: a single fuel cell generates a tiny amount of direct current (DC) electricity.

The purpose of a fuel cell is to produce an electrical current that can be directed outside the cell to do work, such as powering an electric motor or illuminating a light bulb or a city. Because of the way electricity behaves, this current returns to the fuel cell, completing an electrical circuit. The chemical reactions that produce this current are the key to how a fuel cell works.

Therareseveralkindsoffuelcells,andeachoperatesabitdifferently.Butingeneral terms, hydrogen atoms enter a fuel cell at the anode where a chemical reaction strips them of their electrons. The hydrogen atoms are now "ionized," and carry a positive electricalcharge.Thenegativelychargedelectronsprovidethecurrentthroughwiresto do work. If alternating current (AC) is needed, the DC output of the fuel cell mustbe routedthroughaconversiondevicecalledaninverter.



Oxygen enters the fuel cell at the cathode and, in some cell types (like the one illustrated above), it there combines with electrons returning from the electrical circuit and hydrogen ions that have traveled through the electrolyte from the anode. In other cell types the oxygen picks up electrons and then travels through the electrolyte to the anode, where it combines with hydrogen ions.

The electrolyte plays a key role. It must permit only the appropriate ions to passbetweentheanodeandcathode.Iffreeelectronsorothersubstancescould travel through the electrolyte, they would disrupt the chemicalreaction.

Whether they combine at anode or cathode, together hydrogen and oxygen form water, which drains from the cell. As long as a fuel cell is supplied with hydrogen and oxygen, it will generate electricity.

Even better, since fuel cells create electricity chemically, rather than by combustion, they are not subject to the thermodynamic laws that limit a conventional power plant (see "Carnot Limit" in the glossary). Therefore,fuel cellsaremoreefficientinextractingenergyfromafuel.Wasteheatfromsome cells can also be harnessed, boosting system efficiency stillfurther.

11. I) **Explain the working principles , merits and demerits of a fuel cell with schematic diagrams.**

ii) Compare the merits of a pure electric vehicle.(Apr/May 2018)

5. Parts of a FuelCell

Polymer electrolyte membrane (PEM) fuel cells are the current focus of research for fuel cell vehicle applications. PEM fuel cells are made from several layers of different materials as shown in the diagram. The three key layers in a PEM fuel cell include:

- Membrane electrode assembly
- Catalyst
- Hardware

Other layers of materials are designed to draw fuel and air into the cell and to conduct electrical current through the cell.

4. Membrane electrodeassembly:

The electrodes (anode and cathode), catalyst, and polymer electrolyte membrane together form the membrane electrode assembly (MEA) of a PEM fuel cell.

a. Anode:

The anode, the negative side of the fuel cell, has several jobs. It conducts the electrons that are breed from the hydrogen molecules so that they can be used in an external circuit. Channels etched into the anode disperse the hydrogen gas equally over the surface of the catalyst.

b. Cathode:

The cathode, the positive side of the fuel cell, also contains channels that distribute the oxygen to the surface of the catalyst. It conducts the electrons back from the external circuit to the catalyst, where they can recombine with the hydrogen ions and oxygen to form water.

c. Polymer electrolytemembrane:

The polymer electrolyte membrane (PEM) is a specially treated material that looks something such as ordinary kitchen plastic wrap which conducts only positively charged ions and blocks the electrons. The PEM is the key to the fuel cell technology; it must permit only the necessary ions to pass between theanodeandcathode.Othersubstancespassingthroughtheelectrolytewould disrupt the chemical reaction.

The thickness of the membrane in a membrane electrode assembly can vary with the type of membrane. The thickness of the catalyst layers depends upon how much platinum (Pt) is used in each electrode. For catalyst layers containing about 0.15 milligrams (mg) Pt/cm^2, the thickness of the catalyst layeriscloserto10micrometerslessthanhalfthethicknessofasheetofpaper. This membrane/electrode assembly with a total thickness of about 200m (or 0.2mm) can generate more than half an ampere of current for every square centimeterofassemblyareaatavoltageof0.7volts,butonlywhenencasedin well-engineered components such as backing layers, flow fields, and current collectors.

5. Catalyst:

Allelectrochemicalreactionsinafuelcellconsistoftwoseparatereactions:an oxidationhalf-reactionattheanodeandareductionhalf-reactionatthecathode. Normally,thetwohalf-reactionswouldoccurveryslowlyatthelowoperating temperature of the PEM fuel cell. So, each of the electrodes is coated on one side with a catalyst layer that speeds up the reaction of oxygen and hydrogen. It is usually made of platinum powder very thinly coated onto carbon paperor cloth. The catalyst is rough and porous so that the maximum surface area of theplatinum-coatedsideofthecatalystfacesthePEM.Platinum-groupmetals are critical to catalyzing reactions in the fuel cell, but they are veryexpensive.

6. Chemistry of a Fuel Cell:

Anodeside:

$2H_2 => 4H^+ + 4e^-$

Cathode side:

$O_2 + 4H^+ + 4e^- => 2H_2O$

Net reaction:

$2H_2 + O_2 => 2H_2O$

The pressurized hydrogen gas (H_2) enters the fuel cell on the anode side. This gas is forced through the catalyst by the pressure. When and H_2 molecule comes in contact with the platinum on the catalyst, it splits into two H^+ ions and two electrons (e^-). The electrons are conducted through the anode, where they make their way through the external circuit (doing useful work such as turning a motor) and return to the cathode side of the fuelcell.

Meanwhile, on the cathode side of the fuel cell, oxygen gas (O_2) is being forced through the catalyst, where it forms two oxygenatoms.

Each of these atoms has a strong negative charge. This negative charge attracts the two H^+ ions through the membrane where they combine with an oxygenatomandtwooftheelectronsfromtheexternalcircuittoformawater molecule (H_20).

This reaction in a single fuel cell produces only about 0.7 volts. To get this voltage upto a reasonable level, many separate fuel cells must be combined to form a fuel-cell stack.

3. Hardware:

Thebackinglayers,flowfields,andcurrentcollectorsaredesigned tomaximize the current from a membrane/electrode assembly. The backing layers onenext totheanode,theothernexttothecathodeareusuallymadeofaporouscarbon paper or carbon cloth, about as thick as 4 to 12 sheets of paper. The backing layers have to be made of a material (such as carbon) that can conduct the electrons that leave the anode and enter the cathode. The porous nature of the backing material ensures effective diffusion (flow of gas molecules from a regionofhighconcentrationtoaregionoflowconcentration)ofeachreactant gastothecatalystonthemembrane/electrodeassembly.Thegas spreadsoutas it diffuses so that when it penetrates the backing, it will be in contact with the entire surface area of the catalyzedmembrane.

The backing layers also help in managing water in the fuel cell; too littleor too much water can cause the cell to stop operating. Water can build up in the flowchannelsoftheplatesorcanclogtheporesinthecarboncloth (orcarbon paper) preventing reactive gases from reaching the electrodes.

The correct backing material allows the right amount of water vapor to reach the membrane/electrode assembly and keep the membrane humidified. The backing layers are often coated with Teflon to ensure that at least some, and preferablymostoftheporesinthecarboncloth(orcarbonpaper) donotbecome clogged with water which would prevent the rapid gas diffusion necessary for a good rate of reaction at the electrodes.

Pressed against the outer surface of each backing layer is a piece of hardware calledbipolarplatethattypicallyservesasbothflowfieldandcurrentcollector. In a single fuel cell, these two plates are the last of the components making up the cell. The plates are made of a lightweight, strong, gas-impermeable, electron-conducting material. Graphite or metals are commonly usedalthough composite plates are now being developed.

The first task served by each plate is to provide a gas "flow field." Channels are etched into the side of the plate next to the backing layer. The channels carry the reactant gas from the place where it enters the fuel cell to the place whereitexits.Thepatternoftheflowfieldintheplate(aswellas thewidthand depth of the channels) has a large impact on how evenly the reactant gases are spread across the active area of the membrane/electrode assembly. Flow field design also affects water supply to the membrane and water removal from the cathode.

Merits of Fuel Cell

1. Fuel cell eliminate pollution caused by burning fossil fuels, the only by-product is water.
2. Fuel Cell do not need conventional fuels such as oil or gas.
3. Since hydrogen can be produced anywhere where there is water and electricity, production of potential fuel can be distributed.
4. Fuel cellsconvert chemical energy directly into electrical energy without the combustion process.
5. Fuel cells provide high quality DC power.
6. The maintenance of the Fuel Cell is simple since there are few moving parts.

Demerits of Fuel Cell

1. Initial cost is high
2. Service life is low
3. Some Fuel Cells use expensive materials
4. The refueling and the starting time of fuel cell vehicles are longer.
5. Reforming hydrocarbons via reformers to produce hydrogen is technically challenging and not clearly environmentally and friendly.

ii) Merits of Pure Electric vehicle over Conventional Automotive vehicle

1. There is no pollution due to zero emission.
2. Cost of operation is less.
3. Smooth operation and less noise.
4. Less maintenance is required

5. It is easy to start the vehicle.
6. It takes up less space on the road, so they help to reduce traffic congestion

12. Compare the performance and emission characteristic of a vehicle fueled with Bio-ethanol with a neat gasoline fueled vehicle.(Apr/May 2018)

Performance of Compression Ignition (CI) Engine Fuelled with Biodiesel

The performance test of bio-hydro carbon fuels is carried on the engine similar to conventional engines. An electrical dynamometer is loaded when the engine reaches the operating temperature. After attaining the equilibrium state, the speed, fuel consumption and manometer head are noted. For example, the same test is conducted for various blends of B25 (25% biodiesel) and B50 (50% biodiesel). The emission values are also recorded.

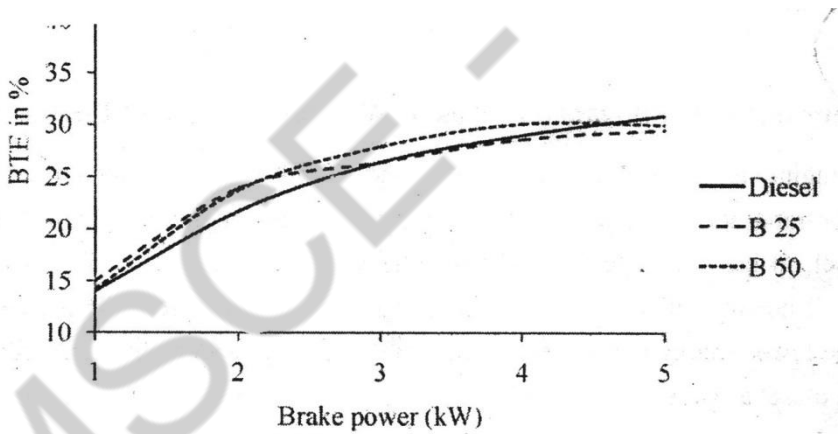


Figure 5.17 Variation of BTE versus brake power

At full load conditions, B50 provides higher brake thermal efficiency (BTE) than B25 and pure diesel fuel as shown in fig. 5.17. At the same time, the brake thermal efficiency of the biodiesel blend B25 is lower than pure diesel at full load conditions because the brake thermal efficiency depends on the combustion quality of the fuel. Therefore, B50 gives better blend to operate IC engines to produce good results.

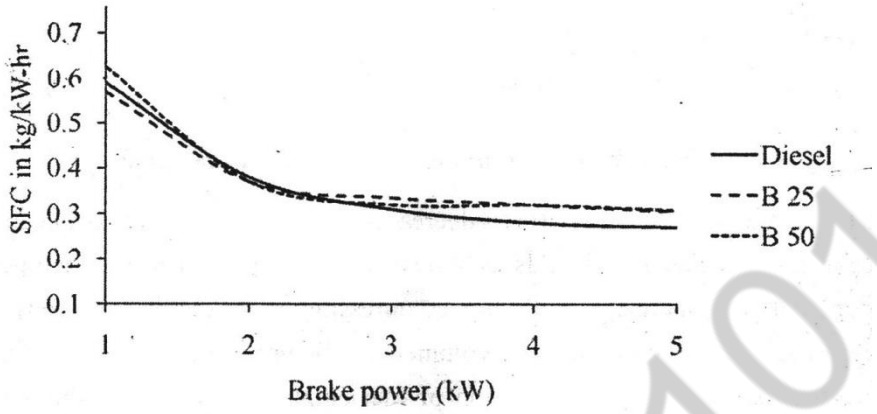


Figure 5.18 Variation of BSFC versus brake power

The specific fuel consumption (SFC) mainly depends on the mass flow rate of hydrogen. The mass flow rate of hydrogen is low for biodiesel whereas for diesel and it is slightly high. Therefore, it leads to increase in specific fuel consumption. At low load condition, the specific fuel consumption of fuel blend B25 is lower than diesel as shown in Fig 5.18. At full load condition, the specific fuel consumption of the fuel blend B25 and B 50 is higher than diesel fuel. At the same time, the specific fuel consumptions decreases with increase in injection pressure.

13. Discuss about the challenges faced in production a d storage of Hydrogen gas (N0v/Dec 2018)

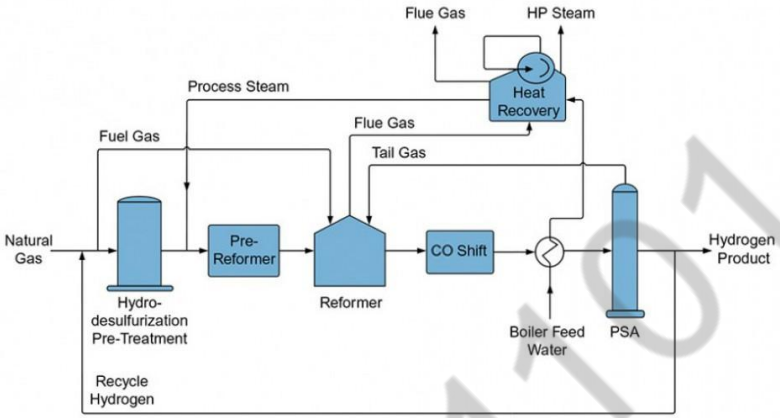
Natural gas contains methane (CH_4) that can be used to produce hydrogen with thermal processes, such as steam-methane reformation and partial oxidation. **Although today most hydrogen is produced from natural gas, the Fuel Cell Technologies Office is exploring a variety of waysto produce hydrogen from renewableresources.**

Steam-Methane Reforming

Most hydrogen produced today in the United States is made via steam- methanereforming,amatureproductionprocessinwhichhigh-temperature steam (700°C–1,000°C) is used to produce hydrogen from a methane source, such as natural gas. In steam-methane reforming, methane reacts with steam under 3–25 bar pressure (1 bar = 14.5 psi) in the presence of a catalyst to produce hydrogen, carbon monoxide, and a relatively small amount of carbon

dioxide. Steam reforming is endothermic—that is, heat must be supplied to the process for the reaction toproceed.

14.
15.



Subsequently, in what is called the "water-gas shift reaction," the carbon monoxide and steam are reacted using a catalyst to producecarbon dioxide and more hydrogen. In a final process step called "pressure-swing adsorption,"carbondioxideandotherimpuritiesareremovedfromthe gas stream, leaving essentially pure hydrogen. Steam reforming can also be used to produce hydrogen from other fuels, such as ethanol, propane, or even gasoline.

Steam-methane reformingreaction

$CH_4 + H_2O$ (+ heat) $\rightarrow CO + 3H_2$

Water-gas shift reaction

$CO + H_2O \rightarrow CO_2 + H_2$ (+ small amount of heat)

Partial Oxidation

In partial oxidation, the methane and other hydrocarbons in natural gas react with a limited amount of oxygen (typically from air) that is not enough to completely oxidize the hydrocarbons to carbon dioxide and water. With less than the stoichiometric amount of oxygen available, the reaction products contain primarily hydrogen and carbon monoxide (and nitrogen, if the reaction is carried out with air rather than pure oxygen), and a relatively small amount of carbon dioxide and other compounds. Subsequently, in a water-gas shift reaction, the carbon monoxide reacts with water to form carbon dioxide and more hydrogen.

16.
Partial oxidation is an exothermic process—it gives off heat. The process is, typically, much faster than steam reforming and requires a smaller reactor vessel. As can be seen in chemical reactions of partial oxidation,thisprocessinitiallyproduceslesshydrogenperunitoftheinput fuel than is obtained by steam reforming of the samefuel.

Partial oxidation of methane reaction

$CH_4 + ½O_2 \rightarrow CO + 2H_2$ (+ heat)

Water-gas shift reaction

$CO + H_2O \rightarrow CO_2 + H_2$ (+ small amount of heat)

14, With aid of a simple sketch discuss about the working of a solid oxide fuel cell, (Nov/Dec 2018)
Solid Oxide Fuel Cells:

Solid oxide fuel cells (SOFCs) use hard and non-porous ceramic compound as the electrolyte. Since the electrolyte is a solid, cells do not have to be constructed in the plate similar to the configuration of typical other fuel cell types. The efficiency of SOFCs is expected around 50-60% in converting fuel to electricity. These cells can be used where the system wants to capture and utilize the system's waste heat (co-generation). The overall fuel efficiency is around 80-85%.

SOFCs operate at high temperature around $1,000^0$C. Temperature operation removes the need for precious metal catalyst thereby reducing its cost. It also allows SOFCs to reform fuels internally which enables the use of a variety of fuels and it reduces the cost associated with adding a reformer to the system.

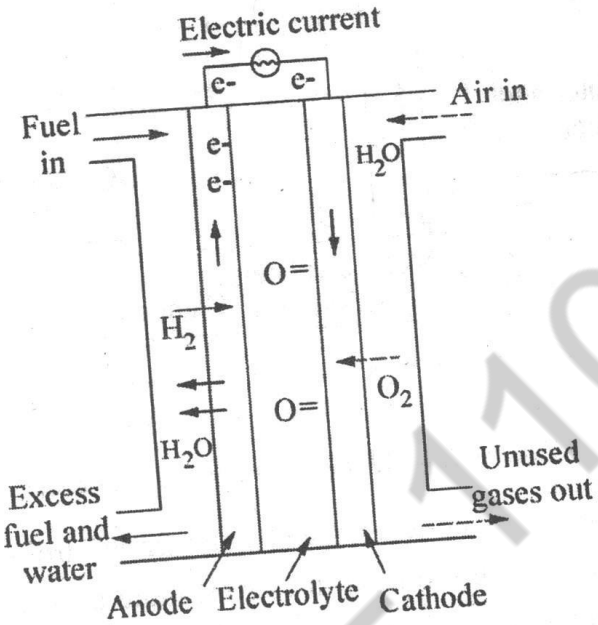


Figure 5.35 Solid oxide fuel cell

19.

SOFCs are also the most sulphur-resistant fuel cell type. They can tolerate several orders of magnitude more sulphur than other cell types. In addition, they are not poisoned by carbon monoxide (CO) which can even be used as fuel. It allows SOFCs to use gases made from coal.

High temperature operation is the main disadvantage of this cell. It results a slow start-up and it requires significant thermal shielding to retain heat and protect personnel which may be acceptable for utility applications but it is not for transportation and small portable applications.

15 ,i) Compare the performance and emission characteristics of a vehicle fueled with bio-diesel with that of a neat diesel fueled vehicle (Apr/May 2019)

Ii) Mention the advantages of ethanol as a fuel in a SI engine.

i). For answer refer question No. 12 (April/May 2018)

ii) **Advantages of Ethanol:**

1)It can be obtained from a number of sources both natural and manufactured.
2) It is a high octane fuel with anti-knock index No of over 100.
3) Less emission when compared to gasoline.

4). It has low Sulphur content in the fuel.
5). Ethanol reduces green house gas emission.
6). Ethanol is low in reactivity and high in oxygen content.
7). It has a high evaporative cooling which result a cooler intake process and compression stroke.

16. **i). Explain the necessary engine modification for SI engines to be fueled with natural gas. Support your answer with a schematic.**
Ii} Draw a schematic of a hybrid electric vehicles and mention its merits over an electric vehicles.(Apr/May 2019)

Hybridelectricvehicles(HEVs)arepoweredbytwoenergysourcessuchasan energyconversionunit(suchasacombustionengineorfuelcell)andanenergy storage device (such as batteries or ultra-capacitors). The energy conversion unitmaybepoweredbygasoline,methanol,compressednaturalgas,hydrogen, or other alternative fuels. Hybrid electric vehicles have the potential to be two to three times more fuel-efficient than conventionalvehicles.

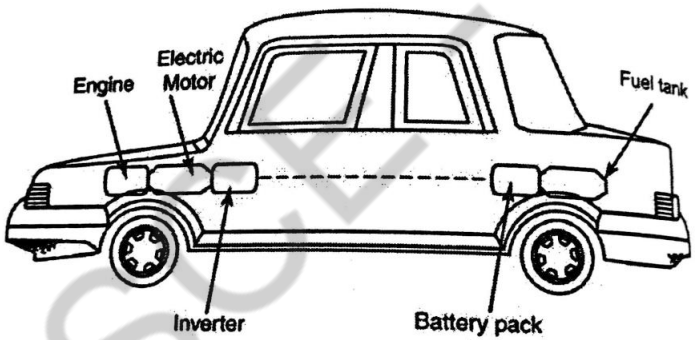


Figure 5.29 Hybrid vehicles

HEVs can have a parallel design, a series design, or a combination of the two. In a parallel design, the energy conversion unit and electric propulsionsystem are connected directly to the vehicle's wheels. The primary engine is used for highway driving. The electric motor provides added power during hill climbs, acceleration,andotherperiodsofhighdemand.Inaseriesdesign,theprimary engine is connected to a generator that produces electricity. There is also the inefficiency of converting the chemical energy to mechanical to electrical energy and back to mechanical energy.

To help reduce emissions and improve vehicle efficiencies, thefollowing

systemsandcomponentsarebeingimprovedthroughresearchanddevelopment.

1. Emission controlsystems
2. Energy management and systemscontrol
3. Thermal management of components
4. Lightweight and aerodynamic body/chassis
5. Low rolling resistance (including body design and tires)
6. Reduction of accessory loads.