
# GOVERNMENTPOLYTECHNIC,DHENKANAL

## Programme:DiplomainMechanicalEngineering

## Course:AutomobileEngineeringandHybridVehicles(Theory)

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# 1.0 INTRODUCTION AND TRANSMISSION SYSTEM

## 1.1
## Automobile:-

“Auto” means self and “mobile” means movable.Thus a self-moving vehicle is known as “automobile”. The term is generally used for motor cars, delivery vans, trucks etc.

### Definition:-

Itisaself-propelledvehiclewhichisusedforthetransportation of goods and passengers(on the ground).

### Necessity:-

Automobiles are an important part of life in today's world. It isa basic need for every household. Imagine walking hundreds of miles for days to get from one place to another, but because of the discovery of automobiles, transportation today is much faster, easier and reliable.

### Classification:-

*Purpose:->goods
E.g-truck,dumptruck,lorry
> Passengers
E.g-car,bus,motorcycle
*Capacityofvehicle:->lightduty
> heavyduty
*Onthebasisoffuelused:->petrol
> Diesel
> Electric
> Gasandsolar
*No.Ofwheelsused:->2-wheeler
> 3-wheeler

> 4-wheeler
> 10-wheeleretc.

*Onthebasisofconstruction:-

> salooncars
> bus
> trucks,halfandfullbody,foldingor detachable
> pickupvans
> stationwagon
> Matadorvans
> Vanityvans
> Jeep
> dumper

MAIN UNITS of a motor-car

(a)Body:Wherepassengerssitorluggageiskept.(b)Chassis: Thisunitwhichisusedasabasefor engine-parts and otherpartsofmotorcar.

(c) Engine: This unit is also known as power unit. It includes fuel pump, carburettor, self, dynamo, distributor, spark plug, lubrication pump, etc.

(d) RunningGear:Thisunitconsistsofthosepartswhichgive motion to the vehicle such as front and rear axles, wheels, springs, frame, brake, steering etc.

(e) TransmissionSystem:Thosepartsofthemotor-carwhich transmit the engine power to its wheels, such as clutch, gear box, universal joint, propeller shaft, differentialandaxleshaftetc.are

includedinthetransmissionsystem.
Variationsofspeedratiosandforward and reverse motion are obtained through the transmission system.

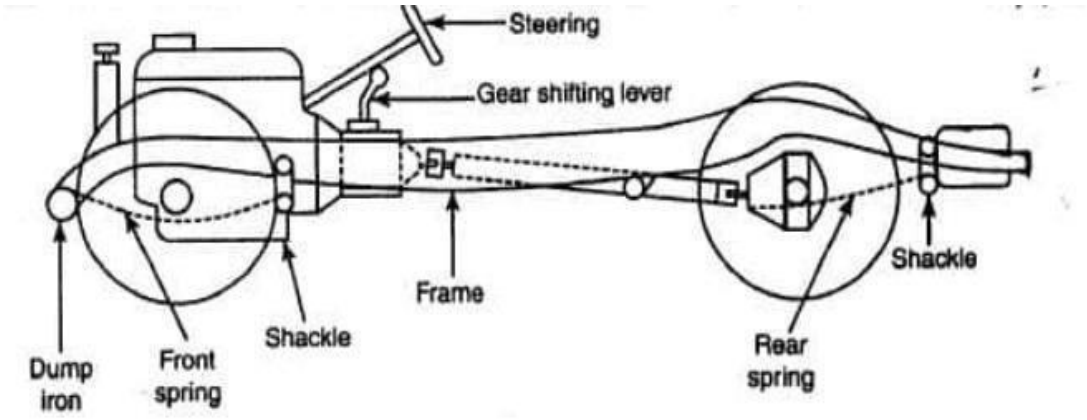
## FunctionsofaCar(MainAssembly)

- Motion
- StoppingofMotion
- ChangingdirectionofMotion
- ComfortofthePassenger
- Musicandair-conditioningsystem
- Protection of the Passengers and goods from external environmentalfactors

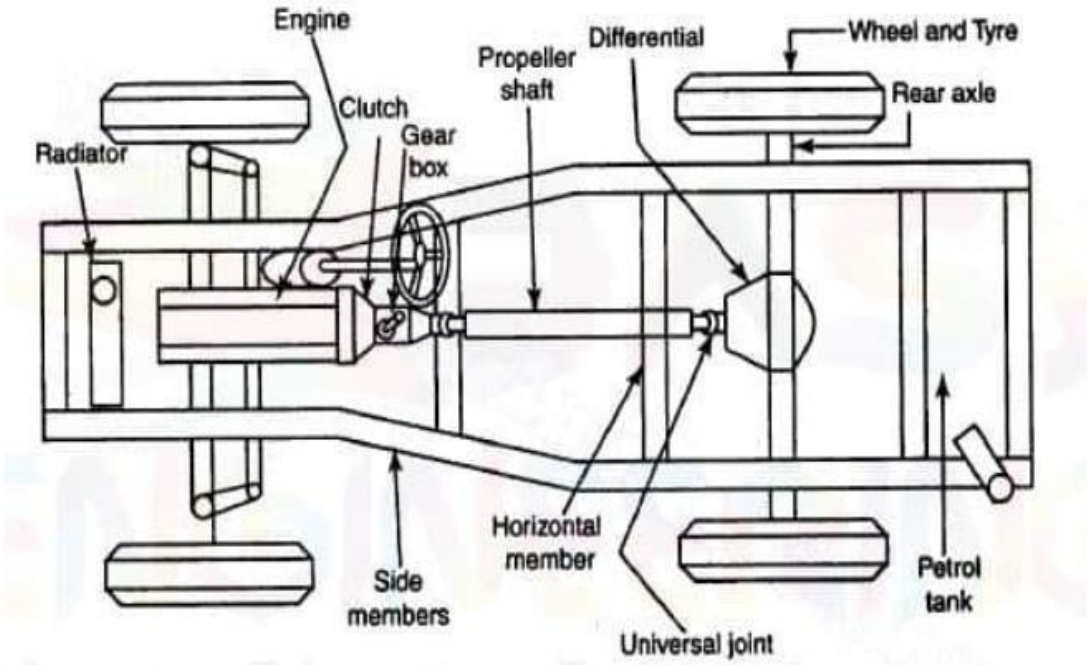
## →(SubAssembly)

- Engine
- TransmissionSystem
- BrakingSystem
- SteeringSystem
- SuspensionSystem
- ElectricalSystem
- SafetySystem

LAYOUTOFAutomobilechassis




*Front view (Elevation)*



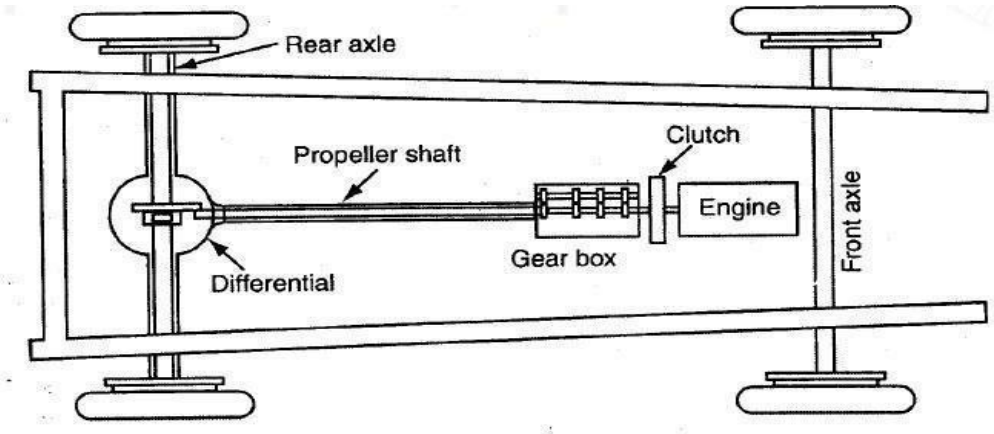

*Top view (Plan)*

# INTRODUCTIONTOTRANSMISSIONSystem

The transmission system is the system utilizing which power developed by the engine is transmitted to road wheels to propel the vehicle. In automobiles, the power is developed by the engine which is used to turn wheels. Therefore, the engine is to be connected to the transmission systems for transmitting power to wheels. Also, there should be a system utilizing which engine could be engaged and disengaged with the transmission system smoothly and without shock so that the vehicle mechanism is not damaged and passengers do not feel inconvenience. A clutch is employed in automobiles for this purpose.

> Theenginesemployedinautomobilesareofveryhighspeed. Hence, aspeed reductionis necessaryto reduce the speedto moderate levelas well as to get the requiredhigh torquewhile moving from rest. For this purpose, a gearbox is employed in automobiles.

> Thefigureshowsthe generalarrangementofapower transmission system of an automobile.




*General arrangement of power transmission*

> The motion of the crankshaft is transmitted to the gearbox through the clutch. The gearbox consists of a set of gears to change the speed according to the requirement. The motion is then transmitted to the propeller shaft from the gearbox through a universal joint. The purpose of the universal joint is to connect two shafts at an angle for power transmission.
> The power is transmitted to the differential unit through another universal joint. Finally, the power is transmitted from the differential to wheels through the rear end. The differential unit is used to provide the relative motion between two-run wheels while the vehicle is taking a turn

## 1.2 CLUTCHSystem

A Clutch is a mechanism used to connect or disconnect the engine from the rest of the transmission elements. It is located between the engine and gearbox.
During normal running and stationary position, it is always in theengagedcondition.Theclutch is disengagedwhenthedriver processes the clutch pedal. The clutch is disengaged forstarting, changing gears, stopping and idling.
Whentheclutchisengaged, theenginewillbeconnected tothe transmission, and power flows from engine to rear wheels through a transmission system.
When ‘the clutch is disengaged by pressing the clutchpedal, the engine will be disengaged from the transmission. Thus, the power does not flow to rear wheels while the engine is still running

## PrinciplesofOperationofFrictionClutch

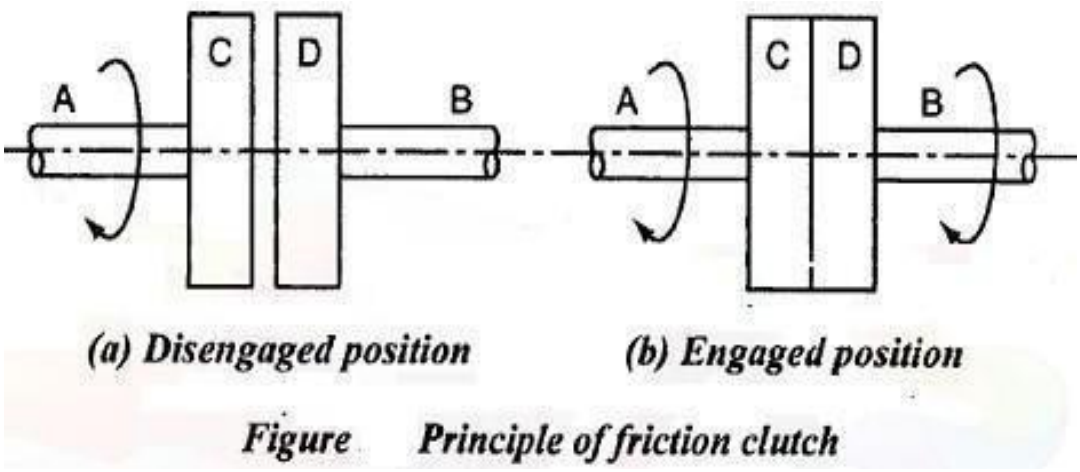



*Figure Principle of friction clutch*

Principleoffrictionclutch

The clutch works on the principle of friction. In Figure, the driving shaft A with flange C is rotating at 'N' rpm, and shaft B with the flange 0 is keyed to the driven shaft which is in stationary position when the clutch is not engaged.

Now, an external force is applied to the flange D so that it comes in contact with flange C.

As soon as the contact is made, they are united due to friction between them and the flange D starts rotating with flange C. The rotational speed of flange D depends on the friction between surfaces C and D which in turn proportional to the external force applied.

## FunctionsofaClutch:

The torque developed b the engine at the starting speed is very low. Therefore, it is not possible to start the engine under load. This requires that the transmission system should provide a means of connecting and disconnecting the engine from the rest of the transmission system. Such an operation must be smooth and without shock to the occupants of the vehicle.

## Thusthetwomainfunctionsofaclutchare:

1. To engage and disengage the transmission from engine to theremaining parts ofthetransmission. (Toallow theengineto be separatedfromrestofthetransmissionsystem)Thisisrequired when:

(a) Starting and running the engine at a sufficiently high speed lo generate sufficient power necessary for moving the vehicle from rest.
(b) Shifting the gears so that damage to gear teeth can be avoided. (c) Stopping the vehicle after applying brakes.

2. The second function of the clutch is to allow the engine to take up the driving load of the vehicle gradually and without shock.

## Requirementsofclutch:

Themainrequirementsofaclutchareasfollows:

Itshouldbeabletotransmitthemaximumtorqueoftheengine.
Itshouldengagegraduallytoavoidsuddenjerks.
Itshouldbeabletodissipatealargeamountofheatgenerated during clutch operation.
Itshouldbedynamicallybalanced,particularlyinthecaseofhigh-speed engine clutches.
Itshouldhaveasuitablemechanismtodampvibrationsandto eliminate noise produced during power transmission.
Itshouldbeassmallaspossiblesothatitwilloccupyminimum space.
Itshouldbeeasytooperaterequiring aslittleexertionas possible on the part of the driver.

It should be made as light as possible so that it will continue to rotate for any length of time after the clutch has been disengaged.
It must be trouble-free and have longer life.
Itmustbeeasytoinspect,adjust,andrepair

## ClutchFrictionLiningmaterialandtheirNecessity:The materials for clutch lining are:

1. Leather
2. Cork
3. Fabric
4. Asbestos
5. RaybestosandFerodo
6. Non-asbestosclutchliningmaterial.

## Necessityofclutchlining:

1. To transmit maximum power from engine flywheel transmission without jerk
2. Todissipatetheheatandabletowithstandhigherheat generated
3. Itshouldhaveahighercoefficientoffriction
4. Itshouldbecheapandeasytomanufacture.

## MainpartsofClutch:

Itconsistsof-

### (a) adrivingmember,

.Thedrivingmembersconsistsofaflywheelwhichismounted on the engine crankshaft
.Theflywheelisboltedtoacoverwhichcarriespressureplate, pressure springs, and release levers.

.As theflywheelis bolted tothecoverassembly, thus,theentire assembly of the flywheel and the cover rotate all the time.
.The clutch housing and cover provided with openings so thatthe heat produced during the function dissipates easily

(b) adrivenmember,and
.Thedrivenmembersconsistofadiscorplatecalledaclutchplate.
.Theclutchisfreetoslideonthesplinesoftheclutchshaft.
.Itcarriesfrictionmaterialsonbothofitssurfaces.
.Whentheclutchplateisgrippedbetweentheflywheelandthe pressure plate, it rotates the clutch shaft through splines.

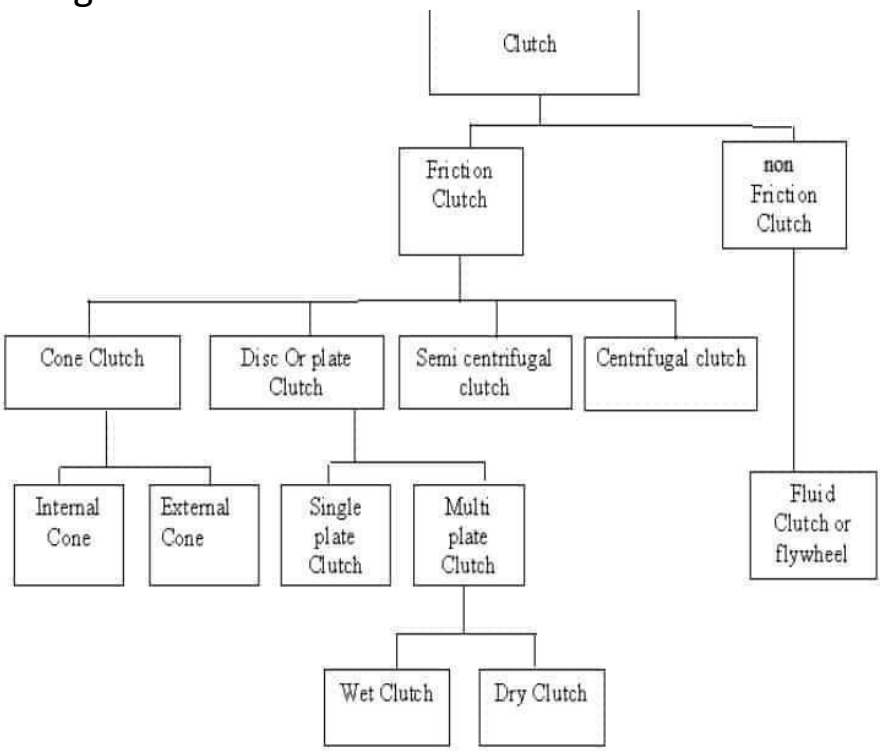
(c) anoperatingmember.
Parts Of Clutch


Theoperatingmemberconsistsofapedalorleverwhichcanbe pressed to disengage the driving and driven plate.

## TypesOfClutch:

Sometypesofclutchesusedinvehiclesaregivenbelow:The classification of clutch

1) Positiveclutch
Dogclutchorsplineclutch(InandOutclutch)
2) GradualengagementClutch
a) Electromagneticclutch
b) Vacuumoperatedclutch
c)Hydraulic clutch
d) FluidclutchorFluidflywheelclutch
e) Frictionclutch
i) Coneclutch(InternalandExternal)
ii) DiscPlateclutch(SingleplateandMulti-Plate)
iii) Semicentrifugalclutch
iv) Diaphragmorconicalspringclutch(Taperfingerandcrown spring)
v) Centrifugalclutch



## Multi-Plate(Dry)Clutch:

Itistheextension ofasingleplateclutch.Itconsistsof several clutch (friction) as well as pressure plates. As the number of plates increased, the friction surfaces also increase. The increase in the number of friction surfaces increases the capacity of the clutch to transmit torque. The plates are alternately fitted to the engine shaft and gearbox shaft. They are firmly pressed by strong coil springs and assembled in a cover assembly. Each alternate plate has inner and outer splines,thiseachofthealternateplateslidesonthesplineson the pressure plate.

Multiplate(dry)clutch

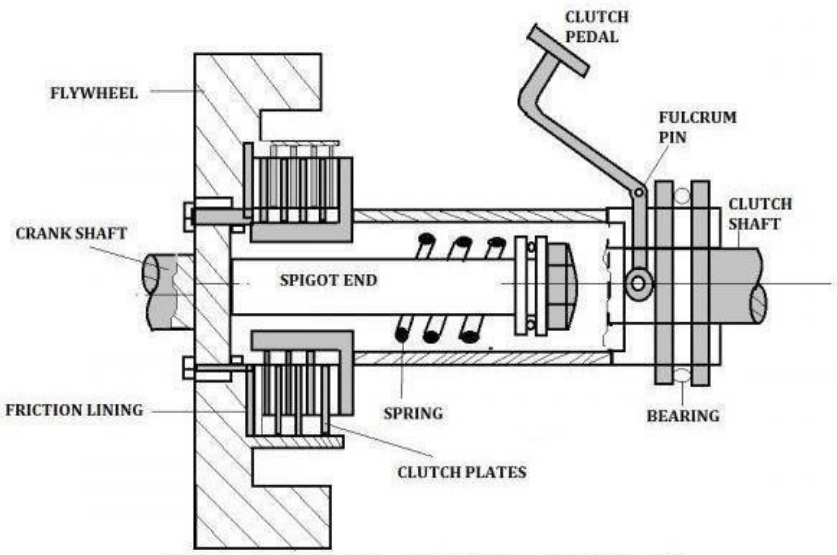



FIG: MULTI PLATE CLUTCH

## WorkingofMulti-PlateClutch:

The pressure plates are used to apply the pressure on friction platesandthe insidediameterof the pressureplateissplined whilemakingtheinsidediametersplined,therotatingmotion ofthepressureplateis restricted.Thepressureplatemoveson thedrivenshaftaxially.Whenweapplythepedalthepressure

platesandthefrictionplatescomein contactwith eachother andthespeedorpoweristransmittedfromtheengineshafttothe transmission shaft.

## ApplicationsOfMulti-PlateClutch:

ThistypeofclutchisusedinScootersandMotorCycles,where spaceavailabilityislimited.Besides,thisfindstheapplicationin some Heavy Transport Vehicles and Racing Cars where high torque is to be transmitted.

## SingleplateClutch:

Asinglediscorplateclutchasshowninthefigureconsistsofaclutch plate whose sides are faced with the friction material (usually ferrodo). It is mounted on the hub which is free to moveaxiallyalongthesplinesofthedrivenshaft.Thepressure plate is mounted inside the clutch body which is bolted to the flywheel. Both the pressure plate and the flywheel rotate with the engine crankshaft or the driving shaft. The pressure plate pushestheclutchplatetowards theflywheelbyaset ofstrong spring which is arranged radially inside the body. The three levers (also known as release levers or fingers) are carried on the pivots suspended from the case of the body. These are arranged in such a manner so that the pressure plate moves away from the flywheel by the inward movement of a thrust bearing. The bearing is mounted upon the forked shaft and moves forward when the clutch pedal is pressed.

## **NecessityofSingleplateclutch**

1) Totransmitalargeamountoftorquesingleplateclutch required

2) Responsetimetooperateisverylesscomparedtothemulti-plate clutch.
3) Itgenerateslowheatsononeedofcoolingmediarequired.
4) Itshouldbedynamicallybalancedandeasytooperate.

singleplateclutchdiagram

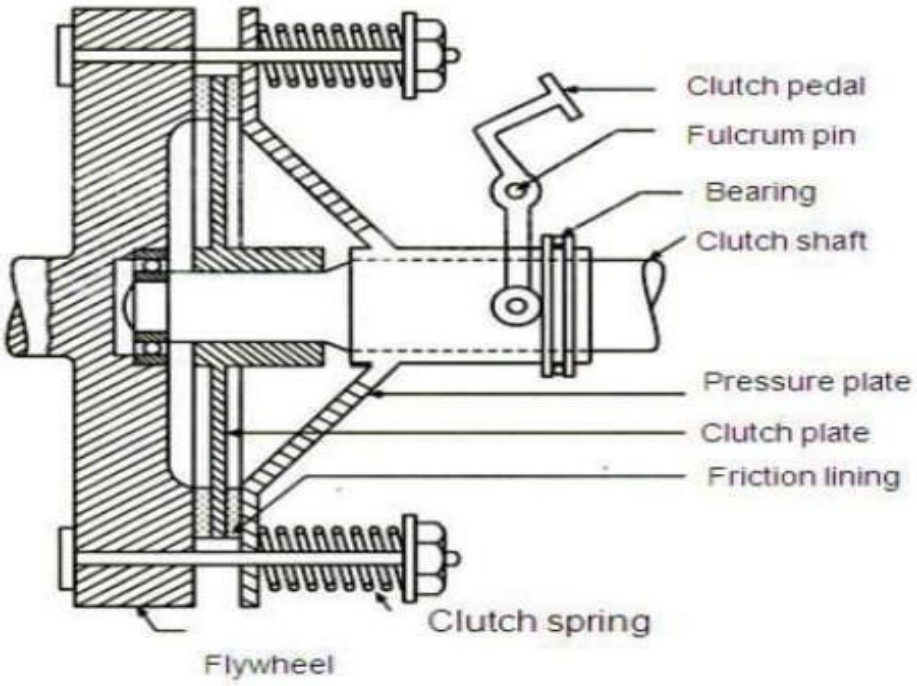


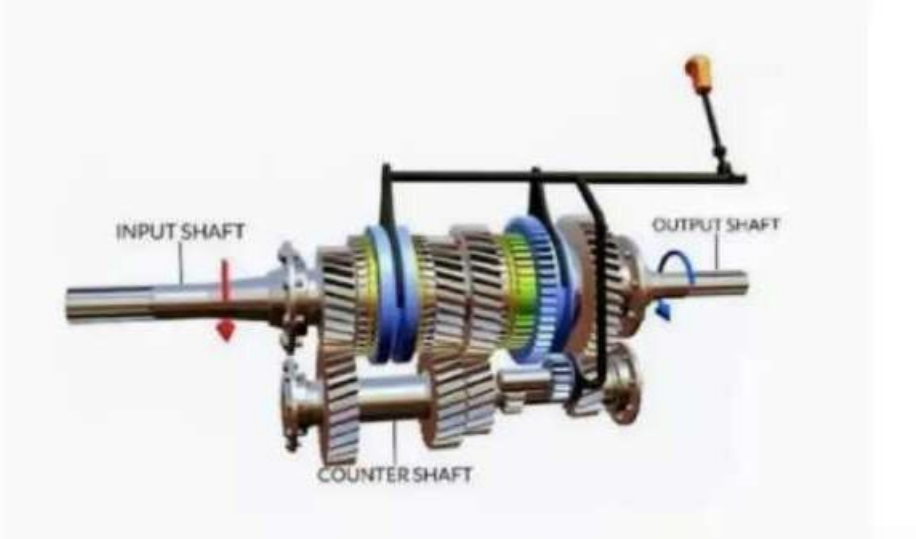

**Figure: Single Plate Dry Clutch**

## 1.3

## Gearbox

Thegearboxisamechanicaldeviceusedtoincreasetheoutput torque or to change the speed (RPM) of a motor. The shaft of themotorisconnectedtooneendofthegearboxandthrough the internal configuration of gears of a gearbox, provides a given output torque and speed determined by the gear ratio.

## Introduction




**GearboxDiagram**

High torque is required to start the vehicle from rest, accelerating, hill climbing, pulling a load and facing other resistances.ButtheICengineoperatesoveralimitedeffective speed range which produces a comparatively low torque. In suchasituation,theengineisresponsibleforthestallandthe vehicle rests if the speed falls below the limit.

Thetorquedevelopedbytheengineisincreasingwithinlimits with the increase of engine speed and reaches a maximum value at somepredominantspeed.Iftheenginedirectlyconnectstothe driving axle, the engine speed may reduce.

Duetothevariablenatureofthevehicleresistanceresultinginload and gradient changes, it require that the engine power should be available over a wide range of road speeds. Hence, forthisreason,theenginespeedmaintainbyusingareduction gear resulting in the road wheels rotating at a proper speed suited to the operating conditions of the vehicle.

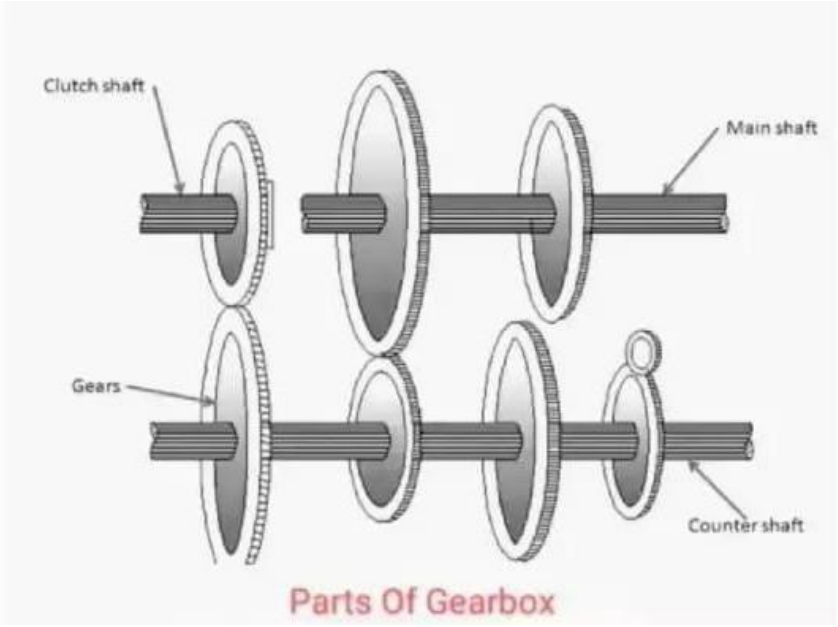
Therefore,asingletorquemultiplicationintherearaxlemust be interposedandavariablemultiplicationfactorinthegearboxis provided for this purpose.

## TheNecessityOfGearbox

Tomaintainenginespeedonallconditionsofloadandvehiclespeed, the gearbox uses a system to maintain engine speed, whilesacrificingthesameroadspeed.Toenabletheengineto run faster on-road wheels as well as to multiply the torque, a gearbox is required.

## PartsOfGearbox

## ThePartsOfGearboxareasfollowsgivenbelow:




## 1. ClutchShaft/DrivingShaft/InputShaft

A clutch shaft is a shaft that takes power from the engine to supply another shaft. The clutch shaft or driving shaft is connectedthroughtheclutchandwhentheclutchisengaged,the driving shaft also rotates. Only one gear is fixed on the

clutchshaftandthisenginerotateswiththesamespeedas the crankshaft.Inaddition,thedrivingshaftandmainshaftarein the same line.

## 2. CounterShaft/Layshaft

Thecountershaftisashaftthatconnectsdirectlytotheclutch shaft.Ithasgearwhichconnectsitto theclutchshaftaswellas the main shaft. It can be run at engine speed or below engine speed according to gear ratio.

## 3. MainShaft/OutputShaft

Themainshaftoroutput shaft thatrotatesatdifferentspeeds and also provides the necessary torque to the vehicle. The outputshaftisasplinedshaft,sothatthegearorsynchronizercanbe moved to engage or disengage.

## 4. Bearings

Thebearingsarerequiredtosupporttherotatingpartand reducefriction.Thegearboxhasbothacounterandmainshaft which is supported by the bearing.

## 5. Gears

Gears are used to transmitting the power from one shaft to anothershaft.Theamountoftorque transmittedthroughthe gearsdepends onthenumberof teethandthe sizeof thegears. Higherthegearratio,higherthetorque/accelerationandlower the speed. All gears except those on the main shaft are fixed to their respective shafts; they can slide in any of the directions along the shaft.

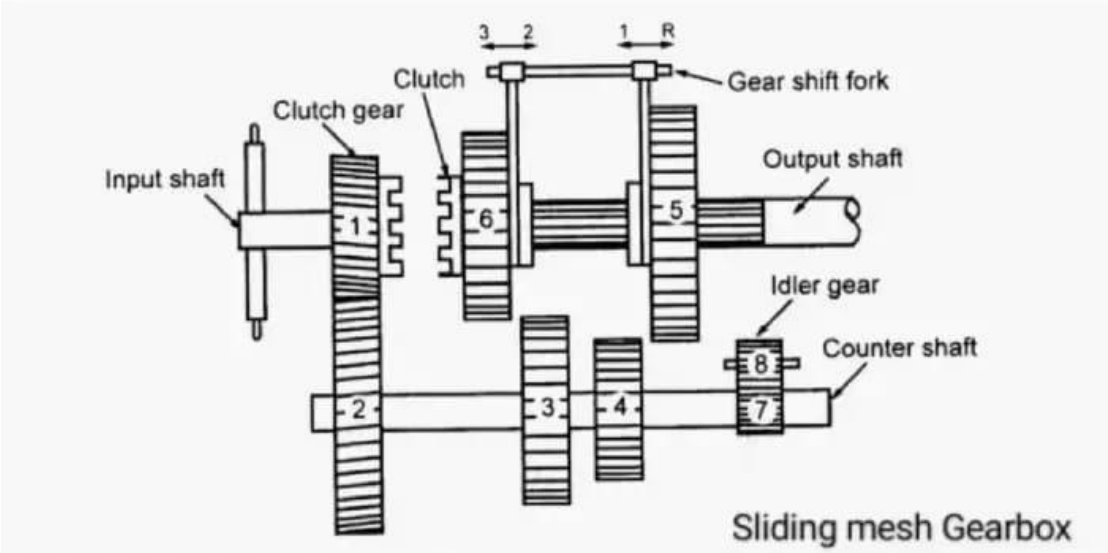
## 6. GearSelectorFork

Gearselectorsaresimpledevicesthatusealeverthatselects gearstoengageindisengagemechanisms.Themotionofthe lever slidestheengagingpartontheshaft. Itdependsonthetypeof gearbox whether the lever slides the gear or synchronizer that are already forged along the main shaft.

TypesOfGearbox

➢ManualTransmission

1. SlidingMeshGearbox



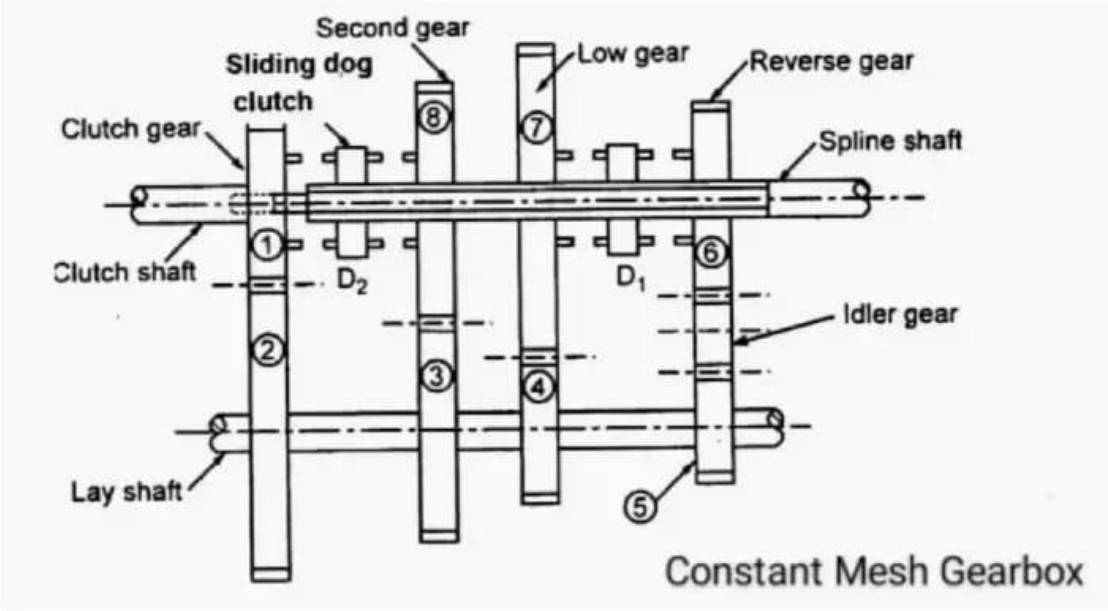

(I) SlidingMeshGearbox

Itisthesimplesttypeofgearbox.Inthisgearbox,spurgearsareused. The Figure shows the construction of a sliding mesh type transmission having three forward and one reverse speeds. Therearethreegears(1,6and5)attachedonthemainshaftand four gears (2, 3,4 and 7) on the layshaft.

Thetwogearsonthemainshaft(6and5)canbeslidedbya shaftingyokeandmeshwiththegears(3and4)onalayshaft.

Therefore,itiscalledaslidingmeshgearbox.Aseparateidlergear (8)ismountedontheidlershaft.

2. ConstantMeshGearbox



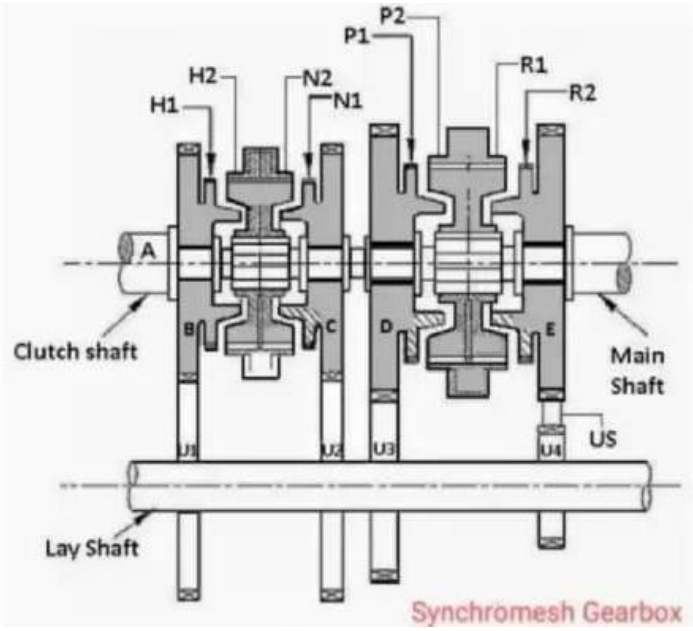

(II) ConstantMeshGearbox

Figureshowstheconstructionofaconstantmeshtypegearbox having three forward and one reverse speeds. In this type of gearbox, all gears are constantly in mesh and dog clutches are usedforengaginganddisengagingthegears.Thedogclutches (D) and D2) are mounted on the main shaft. One (D2) is connected between clutch gear and reverse gear whereas the other (D)) is placed between low speed gear and reverse gear. movementofdogs.Dogclutchcanslideontheshaftandrotatealong with it. All gears are rigidly fixed on the counter shaft.

All main shaft and layshaft gears, and idler gears are engaged bydogclutchtoobtainoppositeandslowspeed.Onlyreversegears are spur gear type and all others are helical gears.

As compared with the sliding mesh type, the constant mesh type gearbox meshes more readily with the gears having less danger of damaging during meshing because the gear diametersaresmallerwithfewnumbersofteeth.So,thistypehas more defects when compared to a synchromesh type. The necessityofdoubleclutchingisneededsothatitisnotusedtoany large extent

3. SynchromeshGearbox




(III) SynchromeshGearbox

Synchromeshgearboxusessynchronizerinsteadofslidingdog clutchestoaffecttheratiochange.Thesynchromeshgearboxis similar to the constant-mesh gearbox, but the synchromesh gearbox is provided with a synchronizer, the device by which twogearstobeengagedarefirstbroughtintofrictionalcontact which equalizes their speed, afterward they are engaged smoothly.

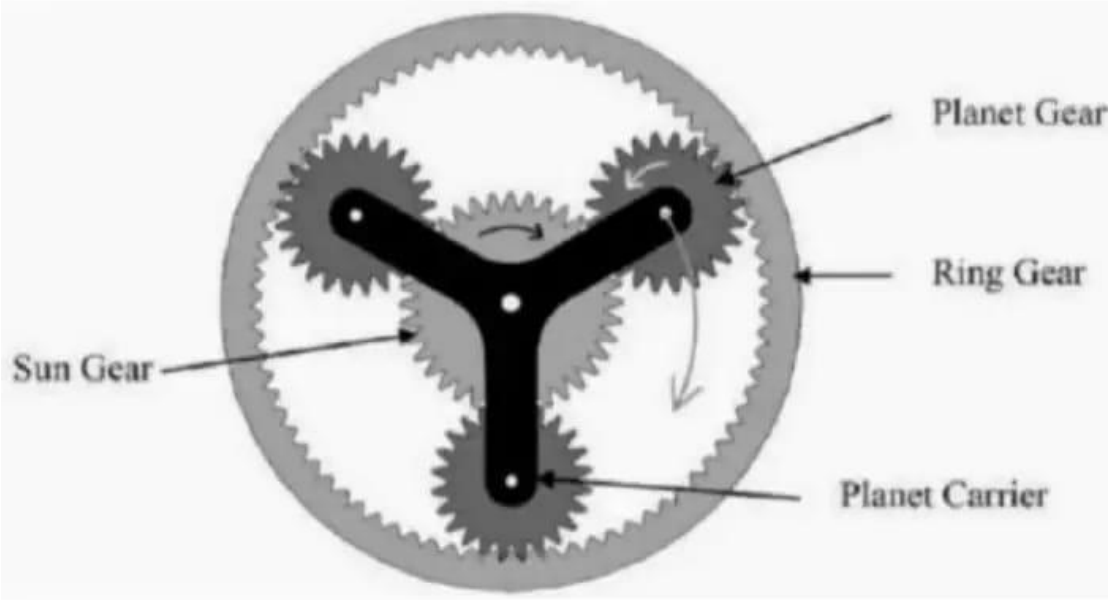
Toengage,whenthegearleverismovedthesynchronizercone meetswithasimilarconeonthepinion.Duetofriction,the rotating pinion is made to rotate at the same speed as the

synchromesh unit. To give a positive drive further, movement ofthegearleverenablesthecoupling tooverrideseveralspringloadballsand thecouplingengageswiththedogsonthesideof the pinion.

Since both pinions and synchromesh units are moving at the samespeed,thisengagementisdonewithoutnoise ordamage tothedogs.A slightdelay isnecessarybefore engaging thedog teethsothattheconeshaveachancetobringthesynchronizerand pinion to the same speed.

➢EpicyclicGearbox

2.EpicyclicGearbox




An epicyclic gear train (also known as planetary gear) consists of two gears so that the center of one gear rotates around the centeroftheother.Acarrierconnectsthecentersoftwogears and rotates to carry one gear, called planet gear or planet pinion,aroundtheother,calledsungearorsunwheel.Therays of theplanet and thesun form traps so that their pitch circles are rolled without slip. A point on the pitch circle of the

planetarygeartracesanepicycliccurve.Inthissimplifiedcase,the sungearisfixedand thereisplanetarygearrolledaroundthe sun gear.

Anepicyclic geartraincanbeassembledsotheplanetarygear isrolled ontoafixed,external gearringorinsidethepitchcircle oftheringgear,sometimescalledtheannulargear.Inthiscase, the curve detected by a point on the planet pitch circle is a hypocycloid.

Thecombinationofepicyclicgeartrainswithaplanetengaging bothasungearandaringgeariscalledplanetarygear train.In this case,theringgearisusuallyfixedand thesungearisoperated

**PurposeOfGearbox**

Ithelpstheenginetodisconnectfromdrivingwheels.
Ithelpstherunningengineconnecttothedrivingwheelsmoothly and without shock.
Itprovidestheleveragebetweenengineanddrivingwheelstobe varied.

Thishelpsin reducingtheenginespeedintheratio of4:1 in case of passenger cars and in a greater ratio in case of heavy vehicles like trucks and lorries.
Ithelpsthedrivingwheelstodriveatdifferentspeeds.
Itgivestherelativemovementbetweenengineanddriving wheels due to flexing of the road spring.

**FunctionOfGearbox**

Torqueratiobetweentheengineandwheelsshouldbevariedfor fast acceleration and for climbing gradients.
Itprovidesmeansofreversalofvehiclemotion.

Transmissioncandisconnectfromtheenginebytheneutral position of the gearbox.

**GearRatio**

Gearratios aregearedreductionstepsinthegearbox.Agear reductionmultipliestheenginetorquebygearratioamount. Torque requirement at the wheel depends on operating conditions.

Forexample:

Movingavehiclefromastandstillrequiresmuchmoretorque than thepeaktorqueoftheengine.Thereforethetorquemultiplies by the first gear ratio.

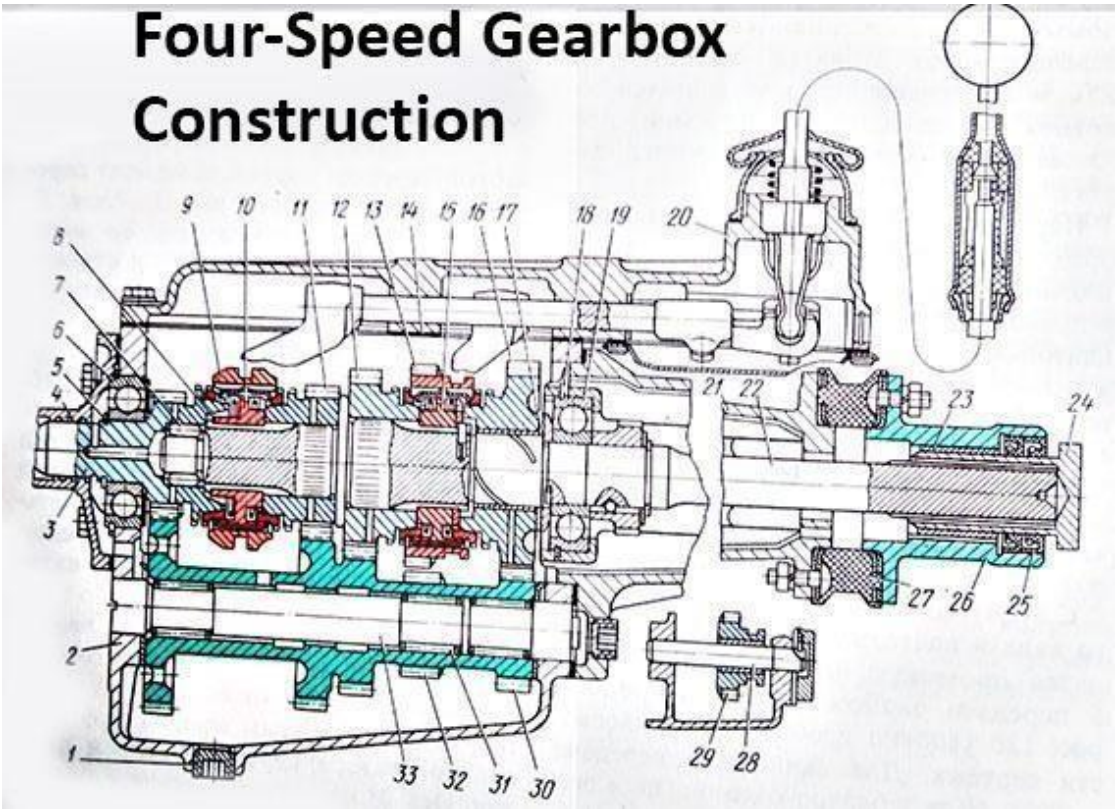
Oncestartingthevehicleandmovingusingfirstgear,itrequiresless torque at the wheels to keep it moving. Hence it requires no multiplication or very less multiplication.

If the vehicle suddenly encounters a gradient , it will require moretorqueonthewheelstokeepthevehiclemoving.Hencean intermediate ratio requires.

**CONSTRUCTIONANDWORKINGOF4SPEEDGEARBOX**

Fourspeedgearboxconstruction
Manualgearboxisatypeoftransmissionusedinmotor vehicle applications. This is article about four speed gearbox construction.Wewillknowabouthowafourspeedgearbox works and its construction.

Atthebeginningweshouldknowtheschemegearboxworkingof the gearbox and then we can new information about 4-, 5-speed gearbox construction too.




Four-speedGearboxConstruction:1 –oil drainplug;2– gearhousing;3– driveshaft;4– driveshaft bearingcap;5,8,18–lockingrings;6–reverse drive shaft bearing; 7 – roller bearing; 9 – synchronizer coupling of third and fourth gears; 10 – synchronizer coupling of the third and fourth gears; 11 – gear wheel of the third speed; 12 – gear wheel of the second speed; 13 – synchronizer coupling of the first and the second gears; 14 – washer; 15 – synchronizer hub of the first and the second gears; 16 – gearwheelofthe firstgear;17– adjustingwasher;19–ballbearing;20– top cap gearbox; 21 – gearbox extension; 22 – driven shaft; 23 – steel-babbit bearing; 24 – screw cap; 25 – stuffing box; 26 – extension flange; 27– rubbercoupling; 28 –axis ofintermediate gear wheelofreverse;29 – intermediategear wheelofreversegear;30 –gear wheels block of intermediate shaft; 31 – needle bearing of intermediate shaft; 32 – gear wheel reverse gear; 33 – axis of intermediate shaft.

The driving shaft 3 of the four-speed gearbox has a gear wheel permanent gearing connect to the block of gear wheels 30 of intermediateshaft.Othergearwheelsofthisblockareinpermanent gearingtothegearwheels11,12,16accordingwiththird,fourth,fifth

gearsofthedrivenshaft22.Toturnonallfourgearsoffrontmovingareused connecting of the sliding couplings 9 and 13 of synchronizers.

WORKINGofFour-speedgearbox
When the first speed is on: The crankshaft rotation moment is transmitting to the gear wheels block of intermediate shaft 30 through drive shaft 3, and then to the driven shaft 22 through gear wheel 16, slidingcoupling13andsynchronizer15hubofthefirstandsecondgears When the second speed is on: The crankshaft rotation moment is transmitting to the driven shaft though the drive shaft 3, gear wheels block of intermediate shaft, gear wheel 12, sliding coupling 13 and synchronizer 15 hub of the first and second gears.

Whenthethirdspeedison:Thecrankshaftrotationmomentis transmittingtothedrivenshaftthoughthegearwheel11,sliding coupling9andsynchronizer10hubofthethirdandfourthgears.

Whenthefourthspeedison:thesynchronizerofthethirdandfourthspeed connects drive shaft to the driven shaft directly.

Whenthe reversegearison:gearwheel29isgearingtogearwheel32of the intermediategearwheelsblockandgearrimof thesynchronizersliding coupling of the first and second gears.

## Conceptofautomaticgearchangingmechanisms

The mostcommon type of automatic transmissionuses hydraulic power to shift gears. This device combines a torque or fluid coupling converter withgearsetsthatprovidethedesiredrangeofgearsforthevehicle.The torque converter connects the engine to the transmission and uses pressurizedfluidtotransferpowertothegears.Thisapparatusreplacesa manual friction clutch and lets the vehicle come to a complete stop without stalling.

As the engine transmits power to the pump of the torque converter, the pumpconvertsthispowerintotransmissionfluidthatpowerstheturbine of thetorqueconverter.Thisapparatusincreasesthepowerofthefluidand transmits even more power back to the turbine, which creates a vortex power rotation that spins the turbine and the attached central

shaft.Thepowercreatedbythisrotationisthentransmittedfromtheshaft to the transmission's first planetary gear set.

This type of transmission has what is called hydraulic control. The transmissionfluidispressurizedbyanoilpump,whichallowsthespeed tochangedependingonthevehicle'sspeed,tirerevolutionperminute, and other factors. The gear pump is placed between the planetary gearset and torque converter, where it pulls and pressurizers transmission fluid from a sump. The pump input leads directly to the housingofthetorqueconverterattachedtotheflexplateoftheengine. When the engine isnot running, the transmission doesnot have the oil pressureneededtooperateandthusthevehiclecannotbepush-started.

Theplanetarygeartrainisamechanicalsysteminwhichthegearsare connectedwithasetofbandsandclutches.Whenthedriverchanges gears,thebandsholdonegearstillwhilerotatinganothertotransmit torque from the engine and increase or decrease gears.

The differentgears are sometimes calledthe sun gear, the ringgear,and the planetary gear. The arrangement of the gears determines how much powerwillflowfromonegeartoanotherandouttothedrivetrainofthevehicle when you shift.

GearsofanAutomaticTransmission
Thegearsofanautomatictransmissionincludethefollowing:

> Whenyoushiftyourvehicleintodrive,youengageallavailableforward gear ratios.Thismeansthatthetransmissioncan movebetweenitsfullrange of gears as needed. Six-speed automatic transmissions are the most common number of gears, but older cars and entry-level compact cars may still have either four or five automatic gears.
> Thirdgear either locks the transmission in third gear or limitsit to the first,second,andthirdgearratios.Thisprovidesthepowerandtraction needed to go either uphill or downhill or to tow a boat, RV, or trailer. Whentheenginereachesadesignatedlevelofrevolutions perminute (RPM),mostvehiclesautomatically dropthirdgeartokeeptheenginefrom harm.
> Secondgeareitherlocksthetransmissioninsecondgearorlimitsitto the first and second gear ratios. This gear is ideal for going uphill and

downhillinslipperyconditionsaswellasdrivingduringice,snow,andother types of inclement weather.
> First gear is used when you want to lock the transmission in first gear, although some vehicles will automatically switch out of this gear to protecttheengineatacertainRPM.Likesecondandthirdgear,thisgearisbest used for towing, driving uphill or downhill, and when traveling during slippery, icy conditions.
AdvantagesofanAutomaticTransmission

Thebiggestadvantageofanautomatictransmissionistheabilitytodrive withouttheneedfor aclutch asisrequired withamanualtransmission. Individuals with many disabilities are able to drive using an automatic since operation only requires two usable limbs.

Thelackofaclutchalsoeliminatesthe needtopay attentiontoshifting manually and monitoring the tachometer tomake the necessary shifts, which gives you more attention to focus on the task of driving.

Many drivers also find it easier to control an automatic transmission at low speeds than a manual transmission. The hydraulic automatic transmissioncreatesaphenomenoncalledidlecreep,whichencouragesthe vehicle to move forward even when idling.

## PROPELLERSHAFT

The drive shaft (also called propeller shaft or prop shaft) is a component of the drive train ina vehicle, with the purpose of delivering torque from the transmission to the differential, which then transmits this torque to the wheelsinorder to movethevehicle. Thedriveshaftisprimarilyused to transfer torque between components that are separated by a distance, since different components must be in differentlocations in the vehicle.A front-engine rear-wheel drive car must have a long drive shaft connecting the rear axle to the transmission since these parts are on opposite sides of the car.

Drive shafts are used differently in different vehicles, varying greatly in cars with distinct configurations for front-wheel drive, four-wheel drive,

and the previously mentioned front-engine rear-wheel drive. Other vehicles also use drive shafts, like motorcycles, locomotives, and marine vessels

PropellerShaftis theshaft thattransmitspowerfrom the gearboxto the differential gear in a motor vehicle from the engine to the propeller in a boat or flying machine.
Propeller shaft, sometimes called a cardan shaft, transmits power from the gearbox to the rear axle. Regularly the shaft has a tubular section and is made in maybe a couple piece construction.
The two-piece arrangement is supported at the mid point by an elastic mounted bearing. Short drive shafts are incorporated for the transmissionof powerfromthe last driveassemblytothe roadwheels in both front and rear wheel drive layouts.

**FUNCTIONSOFTHEPROPELLERSHAFT**

Inmostoftheautomotive vehicles,theengineis locatedatthefrontand the rear wheels of the vehicle are being driven. This arrangement stipulatesalongerpropellershaftto be used.Insomearrangements two or three propeller shafts are used to make up the length.

In some vehicles, the engine is kept at the front and the front wheels of the vehicle are being driven. In some other vehicles, the engine is at the rearand the rear wheels are being driven. Forsucharrangementsa short propeller shaft is used to drive each wheel.

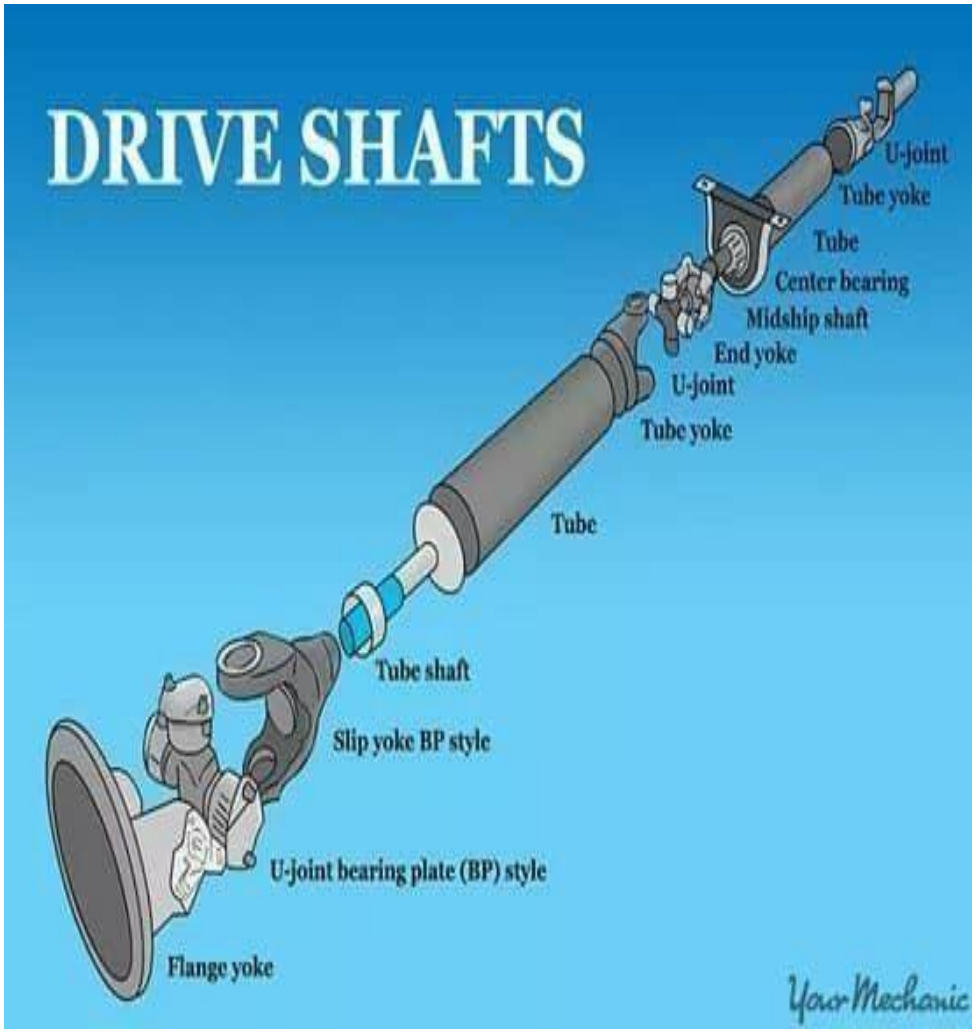
The engine and the transmission unit are attached to the vehicle frame with some flexible mounting. The rear axle housing with differential and wheels are attached to the vehicle frame by suspension springs.

Due to the above arrangement, the transmission output shaft and the input shaft to the rear axle housing are in different planes. This compels the propeller shaft that connects these two shafts to be kept inclined.

Further, whenever the rear wheels encounter irregularities in the road, the rear axle housing moves up and down, compressing and expanding the suspension springs. As this happens, the angle between the transmission output shaft and the propeller shaft changes. Further, the length to be occupied by the propeller shaft also changes.
The variation in the length of the propeller shaft happens because the propeller shaft and the rear axle housing rotate on arcs with different points as their centres of rotation.

The rear axle housing moves in the shorter arc than thatof the propeller shaft. This is because the centre of the rear axle housing arc is the point of attachment of the rear spring or control arm to thevehicleframe. This aspect causes a reduction in the length occupied by the propeller shaftas theangle betweenthe transmissionand the propellershaft increases.

PROPELLERSHAFT



**TYPESOFPROPELLERSHAFT:**

1. Single-Piece-TypePropellerShaft:

Usedinvehicles witha shortdistance betweenthe engineandaxles,and MR based four-wheel-drive vehicles.

The friction welding adopted at the junction contributes to an improvement in the strength, quality, and durability of the junction.

2-piece-type/3-piece-typePropellerShaft:

Utilizedas apartofvehicles withalong distancebetweentheengineand axles, and Front engine front drive base four-wheel-drive vehicles.

The division of the propeller shaft into two- or three-parts allows the critical number of revolution to lowered preventing vibration issue from occurring, when the overall length of the shaft increased.

**COMPONENTSOFPROPELLERSHAFT:**

The propeller shaft transfers engine torque to the rear axle through one or more universal joints.

The splines onthe ends atthe propellershaftfitperfectlyintothe splines inthesleeve.Thispermitsalengthvariationbetweenthedrivingandthe driven unit to vary slightly without damaging the output and input bearings.

The mainbearingsupportandguidethe propellershaft.

Theflangesassociatethe propellershafttothegearbox.

**REQUIREMENTSOFPROPELLERSHAFT:**

Forachievingefficientfunctions,thefollowingareexpectedinapropeller shaft

High torsional strength: Therefore, they are made of solid or hollow circular cross section

Toughened and hardened: Therefore, they are made of superior quality steel and are induction hardened

Efficiently jointed: Therefore they are generally welded by submerged are carbon dioxide welding process.

Dynamically balanced: Since the phenomenon of whirling may be critical at higher speeds, therefore, propeller shafts are tested on electronic balancing machine.

Reduced thrust loads: Since resonance is dangerous for the life of shaft. It also transmits excessive dynamic force to the shaft'sendsupports, and so its occurrence should be avoided.

**NOTE:** Since the propeller shaft sleeve end is pulled out from the transmission extension housing with the transmission still mounted, overflow of the transmission oil, damage of oil seal lip or entrance of dust may result if the vehicle is raised higher toward its front end. Use extreme care in removing the propeller shaft.

# DIFFERENTIAL

**FunctionsOfDifferentialgearBox.**
Whenafour-wheeler(car)takesaturn, theouterwheel turns fasterthan the inner wheel. Thus, there is relative movement between the innerand outer wheel.

The function of the differential is to permit the relative movement between inner and outer wheels when vehicle negotiates (takes) a turn. The torque transmitted to each rear wheel is equal inthis case, although their speed is different.

The differential is made up of a system of gears that connect the propeller shaftand rear axles. It is a part of inner axle housing assembly. The assembly consists of differential, rear axles, wheels, and bearings.

Theneedofdifferentialgearbox:
When a vehicle travels in a straight line, the two rear wheels turnon the road exactly at the same speed and there is no relative movement between two rear wheels.
But when vehicle takes a turn the outer wheel travels on a longer radius than the inner wheel. The outer wheel turns faster than inner wheel i.e. there is relative movement between two rear wheels. If two rear wheels are rigidly fixed to a rear axle, the inner wheel will slip, which will cause rapid tire wear, steering difficulties and poor road holding. Therefore there must be some device, which will divide the input torque of the transmission system between two rear axles. Differential serves this purpose.

**DifferentialgearboxLocation:**
Locationinadifferenttypeofvehiclelayouts-

1. InFront-enginefront-wheel-drivelayout–differentialislocatedatthe front next to gearbox.
2. InRearenginerear-wheel-drivelayout–differentialislocatedatthe rear next to gearbox.
3. Fourwheelsdrivelayout–differentialislocatedatthefrontaswellas rear.
4. Frontenginerear-wheel-drivelayout–itislocatedattherearinbetween two half shafts.

**Principleofdifferential-**

If a vehicle travels in a straight line, the two rear wheels turn exactly at the same speed, and there is no relative movement between them. But when the vehicle takes a turn the outer wheel travels a longer radius than the inner wheel i.e. there is relative movement between the two rear wheels. The outer wheel turns faster and covers a larger distance than the inner wheel. The inner wheel makes a larger angle than the outer wheel. thus the vehicle negotiates the turn safely.

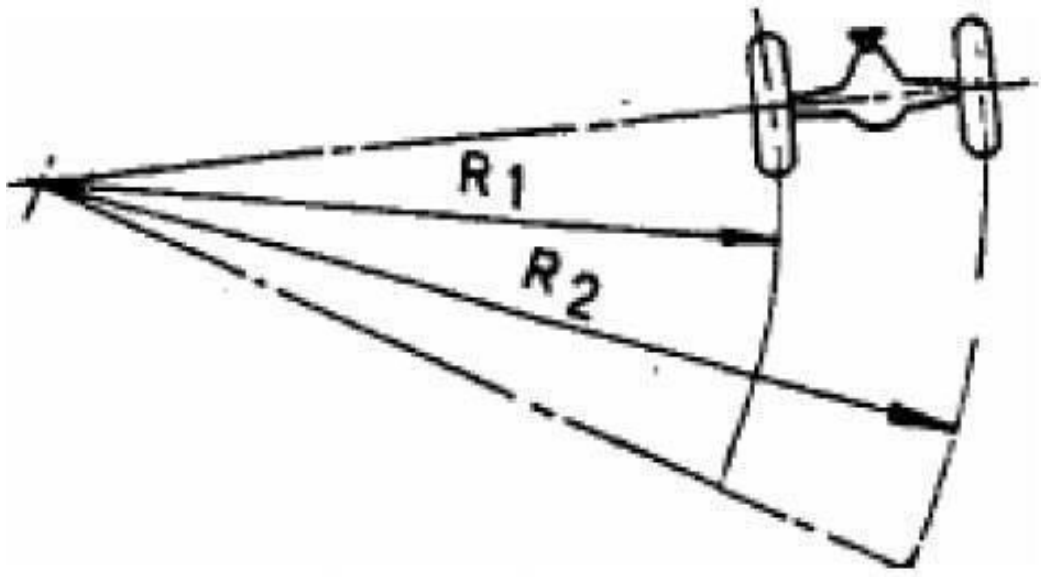



Figure: Principle of Differential

# DIFFERENTIALGEARBOXDIAGRAM

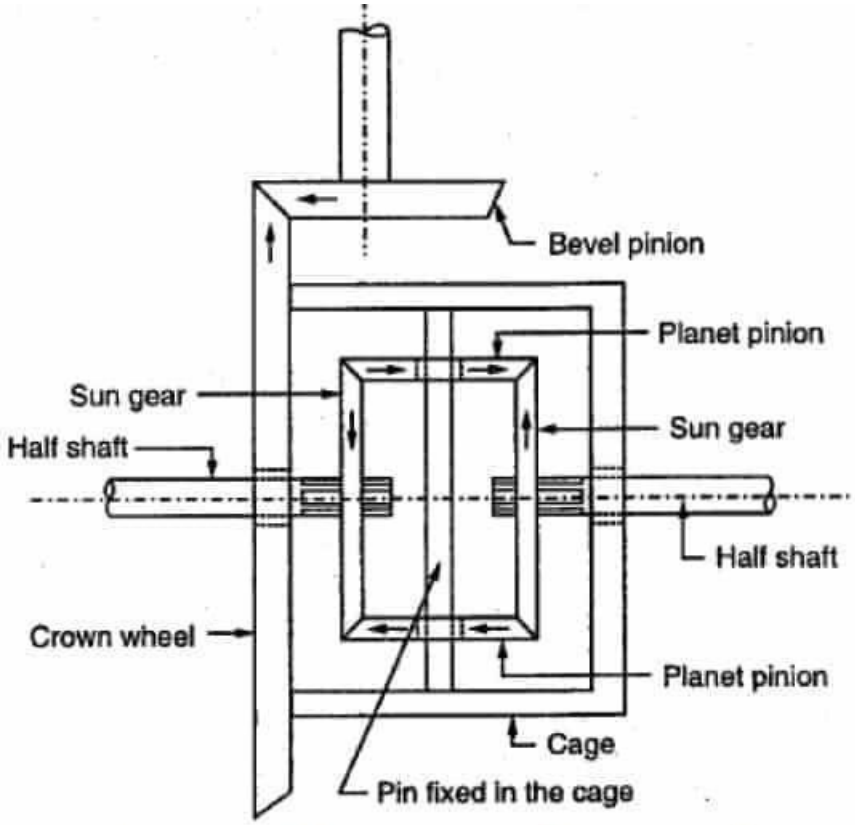



**Figure: Working of differential**

Constructionofdifferential:
MajorComponentsofDifferential
Thefollowingmaincomponentsareusedinthedifferential assembly.

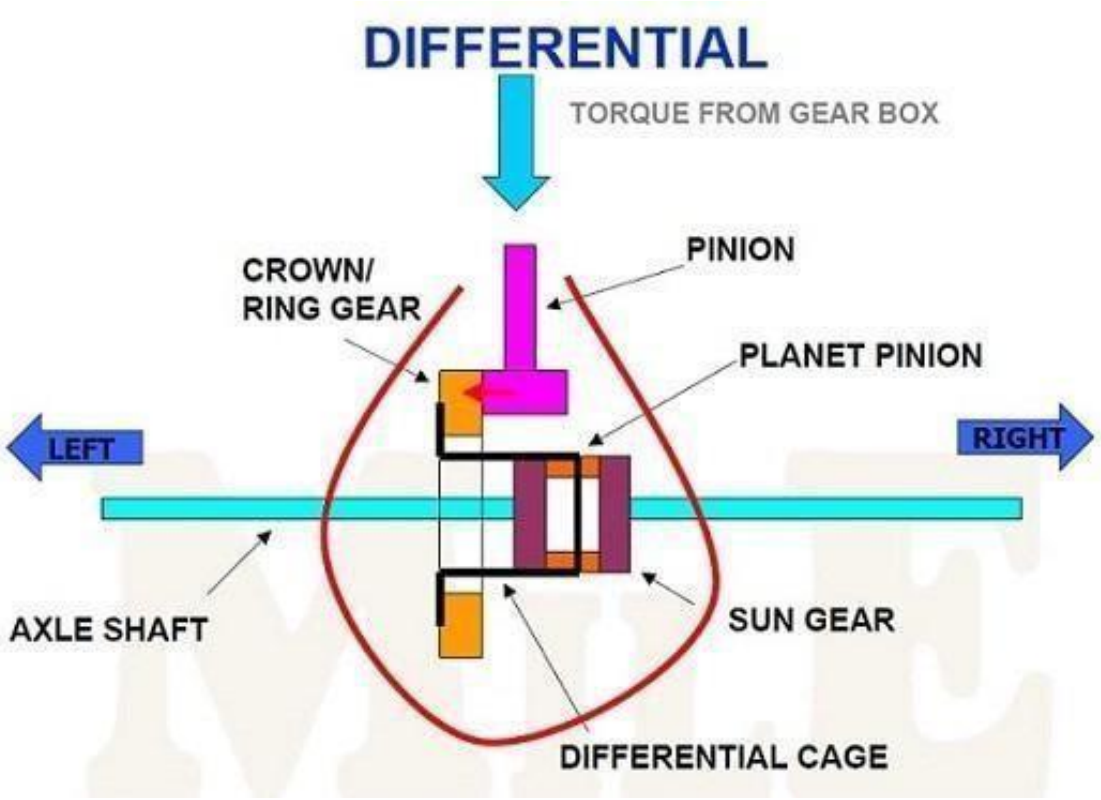
l.DrivepinionorBevelpinion
2. RinggearorCrownwheel
3. Differentialcase
4. DifferentialsidegearorSungears
5. Differentialpinions(or)Planetgears
6. AxleshaftsorHalfshafts
7. PinionshaftorCrosspin(or)spider.

Figure.showsthebasicparts ofthetypeofdifferentialusedin rear-wheel-drive cars.

On the inner ends of each axle a smaller bevel gear called differential side gear is mounted. Two bevel gears are put together to mesh both 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 that rotate two axle shafts. Then, the two pinion gears and their supporting shaft, called pinion shafts, are fitted into the differential case. Then, the pinion shaft meshes with the two differential side gears connected to the inner ends of the axle shafts.

The ring gear is bolted to a flange on the differential case. The' ring gearrotatesthedifferentialcase. Finally, thedrivepinionis mounted. The drive pinion is assembled with the differential housing called differential case or carrier. The driver shaft is connected with the drive pinion by a universal joint and it meshes with the ring gear. So, the drive pinion is rotated when the drive shaft turns. Thus, the ring gear is rotated.

**WORKINGOFGEARBOX**




**Workingofdifferentialgearbox:**

1. WhenRunningStraight:
When the vehicle moves in a straight line, the power comes from the propeller shaft to the bevel pinion which drives the crown wheel. Then it is carried to the differential cage in which a set of planet pinions and sun gears are located. From the sun gear it is transmitted to the road wheels through-axle half shafts. In this case, the crown wheel, differential cage, planet pinions, and sun gears all turn as a single unit and there is no relative motion between the sun gear and planet pinion. The planet pinions do not rotate about their own axis. The road wheels, halfshafts, andsunwheelsofferthesameresistanceto being turned and the differential gearing does not therefore operate. Both the road wheels turn at the same speed.

2. Whentakingaturn:

When the vehicle takes a turn, the inner wheel experiences resistance and tends to rotate in the opposite direction. Due to this the planet pinions start rotating about their own axis and around the sun gear and transmit more rotary motion to the outer side sun gear. So that outer sun gear rotates faster than the inner sun gear. Therefore the outer road wheel runs faster than the inner road wheel and covers a more distance.

**TYPESOFDIFFERENTIAL**

Therearethreetypesofdifferential:

(a) Conventionaltype,

(b) Non-sliporself-lockingtype,and

(c) Doublereductiontype.

1) ConventionalType

Conventional type differential described in Section 5.6 delivers the same torque to each rear wheel. If any of the wheels slips due to any reason the wheel does not rotate and the vehicle does not move.

2) Non-sliporSelfLockingType

Non-slip or self-locking type differential overcomes this drawback. It construction is similar to that of conventional type differential. But, two sets of clutch plates are provided additionally. Also, the ends of planet shafts are left loose in notches provided on the differential cage.

3) DoubleReductionType

Double reduction type differential provides further speed reduction by additional gear. This type of differential is used in heavy-duty automobiles which require larger gear reduction between engine and wheels.

# 2.0 BRAKING SYSTEM

A brake is one of the most important controls of the vehicle. This is a combinationofsomeinteractiveparts.Itabsorbsenergyfromthemoving part and slows down the vehicle with the help of friction.

FunctionsofBrakeSystem:

Thefunctionofthebrakesystemistostop thevehiclewithinthesmallest possibledistanceandhencethisisdonebyconvertingthekineticenergy of the vehicle into the heat energy which is dissipated into the atmosphere.

## TypesofBrakeSysteminAutomobile:

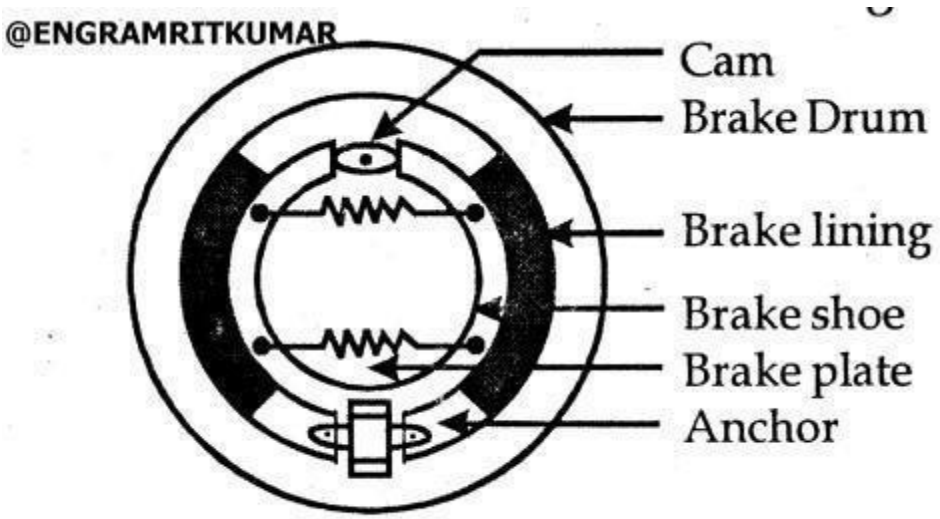
Thebrakesysteminanautomobilecanbeclassifiedintothesefollowing categories:

- MechanicalBrake
- DiscBrake
- HydraulicBrake
- Power-assistedBrake
- AirBrake
- Electricand
- HandbrakeSystem

Letmegothroughallthesebreaksystems.

MechanicalBrake:

Themechanicalbrakeisusedinsmallpowerautomobileslikescooters, motorcyclesandsomemodernvehicles.Thefigureofthemechanical brake is shown below:



Mechanical Brake

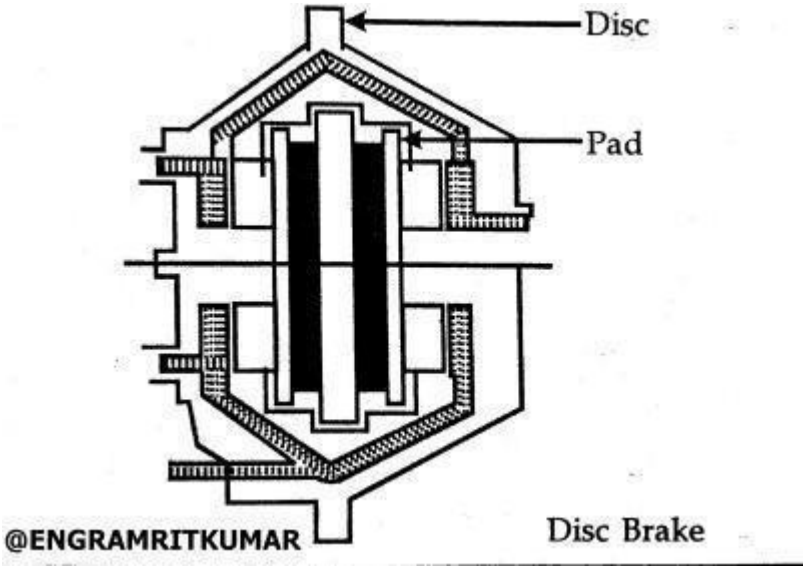
As the brake pedal is pressed cam rotates, which pushes the brake shoesoutwardsandhencebrakeliningprovidedontheoutersurfaceof the shoesrubagainstrotatingthedrumandhenceslowdownor stopsthe vehicles because the drum is connected to the wheels.

Asthepedalisreleased,due toretractingspringforceshoesreturntoits original position.

DiscBrake:

Thediscbrakeisusedinmotorvehiclesandcars,etc.

Whenthepedalispressedpistonpushesthepadbythepressureofthe hydraulic fluid. The diagram is shown below:



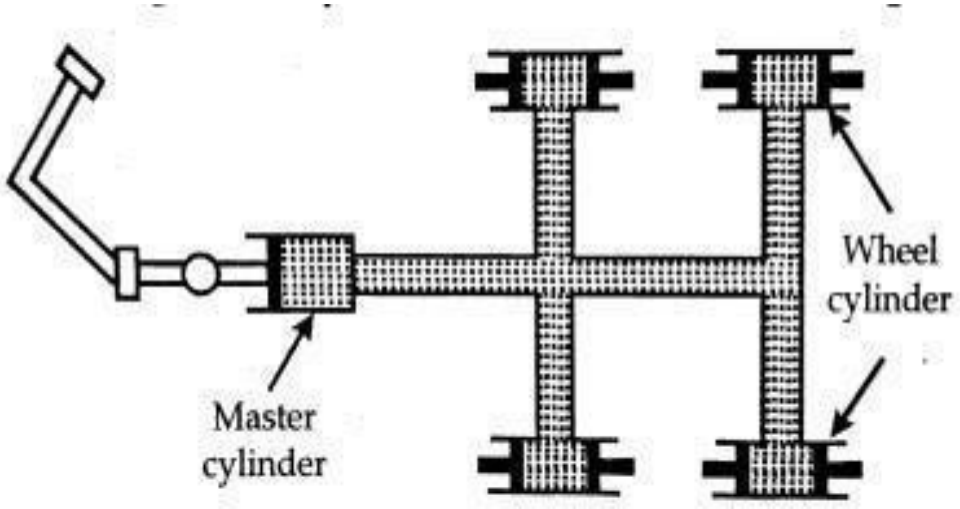
Disc Brake

Thesefrictionpadrubagainsttherotatingdiscconnectedtothewheelsof the vehicle and thus braking takes place.

Andasthepedalisreleasedfrictionpadreturnstoitsoriginalposition between the pressure of hydraulic fluid reduces.

HydraulicBrake:

Hydraulic brake works on the principle which is based on Pascal's principle,whichstatesthat"confinedliquidtransmitspressurewithoutlossin all direction".




Thisissimple inconstruction and hasanequal brakingeffort to all wheels and smooth operation.

Whenthebrakepedalispressed,fluidfromthemastercylinderentersintothe wheel cylinders through pipelines by the force of the piston.

Duetotheliquidforce,thepistonofthewheelcylinderpushesoutward which pushes the shoes outward.

Liningrubagainstthedrumandhencebrakingtakeplace.

Now whenthe pedal isreleased,the piston ofthe mastercylindermoves backwardandfluid fromthewheelcylindermovestothemastercylinder through the check valve.

Thistypeiscommonlyusedinallcarsetc.

---

Master Cylinder:

Themastercylinderistheheartofthehydraulicbrakesystem. It

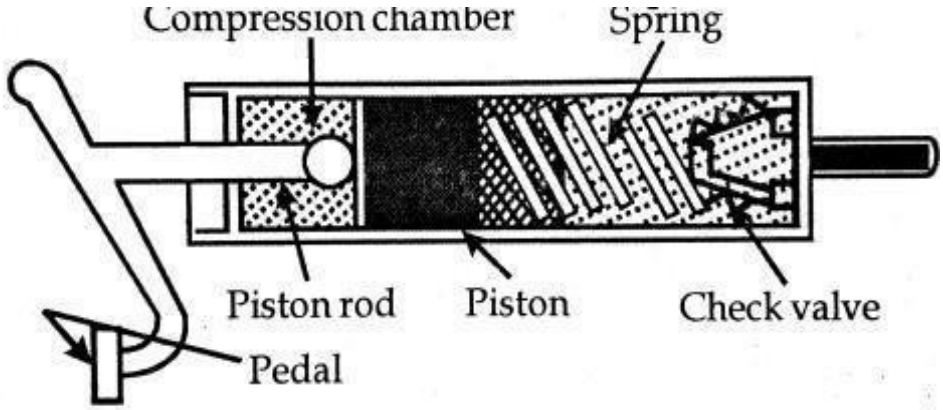
consists of two chambers:

- Thereservoir.
- Compressionchamber,inwhichpistonreciprocates.

The piston is connectedtothe brake pedal through the pistonrod. From thereservoir,fluidentersthecompressionchamberthroughthepartsas shown.

Themastercylinderisconnectedtothewheelcylinderthroughthepipe.

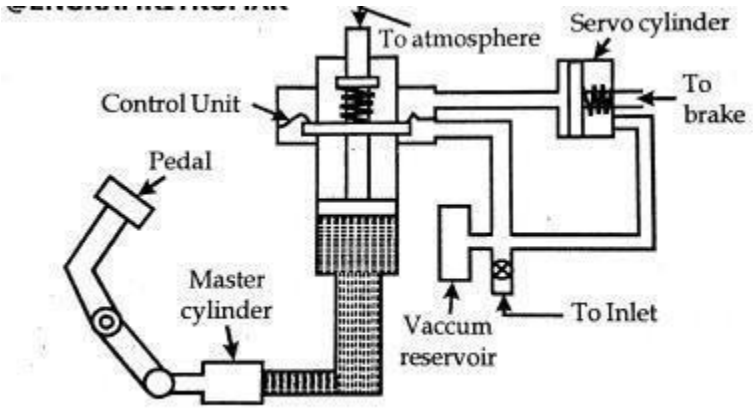
Thecheckvalveisprovidedinordertogivepassageforenteringfluid fromthewheel cylindertothemastercylinderwhenthepedalisreleased.




Master Cylinder

Power-assistedorVacuumbrake:

Thelinediagramindicatestheconstructionofapower-assistedorvacuums brake as shown below.




Power Assisted Brake

Asthebrakepedalispressed,thefluid pressurecausestheuppervalveof a control unit to open and lower the valve to close.

Thusleftthesideoftheservocylinderpistonisexposedtoatmosphereand vacuum acts on the right side, which causes the braking effort.

Brakingtakesplacebysuctionfromtheengineinletmanifold.

AirBrake:

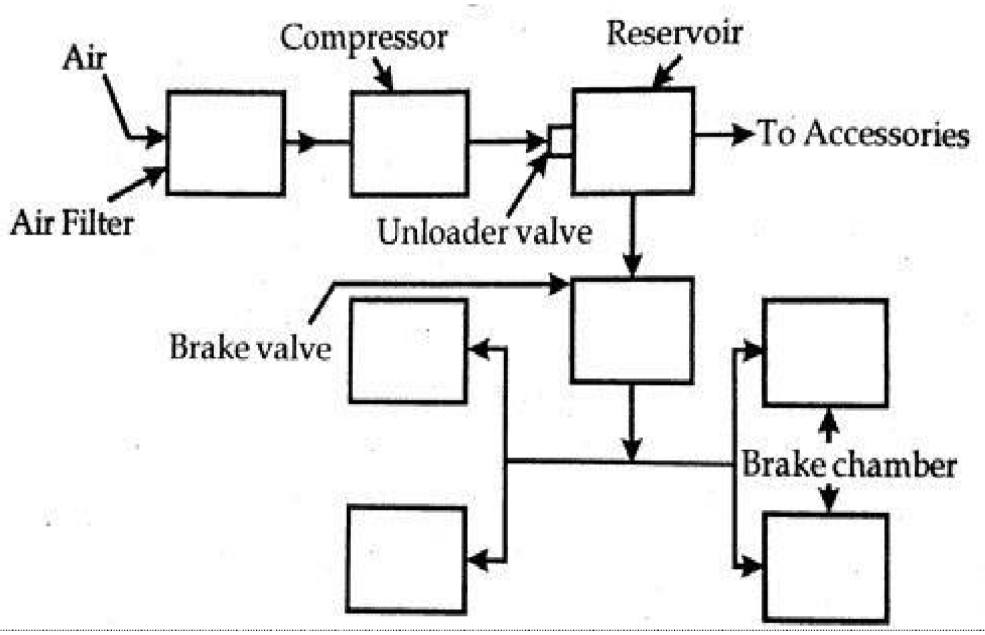
Thistypeofairbrakesystemiscommonlyusedinheavyvehiclessuchasbuses, trucks, etc.

Inthisalsowhen thebrakepedalispressed,airtoatmosphereenterstheCompressorthroughtheairfiltertothereservoirthroughunloadervalue.

Fromunloadervalveairenterbrakechamberthroughbrakevalve.

Brakevalveisfittedinordertocontroltheintensityofbraking.Thus braking takes place.

Whenthepedalispressedshoesreturntoitsoriginalthroughpositionthrough the spring force.



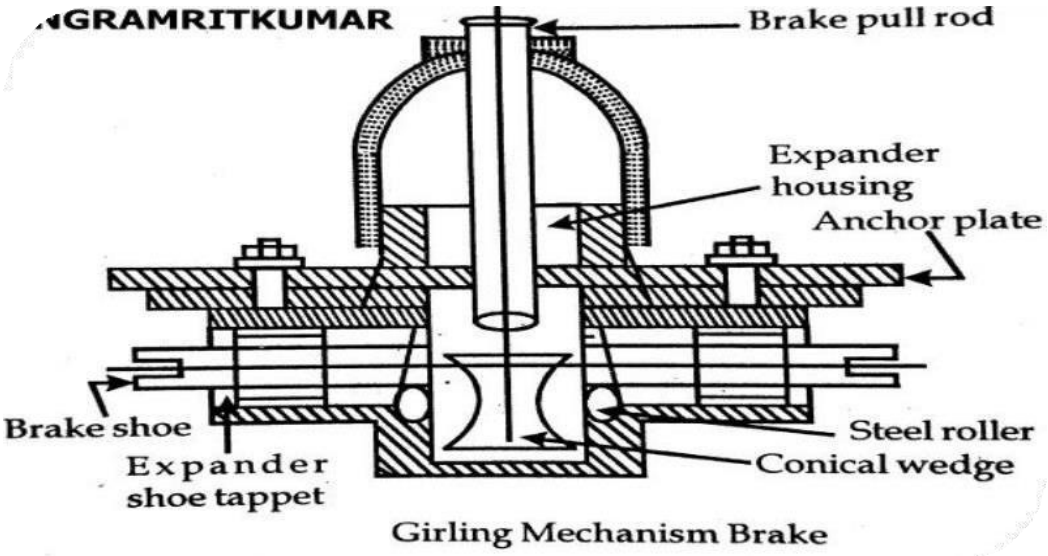

GirlingMechanismBrake:

Thissystemconsistsofanexpanderusedforbrakingandadjusterunitto adjust the brake shoes when desired.

Asthebrakepedalispressed,thepullsrodofexpanderpulledoutwhichpulls out the conical wedge.

Thebrakeshoeconnectedtotheconicalwedgethroughplungerand steel roller ball pulls outward. Thus braking the wheel.

Whenthepedalisreleased,springforce bringsthebrakeshoetoits original position.It requiresless friction. Without jacking up vehicles brakes can be adjusted.



Girling Mechanism Brake

ElectricalBrakeSystem:

Theprincipleofworkingofthistypeofbrakeistoutilize theelectromagneticforceonthebrakeshoes.

Itconsistsofanelectromagnet,armaturedisc.

Anelectromagnetismountedonthebackplateandarmaturediscisfed to the drum.

Thisissimpleinconstruction.

Forworking,electriccurrentforthebatteryisutilizedtoenergizethe electromagnetwhichactuatesthecamsthatexpandstheshoes.Thus braking the wheel.

HandbrakeSystem:

Handbrakesortheparkingbrakesoperateindependentlyofthefoot brakes.

Theseareusedforparkingonslopesor whilewaitingattrafficlights, where the handbrake function is mainly to minimize accidents.

Thisbrakeisappliedafterthefootbrakeisapplied.

Thesearemechanicalbrakes.

Apartfromthehydraulicbrakingsystem,allcarshaveamechanical handbrake acting on two wheels - usually the rear ones

Thehandbrakegiveslimitedbrakingifthehydraulicsystemfailscompletely, but its main purpose is as a parking brake.

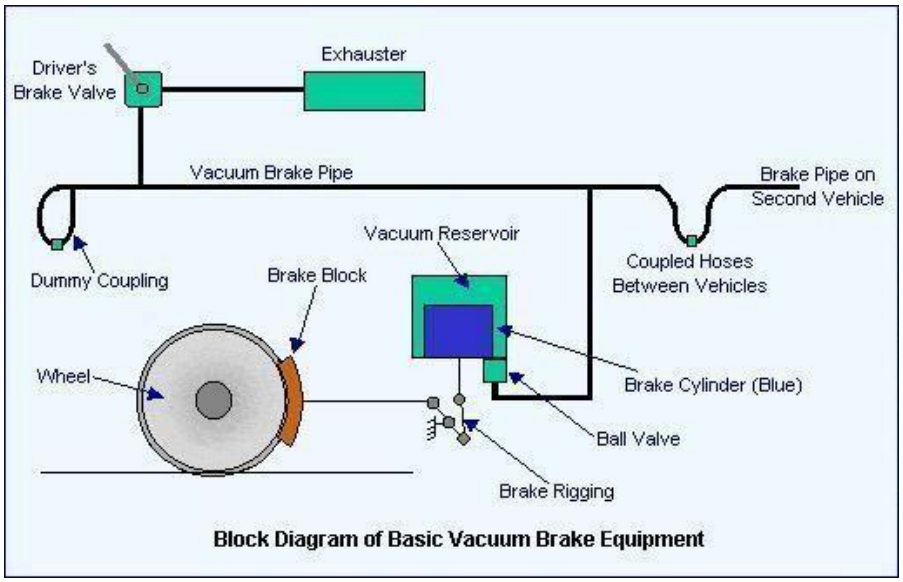
The handbrake leverpullsa cable or pair of cableslinkedtothe brakes by asetofsmallerlevers,pulleys,andguideswhosedetailsvarygreatlyfrom car to car.

Aratchetonthehandbrakeleverkeepsthebrakeononceitisapplied.Apush-button disengages the ratchet and frees the lever.

Ondrumbrakes,thehandbrakesystempressesthebrakeliningsagainst the drums.

Discbrakessometimeshaveacomparablehandbrakearrangement,but becauseitisdifficulttoplacethelinkageonacompactcaliper,theremay be a completely separate set of handbrake pads for each disc.

## PrincipalPartsoftheVacuumBrakeSystem



Block Diagram of Basic Vacuum Brake Equipment

**1) Driver'sBrakeValve:**

driver controls the brake using this. It has the following positions: "Release", "Running", "Lap" and "Brake On"."Neutral" or "Shut Down" positions are also available which locks the valve out of use. he "Release" position connects the exhauster to the brake pipe and switches the exhauster to full speed. This raises the vacuum in the brake pipe as quickly as possible to get a release. the exhauster keeps running but at its slow speed in the "Running" position. This ensures that the vacuum is maintained against any small leaks or losses in the brake pipe, connections and hoses."Lap"isused toshut offtheconnectionbetweentheexhausterandthebrakepipetoclose off the connection to atmosphere after a brake application has been made."Brake On" closes off the connection to the exhauster and opens the brake pipe to atmosphere.

2) Exhauster

Atwo-speed rotary machinefittedtoa trainto evacuate the atmospheric pressure from the brake pipe, reservoirs and brake cylinders to effect a brake release.

3) DummyCoupling:

a dummy coupling point is provided At the ends of each vehicle to allow the ends of the brake pipe hoses to be sealed when the vehicle is uncoupled.

4) CoupledHoses:

The brake pipe is carried between adjacent vehicles through flexible hoses.

5) VacuumReservoir:

a vacuum reservoir is provided on, or connected to the upper side of the piston to ensure there is always a source of vacuum available to operate the brake.

6) BrakeCylinder(showninblue):

The movement of the piston contained inside the cylinder operates the brakes through links called "rigging".

7) BrakeRigging:

the movement of the brake cylinder piston transmits pressure to the brake blocks on each wheel through this system.

8) BrakeBlock:

the friction material which is pressed against the surface of the wheel tread by the upward movement of the brake cylinder piston.

9) BallValve:

The ball valve is needed to ensure that the vacuum in the vacuum reservoir is maintained at the required level, i.e. the same as the brake pipe, during brake release but that the connection to the brake pipe is closed during a brake application.

## ADVANTAGES

- simpleindesign
- abilitytogetpartialrelease,somethingthepneumaticbrakecouldnot do without additional equipment
- greateramountofsafetybecausethevacuumlossageresultsinthe braking of the vehicle
- highlyreliableinthecaseofrailwagons
- Permitstheautomaticapplicationofbrakesdowntheentirelengthof the train from a simple control in the drivers hand
- vacuumbrakesarealsofailsafe sincethevacuumisusedforapplying the brake

## CONCLUSION

The vacuum brake was consideredpreferential to the air brake inrailroad applications largely because it was cheaper to install on a steam locomotive. Air brakes required a steam-powered compressor – bulky, noisy, unsightly and using a lot of power, while the vacuum ejector used to generate vacuum was a much simpler device. It has the advantage of being simple in design and of having the ability to get a partial release, something the air brake could not do without additional equipment.

# 3.0 IGNITION & SUSPENSION SYSTEM:

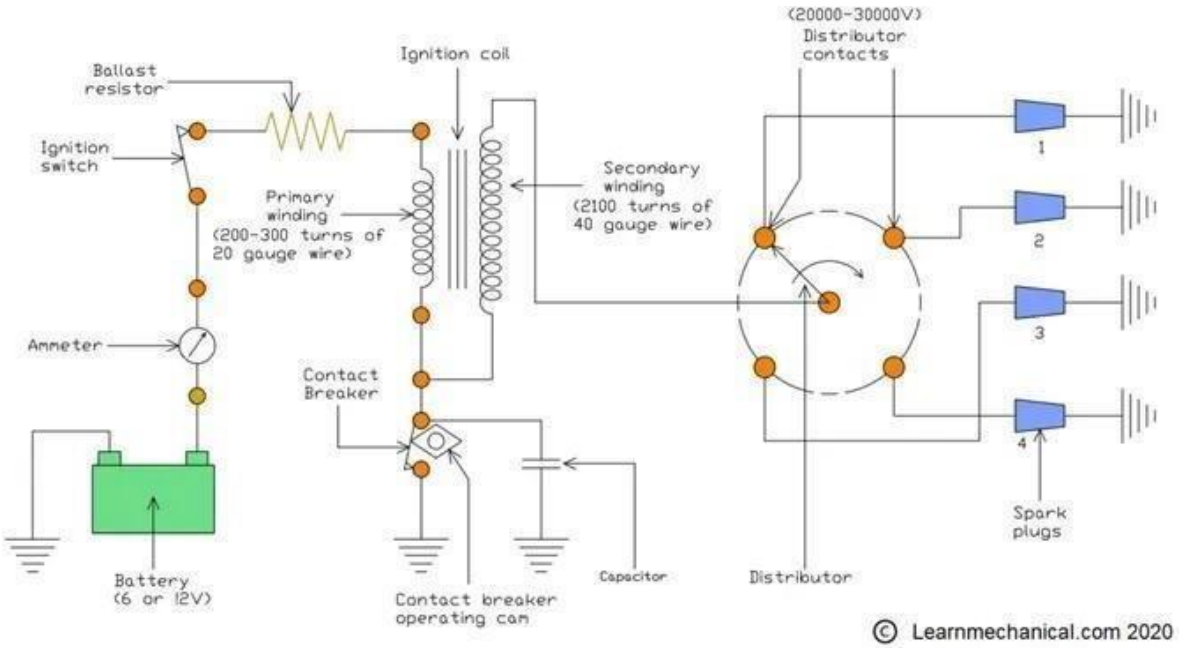
## DescribetheBatteryignitionandMagnetignitionsystem

AbatteryIgnitionSystemisusedinanautomobiletoproduceasparkin the spark plug with the help of a Battery. It is generally used in the 4-wheeler vehicle but nowadays it is also used in two-wheeler vehicles wherea6-voltor12-voltbatterysuppliesthecurrenttotheignitioncoil.

PartsofBatteryIgnitionSystem:

ThemaincomponentsofBatteryIgnitionsystemarelistedbelow:

1. Ignitionswitch
2. Battery
3. Ignitioncoil
4. Ballastresistor
5. Contactbreaker
6. Distributor
7. Capacitor
8. SparkPlug




DiagramofBatteryIgnitionSystem,LearnMechanical

## #1IgnitionSwitch:

ItisusedforONorOFFtheengine.Oneendoftheswitchisconnectedwiththe PrimaryWindingofIgnitionCoilviaBallastResistor,andanotherendis connected with the Battery.

Basically when the key is put inside it and turned the switch in ON position thenthecircuitiscompleted(CloseCircuit),andwhenmovedtowardstheOFF positionthanitsworkasanopencircuit.Nowadays,thisswitchisreplacedby the Push Button, and this system is called a keyless system.

## #2Battery:

The battery is provided for supply the initial current to the ignition system more specifically ignition coil. Generally, the voltage of the battery is 6V or 12Vor24V.Inanautomobilethere aretwotypesofBatteryusewidely,oneis lead-acidbatteryandanotheroneisthealkalinebattery.AlthoughthereareZinc Acid Battery and Lithium-Ion Battery is used in modern vehicles.

## #3Ignitioncoil:

ItisthemainjunctionoryoucansaythemainpartofBatteryIgnitionSystem.The main purpose of it is to step up battery voltage so that it is sufficient for generates the spark.

It is working as a step-up transformer, and have two winds, one is primary whichhavealesserturn,andtheotheroneissecondarywhichhaveahighernumber of turn.

## #4Ballastresistor:

ThisisusedtolimitthecurrentintheignitioncircuitandgenerallymadeofIron.Itis placed in series between the Ignition Switch and Ignition Coil. However,itisusedinoldautomobilevehicles.

## #5ContactBreaker:

Thecontactbreakerisanelectricalswitchwhichisregulatedbythecamand whenthebreakerisopen,currentflowsthroughthecondenserandchargesit.

## #6Distributor:

Itisusedinthemulti-cylinderengine,anditspurposeistoregulatesparkineach spark plugat the correct sequence.

Therearetwotypesofdistributors.

- CarbonBrushType
- GapType

**CarbonBrushType:**

ItisconsistofCarbonBrushwhichisslidesoverthemetallicsectionembedded in the distributor cap.

**GapType:**

In this type, the rotor arm is passed through the metallic section of the distributorcapbutitdoesnottouchthesurfaceofthedistributorcap.that'swhyitis called Gap Type Distributor.

## #7Capacitor:

A capacitor is a storing device where electrical energy is stored. It is fitted paralleltothecontactbreaker,whenthecurrentdropsthenitsuppliedthe additionalcurrentsothatthesparkisproduced.Itismadeoftwometalplates separated by air or any other insulating material.

## #8SparkPlug:

Spark Plug is another important part of Battery Ignition system. Here the actual Spark is generated for the combustion of Fuel or Charge.Ifthereismorethenonespark plugexiststheneachoneis connectedseparatelywiththedistributorandgivesthesparkinthe sequence.

## WorkingPrincipleofBatteryIgnitionSystem:

InBatteryIgnitionSystem,whenthe IgnitionSwitchisturnedon then thecurrentwillflowstotheprimarycircuitthroughballastregister, primary winding and contact breaker

The flowing current induced a magnetic field around the primary winding, the more current we supply the more magnetic filed will generate. At a certain time, the contact breaker opens the current is flowingthroughtheprimarywindingandfall.Thissudden fallof

currentgeneratesveryhighvoltagearound300Vintheprimary winding section.

Duetothisimmenseamountofvoltagethecapacitorcomesinto the charging state when the capacitor charged fully then it starts delivering the current towards the battery, due to this reverse flowingofthecurrentandalreadyinducedmagneticfieldinthe primary winding, a very high voltage of 15000 V to 30000 V is generated in the secondary winding.

This high voltage current then transferred to the distributor via high tension cable, where already a rotor rotates inside the distributor cap and has metallic segments embedded on it. So whenits start rotatingthenat a certainstageit opens thecontact breakerpointwhichallowsthehighvoltagecurrenttotransferredtothe spark plugs through the metallic segments.

Sowhenthehighvoltagecurrentreachesthesparkplugthen its generatesahighintensityofsparkinsidetheenginecylinder, which allows the combustion fuel to burn.

**AdvantagesofBatteryIgnitionSystem:**

ThesearethefollowingadvantagesofBatteryIgnitionSystem:

- Theintensityofsparkisgood.
- Itcanalsoprovideahighconcentrationofsparkeveninlow engine speed or starting of Engine.
- Themaintenanceofthisignitionsystemisveryless compared to others.

**DisadvantagesofBatteryIgnitionSystem:**

Thedisadvantagesare:

- Efficiencydecreasedwithareductioninsparkintensity.
- Occupiesmorespace.
- Efficiencydecreasedwithareductioninsparkintensity.
- NeedperiodicmaintenanceisneededforBatteryonly.

## ApplicationsofBatteryIgnitionSystem:

Hereistheapplicationofit:

- BatteryIgnitionSystemisusedinAutomobile(Car,Bus,Truckeven in the Bike) to produce the Spark so that Combustion fuel can be burned

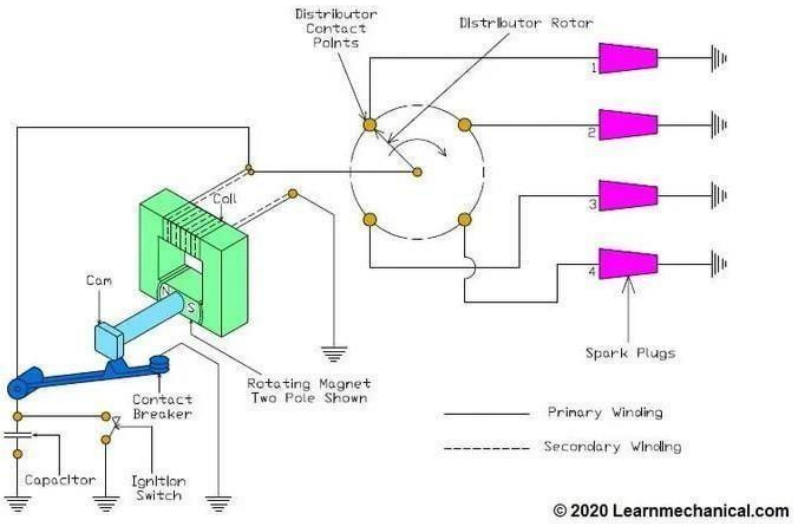
### MAGNETIGNITIONSYSTEM

Magneto ignition system is an ignition system in which magneto is used [produces high volatge] for the generation of electricity and further that electricityisusedinseveralthingsliketorunthevehicles.Thisisbasicallyusedin two-wheeler vehicles (Spark Ignition Engine) nowadays.

PartsofMagnetoIgnitionSystem:

ThemainpartsofMagnetoIgnitionSystemare:

1. Transformercore
2. ContactBreaker
3. Cam
4. Capacitor
5. IgnitionSwitch
6. Distributor
7. SparkPlug




MagnetoIgnitionSystem

#1Transformercore:

ThereareetwotypesofwindingwecanseeinMagnetoIgnitionSystem,those are:

1. PrimaryWinding:Themainfunctionofthiswindingistodrawthe power from the source.
2. SecondaryWinding: Thiswindinghasmore turnsof wire(the numberis1000ofturnsofwire)ascomparedtotheprimary winding.ThisisconnectedtotheDistributor(Whichishavinga rotor ).

#2ContactBreaker:

Thecontactbreakerisregulatedbythecamandwhenthebreakerisopen, current flows through the capacitor and charges it.

#3Cam:

CamisconnectedtotheNorthandsouthmagnet.#4

Capacitor:

Themainworkofthecapacitoristo Storethecharger.Thecapacitoris used here is a simple electric capacitor.

#5Ignitionswitch:

Worksforofandonthevehiclesandthisissettotheparallelofthe capacitor because it helps to avoid the damage of excessive air.

#6Distributor:

ThisisconnectedtothesparkplugandDistributorhavingtherotor.#7

Spark Plug:

ThemainworkofthesparkplugisfiringtheexplosivemixtureintheİCengine.

WorkingPrincipleofMagnetoIgnitionSystem:

IntheMagnetoIgnitionSystem,magnetoisused.Whentheengineofthe system starts,ithelpsthemagnetotorotateandthusit'sproducingthe energy in the form of high voltage then, one end of the magneto is grounded through a contact breaker, and the ignition capacitor is connected to its parallel.

Thecontactbreakerisregulatedbythecamandwhenthebreakerisopen, current flows through the capacitor and charges it.

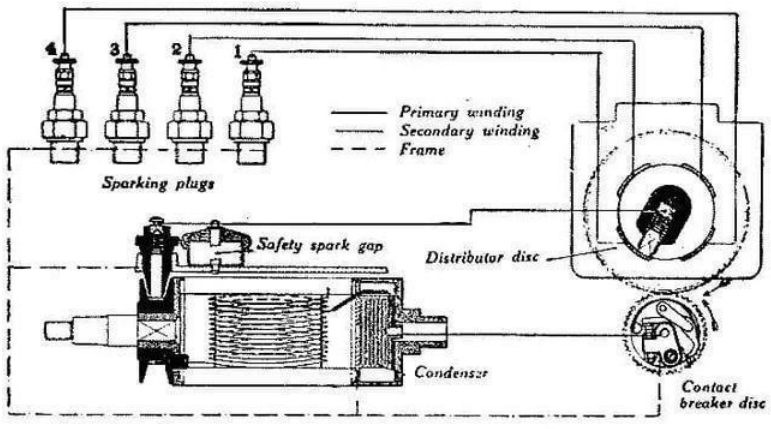
Nowthecapacitorisactingasachargernow,theprimarycurrentflowis reduced,thusreducingtheoverallmagneticfield,generatedinthe system.

Thisincreasesthevoltageinthecapacitor. Thisincreasedhighvoltagein the capacitorwillactasanEMFthusproducingthespark,attherightspark plug through the distributor.

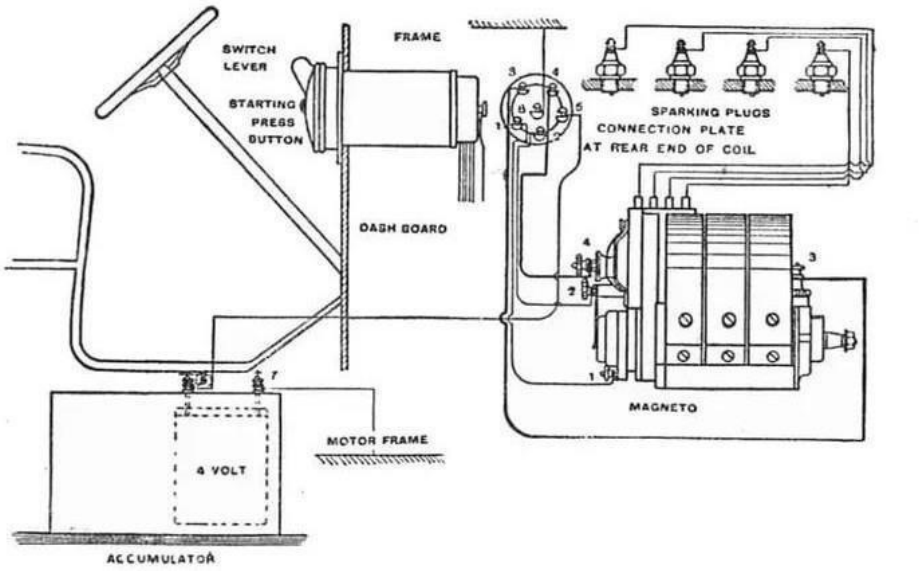
Andatthestartingstage,thespeedoftheengineislowandhencethe voltage generated by the magneto is low.

Butastherotatingspeedoftheengineincreases, it alsoincreasesthe voltagegeneratedbythemagneto thusthe flow ofthecurrentis also increased.

# SchematicDiagramofMagnetoIgnitionSystem:



## CircuitDiagramofMagnetoIgnitionSystem:




## ApplicationsofMagnetoIgnitionSystem:

MagnetoIgnitionSystemnowadayswidelyusedin:

- *Thissystemisusedforthegenerationofelectricity (IncaseofBatterysystemtheirBatteryisused)andtorun the vehicles.*
- Thisisbasicallyusedintwo-wheelervehicles(SI Engine) nowadays.
- Arotatingmagnetproduceshighvoltage.

.Andalsothisisusedinvariousplaceslike:Tractors, Outboard Motors, Washing Machines, Buses, Power Units, Marine Engines, and Natural Gas Engines.

AdvantagesofMagnetoIgnitionSystem:

ThesearethefollowingadvantagesofMagnetoIgnition System:

- Thissystemrequireslessmaintenanceascomparedto the Battery ignition system.
- Thisismoreusefulbecausenobatteryisused.
- Itoccupiesless space.
- Anelectriccircuitisgeneratedbythemagneto
- Nobatteryisneeded,sonoproblemofbattery discharge
- Efficiencyimprovesduetohigh-intensityspark.

Disadvantages of Magneto Ignition System:

Although there are some disadvantages:

- Duringstarting,thequalityofsparkispoorduetolow speed.
- Thisisalittleexpensiveascomparedtoanother ignition system.

SomeFAQ:
WhatisMagnetoIgnitionSystem?
The magneto ignition system is an ignition system in whichweusemagnetoforthegenerationofelectricity.How do magneto ignition systems work?
Whentheengineofthesystemstarts,ithelpsmagneto torotateandthusit'sproducingtheenergyintheform of high voltage. This increased high voltage in the capacitorwillactasanEMFthusproducingthespark,at the right spark plug through the distributor.
Whatarethe3typesofignitionsystems?The3-types of Ignition Systems are:
1. BatteryIgnitionSystem
2. MagnetoIgnitionSystem
3. ElectronicIgnitionSystem

# Sparkplugs:Purpose,constructionandspecifications

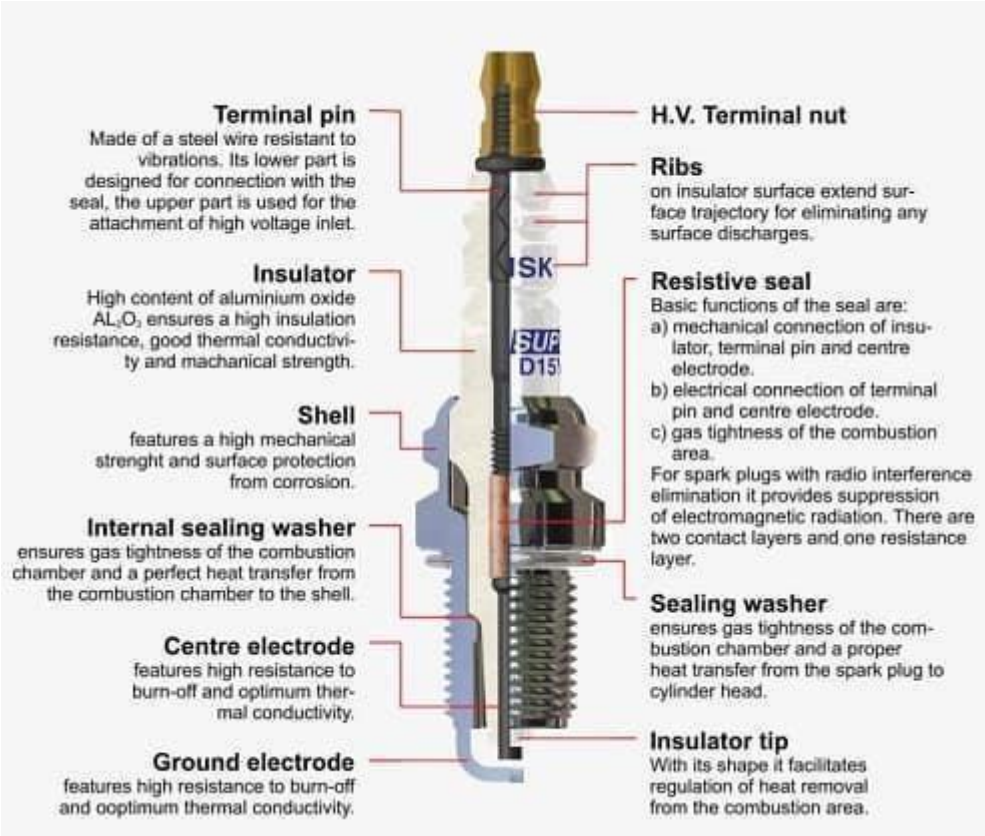
Asparkplugisanelectricaldevicethatfitsintothecylinder head of some internal combustion engines and ignites compressedaerosolgasolinebymeansofanelectricspark. Spark plugs have an insulated center electrode which is connected by a heavily insulated wire to an ignition coil or magneto circuit on the outside, forming, with a grounded terminalonthebaseoftheplug,asparkgapinsidethecylinder.

PURPOSEOFSPARKPLUG

1. Toignitetheair/fuelmixture.
Electrical energy is transmitted through the spark plug,jumping thegapintheplugsfiringendifthevoltagesuppliedtotheplugishigh enough. This electrical spark ignites the gasoline/air mixture in the combustion chamber.

2. Toremoveheatfromthecombustionchamber.
Sparkplugscannotcreateheat,theycanonly removeheat. The temperature of the end of the plug\'s firing end must be kept lowenoughtopreventpre-ignition,buthighenoughtoprevent fouling. The spark plug works as a heat exchanger by pulling unwanted thermal energy from the combustion chamber and transferringheat to the engines coolingsystem.The heat range ofaspark plugisdefinedasitsabilitydissipateheatfromthetip.

## CONSTRUCTION




sparkplugconstruction

1. Ribs-

Insulator ribs provide added protection against secondary voltageorsparkflashoverandalsohelptoimprovethegripofthe rubber spark plug boot against the plug body.

The insulator body is molded from aluminum oxide ceramic. In ordertomanufacturethispartofthespark plug,a high-pressure, dry moldingsystemisutilized.Aftertheinsulatorismolded,itiskiln- fired to a temperature that exceeds the melting point of steel. Thisprocessresultsinacomponentthatfeaturesexceptional dielectric strength, high thermal conductivity and excellent resistance to shock.

2. Insulator:

The insulator body is molded from aluminum oxide ceramic. In ordertomanufacturethispartofthespark plug,a high-pressure, dry moldingsystemisutilized.Aftertheinsulatorismolded,itiskiln- fired to a temperature that exceeds the melting point of

steel. This process results in a component that features exceptionaldielectricstrength,highthermalconductivityand excellent resistance to shock. Thepointershowsthesparkpluginsulator.Asmentionedabove,itis formed from aluminum oxide ceramic. The outer surface is ribbed to provide grip for the spark plug boot and to simultaneously add protection from spark flashover (crossfire).

3. Hex:
Thehexagonprovidesthecontactpointforasocketwrench. Thehexsizeisbasicallyuniformintheindustryandisgenerally related to the spark plug thread size.

4. Shell:
Thesteelshellisfabricatedtoexacttolerancesusingaspecial coldextrusionprocess.Certaintypesofsparkplugsmakeuseof a steel billet (bar stock) for shell construction.

5. Plating:
Theshellis almostalwaysplated.Thisenhancesdurabilityand provides for rust and corrosion resistance. The steel shell is fabricated to exact tolerances using a special cold extrusion processorinotherspecializedcases,machinedfromsteelbillet. Thehexagonmachinedontotheshellallowsyoutouseasocket wrench to install or remove the plug.

6. Gasket:
Certain spark plugs use gaskets while other examples are “gasketless.” The gasket used on spark plugs is a folded steel design that provides a smooth surface for sealing purposes. Gasketlesssparkplugsuseataperedseatshellthatsealsviaaclose tolerance incorporated into the spark plug.

7. Threads:
Sparkplugthreadsarenormallyrolled,notcut.Thismeetsthe specifications set forward by the SAE along with the International Standards Association.

8. Groundelectrode:
There are a number of different ground electrode shapes and configurations, but for the most part, they are manufactured fromnickelalloysteel.Thegroundelectrodemustberesistant tobothsparkerosionandchemicalerosion,bothundermassive temperature extremes.

9. Centerelectrode:
Center electrodes must be manufactured from a special alloy thatisresistanttobothsparkerosionandchemicalcorrosion. Keepinmindthatcombustionchambertemperaturesvary(and sometimes radically). The center electrode must live under these parameters.

10. Sparkparkelectrodegap:
The area between the ground electrode and the center electrode is called the gap. Center electrodes must be manufacturedfromaspecialalloythatisresistanttobothspark erosion and chemical corrosion.

11. Insulatornose:
There are a large number of insulator nose shapes and sizes available,butinessence,theinsulatornosemustbecapableof sheddingcarbon,oilandfueldepositsatlowspeeds.Athigher engine speeds, the insulator nose is generally cooled so that temperatures and electrode corrosion are reduced.

## WORKINGPRINCIPLE

The spark plug is connected to a high voltage source like the magnetoortheignitioncoilatoneend.Theotherendwiththetwo electrodes is immersed into the combustion chamber.
When current passes through the terminal and into the main centerelectrode,apotentialdifference(voltagedrop)iscreated betweentwoelectrodes.Thegasmixturethatoccupiesthegap between them acts as an insulator and thus the electricity doesn’tflowbeyondthetipofthecenterelectrode.

But as the voltage increases, the gases in the gap begin to get energized.Once the voltage increasesto the point thatcrosses the dielectric strength (resistance to conduct electricity) ofthe gases, they become ionized. Once the gases get ionized, they begin to act as conductors and permit the current to travel through the insulating gap. When the dielectric strength is crossed, the electrons begin to surge through that gap. This suddenmovementofelectronsrapidlyincreasestheheatinthat regionduetowhichtheybegintoexpandrapidlycausingamini explosion which results in the formation of a spark.

## TYPES

SparkPlugscanbeputintotwodifferentprimaryclassifications, based on their operating temperatures and based on their construction.

### *BasedonOperatingTemperatures*

Once the combustion process is completed in the combustion cycle, the heat generated needs to dissipate. The heat escapes through the exhaust gases, the cylinder wall of the engine and thesparkplugsurface.Basedontheoperatingtemperatureandlevel of heat dissipation, spark plugs can be classified into two types:

1. HotSparkPlug:
Ahotsparkplugoperatesinahighertemperaturerange.Ithas a lesser ceramic area which is used to insulate the heat. A hot spark plugdissipateslessercombustion heatand allows thetip and electrode to stay hotter. This ensures that any deposit accumulationisburnedoffandisn’tallowed tostay forlong.

2. ColdSparkPlug:
For high-performance engines that run hot by default, using a hot spark plug will cause pre-ignition. In extreme cases, it can alsoleadtothetipmeltingoff.Insuchcases,acoldsparkplugisused. Here the ceramic insulation area is higher and this it will

dissipate more heat. But on the flipside, it is prone to greater depositaccumulation.Besuretofollowyourinstructionmanualand use the correct type of plug recommended for your engine for optimum performance.

*BasedonMaterialUsed*SparkPlugsarefurtherclassifiedbasedonthe materialusedonthe ends of the electrodes.

Theyareof4types:

1. Copper-NickelType:
These are the most basic types of spark plugs. Here the center electrode is made of a copper-nickel alloy as copper on its ownisveryweakandwillmeltoffduetoengineheat.Nickelisaddedto strengthen the plug but even then these are the weakest typesavailable in the market.Theyare also required to bemade with a larger diameter and hence require more voltage for operation.

2. SinglePlatinumType:
These plugshavea smallplatinum disc on the tipof thecenter electrode. This platinum tip is exponentially stronger than a copper-nickelcoatingmakingthistypeofpluglastlongaswell.They are also less prone to debris build up.

3. DoublePlatinumType:
These plugshave platinum tips on both the center electrode and the side electrode. They spark up twice in the combustion cycle, oncebeforethecombustionandonceduringtheexhauststroke.The second spark is wasted and so this spark plug can only be used if your vehicle is equipped with a waste spark ignition type distributor.

4. IridiumType:
Thesearethebestsparkplugsavailableinthemarket.Herethetipof the center electrode is made of Iridium which is the

strongest out of nickel, copper, and platinum. Hence, they are theleastpronetodepositsanddamage.Theyalsohaveasmall sizedelectrodewhichrequireslessvoltageforoperationaswell. Iridiumplugsaremuchmoreexpensivethantheothertypesbutthen again you pay for what you get.

## Statethecommonignitiontroublesanditsremedies

### COMMONIGNITIONPROBLEMS

1

FAULTYIGNITIONCOIL,SPARKPLUG,ORSPARKPLUGWIRES

Anignitionissuecanbecausedbya faultyorfailingignitioncoil, spark plug, or spark plug wire set. These critical components of your ignition system keep your engine running smoothly. If they have a problem, you'll notice a rough ride, enginemisfires,andpossiblydecreasedgasmileage,alongwithin most cars, a Check Engine Light (CEL) for a misfire.

Oftentimes,replacingthefailedorfailingpartwillcorrectthisissue.

Ignitioncoilsandwiresetsarefairly straightforwardtoreplace. However,someapplicationswillrequireremovalofmajor components such as the upper intake plenum manifold. Referencearepairguideformorespecificinformationforyour vehicle.

Sparkplugsmayrequireabitmoreattention onsomevehicles. Somecanbevery easy togettoandreplace,whereotheronesarea long, complex job depending on their location. We have

a guide on replacingspark plugs.Some spark plugs need tobe gappedandhaveanti-seizeappliedbeforeinstallingandsome do not. Check the spark plug manufacturer's requirements.

Sparkplugsshouldalwaysbeinstalledwitha sparkplugsocket andtightenedtothepropertorque.Ifyouneedatorquewench.

## CRANKPOSITIONSENSORFAILURE

Anymodernignitionsystemthatdoesn'tuseadistributorhastohave a methodat which to determine the precisemoment to fire the ignition coils. To do this,a crank position sensor is used, whichisessentiallyamagnetictrigger.Attheprecisemomentin revolution, the sensor picks up a trigger point in the rotating crank,and sendssignal. When this sensor fails, this signalis lost. Sometimes, it the part fails completely and you have either a dead vehicle on the road, or a no-start situation. Other times, theproblemcanbeintermittent,leadingtomisfires,orstalling issues. In most cases, when this occurs, the vehicles engine computer will pick up a code for crank position sensors.

## CAMPOSITIONSENSOR

Likeit'scousin,thecrank positionsensor,acampositionsensor does the same thing on the engine's camshafts, or multiple camshafts.Thesedevicesreadthepositionofthecaminrespect to ignitiontiming,toeitheradvance(makethespark comeearlier) or retard (make the spark come later) in the stroke.

When a cam position sensor goes awry, you can experience much of the same issues – misfires, lack of power, poor gas mileage,orano-run/no-startsituation.Likemostsensors,it's also pickedupbythevehiclesenginecomputer,soifthere'safault, an engine code will pick it up.

4

## DISTRIBUTORPICK-UPCOIL/HALLEFFECTSENSOR

Very similar to a crank position sensor, in distributor-style ignitionsystemsthatdonotusebreakerpoints,eachdistributor hasapick-upcoil,orhalleffectsensor(samething)thatreadsa cogwheelinsidethedistributortoaccuratelypickupandtell the precise momentwhen to send a signal to the coil to fire.

When a pick up coil goes out, you generally have a no-start situation. Many people often think this is the ignition coil, but oftentimes,thepick-upcoilistheculprit.Changingthesecoilscanbe difficult, because often, the distributor must be completely removed to gain access to it.

5

## IGNITIONMODULE

Many vehiclesmadeinthelast10yearsnolongerusea proper Ignition Module, and instead house its function either in each individual coil, or in the vehicles onboard computer. Ignition Moduleswerethestandardformanyelectronicignitionsystems from the late 70's all the way through the early 2000's. Many foreign vehicles refer to the unit as a power output stage control,orignitioncontrolunit,butthey areall thesamething.

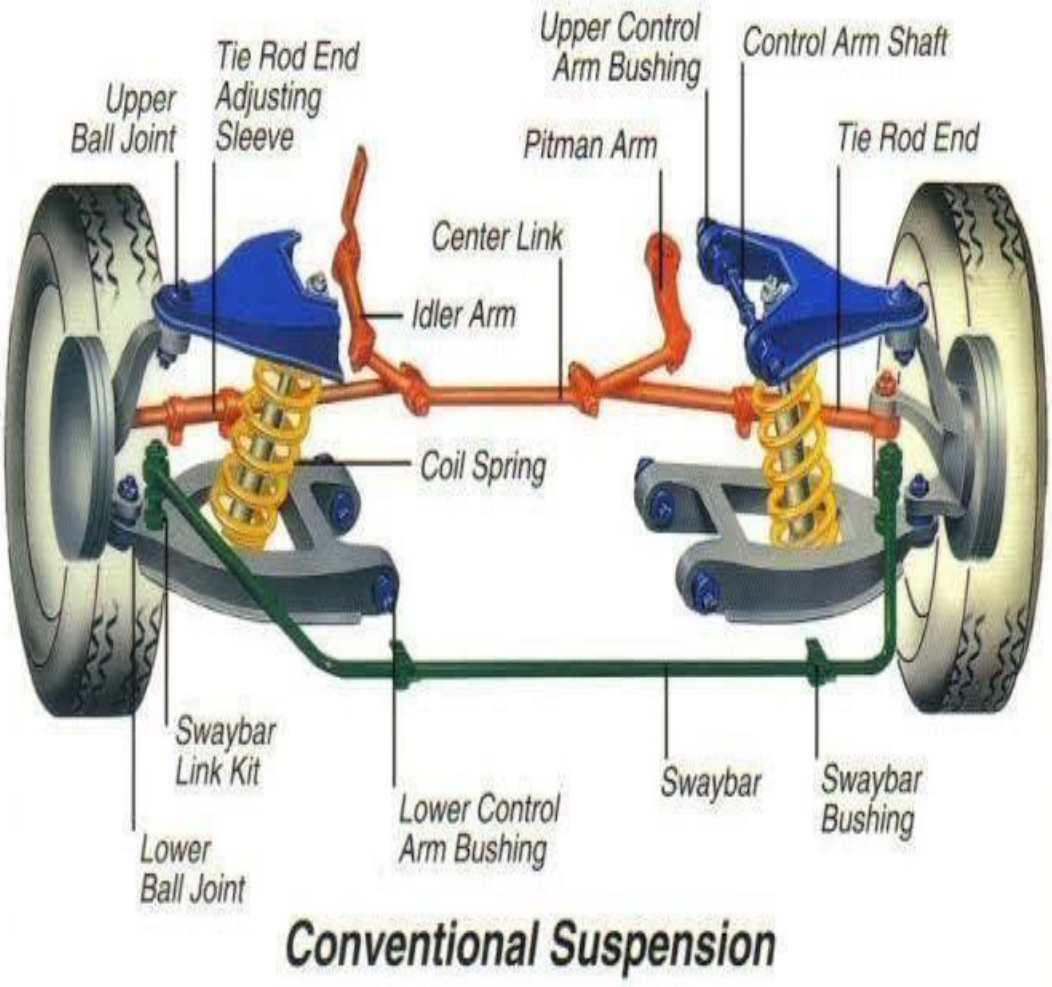
These devices help process the signal from a crank position sensororpick-upcoilinadistributorsystemanddistributethe signal of when the coil should fire. When they go out, you can haveamisfire,coilpacksnotfunctioningproperly,orano-run/no-start situation.

# Descriptionofthe conventionalsuspensionsystemforReara ndFront axle

Inthistype,wheelsaremountedon

thetwosidesoftheaxle.Leafspringorcoilspringismountedin between the chassis frameand axle. One end of the leaf spring is attached rigidly usually the front, and the other end is attached through a shackle as movable. The vibration is absorbedbythecompressionand expansionofleafspringwhile travelling over a road with bump and pit. Two ends of the masterleafareconnectedwiththekingpinandknuckle,sothat vibration transferred from one side to

another.Thesetypesofsuspensionsystemsaremostlyusedinrear wheels alone.




Advantages

1. Simpleindesign
2. Lowcost
3. Lessnumberofcomponents
4. Lessmaintenance

Disadvantages

1. Road shocks from one wheel is

transmittedtoanotherwheel.Ifthe

roadisirregular,thewholevehicle

leans on one side.

2. Asboththewheelsdonotgetupor

downsimultaneously,sothey will

rotate in different positions.

NoteDuetothegyroscopiceffectduringturning,wheelwobble orwheelshimmytakesplaceinawheel.Thisisaverydangerous problem.

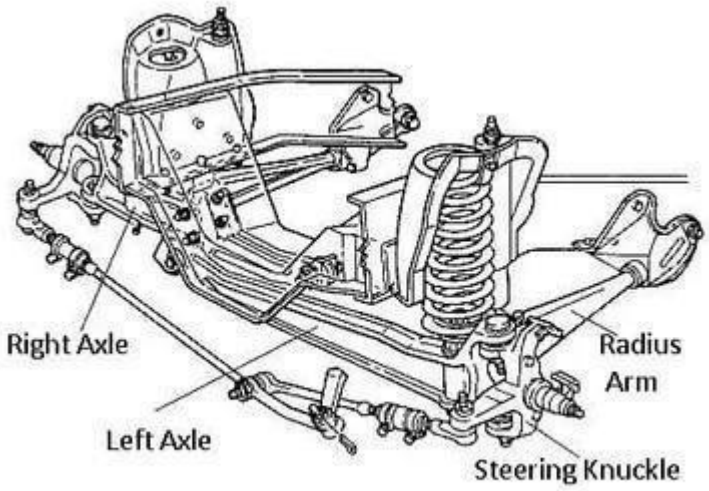
## Descriptionofindependentsuspensionsystem used in cars (coil spring andtensionbars)

Inthistypeofsuspension,eachfrontwheelisindependently supported byacoil,torsionbar,orleafspring.Mostofthepassengercarsnow use theindependent front suspension inwhich the coil spring system is the most common.

TypesofIndependentFrontSuspension

1. TwinI-BeamSuspensionSystem

Different types of front suspension, besides coil spring type, are also in use. The twin I-beam construction is another type, used on some models of Ford trucks. Each front wheel is supported at the end by a separate I beam.




**Twin I-Beam Front Suspension**

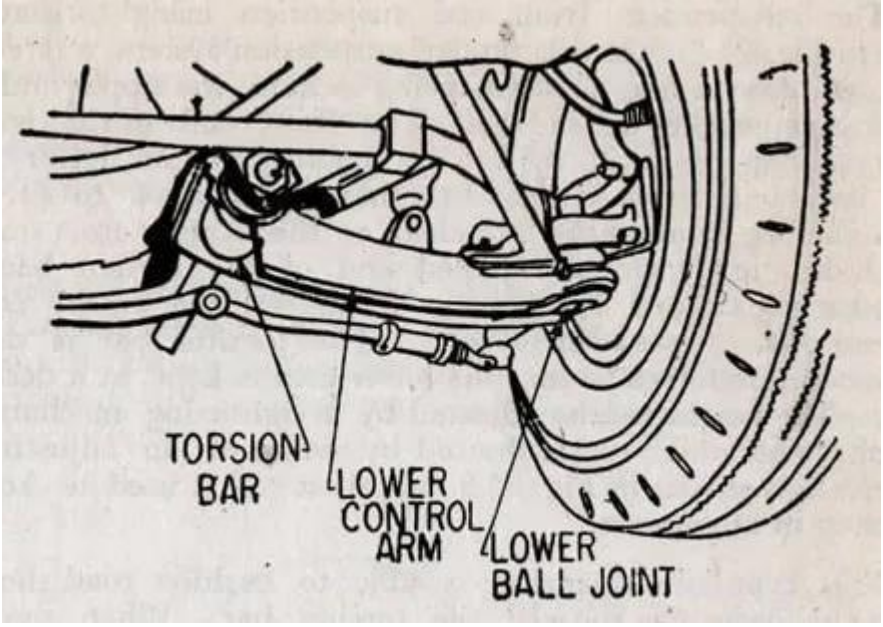
The ends of the I-beams are attached to the frame by pivots. The wheel ends of the two I-beams are attached to the frame by radius arms, which prevent backward or forward movement of the wheels. This type of suspension provides more flexibility.

2. SingleI-BeamFrontSuspensionSystem

Single I-beam front suspension is employed in larger vehicles. The I-beam has a hole in each end through which a kingpin is assembled to hold the steering knuckle in place. Each end of the I-beam is supported by a leaf spring.

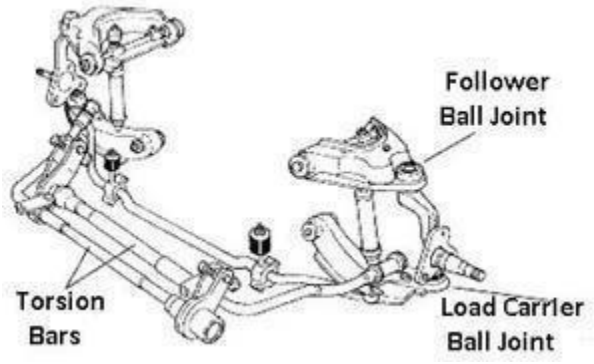
3. IndependentFrontEndSuspensionUsingTorsionBar

Thistype ofsuspension system, a steelrod, knownasa torsion bar,act as a spring to hold the upper and lower control arms parallelunder load. The front end of the rod is of hexagonal shape to fit tightly into an opening in the lower control arm.




Itsrearreactionisalsothehexagonalshapetofittightlyintoanopeninginan anchor attached to the frame cross member. A seal hides the hexagonally shaped end of the torsion bar.

Thetorsionbargetstwistedduetotheforcesonthewheelassembly outer end of the lower control arm. The torsion bar is designed to balancetheseforcessothatthelowerarm iskeptatadesignatedheight.




The height can be adjusted by a tightening mechanism at the anchor end which twistsithe rod by meansof an adjustingbolt and swivel.A strut rod is used to keep the suspension in alignment.

This suspension is able to protect road shock causing the lower arm to twist the torsion bar. When the wheels are no longer under stress, the arm returns to normal.

4. ParallelogramTypeIndependentFrontSuspension

The figure shows the simplified diagrams of the independent front suspensions using a coil, torsion bar and leaf spring. Basically, the system is known as parallelogram type independent front suspension. It consists of an upper and lower link connected by stub axlecarrier.

Ingeneral,the lower link islarger than the upper andthey may notbe parallel.Thisarrangementmaintainsthetrackwidthasthewheelsriseandfall and so minimize tyre wear caused by the wheel scrubbing sideways.

5. StruckandLinkTypeSuspensionSystem

Thistype of suspension system isunusually for integral body construction because the loading points are widely spaced. The normal top link is replaced by a flexible, mounting and the telescopic damper acts as the kingpin. This suspension system known as the Mac Pherson System has slight rolling action and absorbs shocks easily.

6. TrailingArmIndependentFrontSuspension

Trailing arm independent front suspension maintains constant track and wheel attitude with a slight change in wheelbase and caster angle. A coil spring is attached to the trailing arm which itself is attached to the shaft carrying the wheel hub. When the wheel moves up and down, it winds and unwinds the spring. A torsion bar has also been used in certain designs in place of the coil springs.

7. SlidingTypesSuspensionSystem

In this type suspension system, the stub axle can move up and down as wellasrotateintheframemembers.Track,wheelattitudeandwheelbase remain unchanged throughout the rise and fail of the wheel.

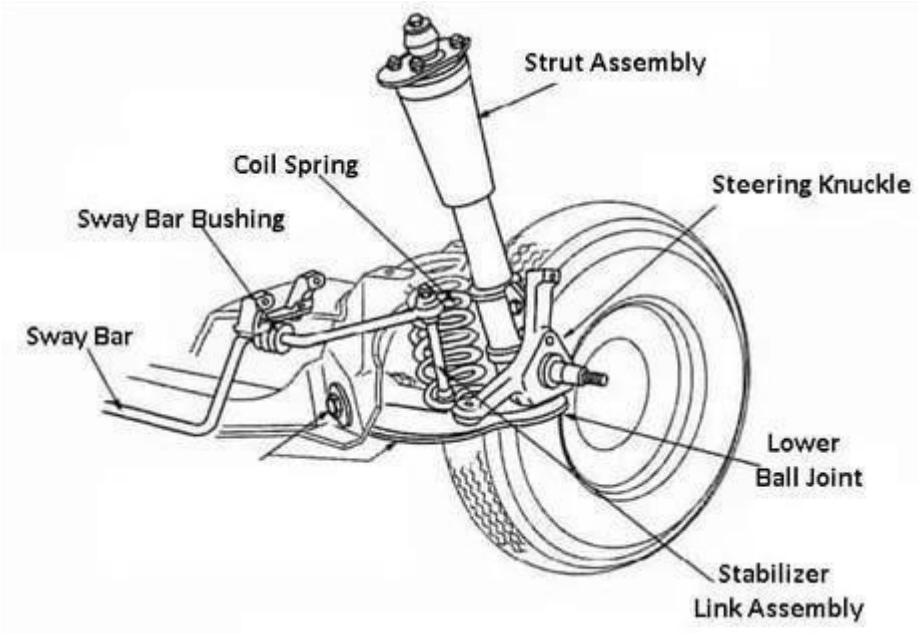
8. VerticalGuideSuspensionSystem

Inthe vertical guide suspensionsystem,the kingpinisattacheddirectly tothe cross member of the frame. It can slide up and down, thus compressing and expanding springs.

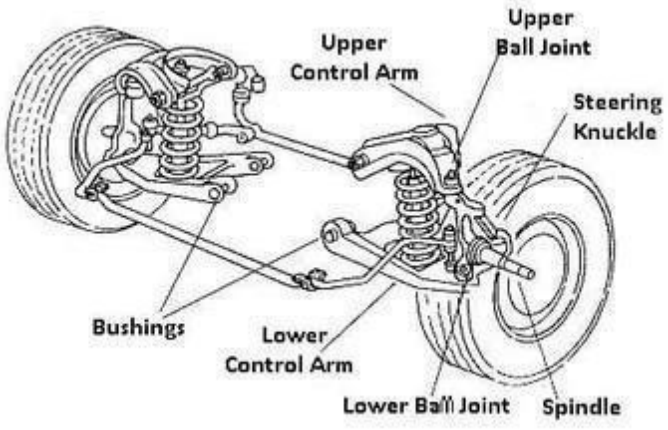
CoilSpringFrontSuspension.

Thereare3typesofcoilspringfrontsuspension.

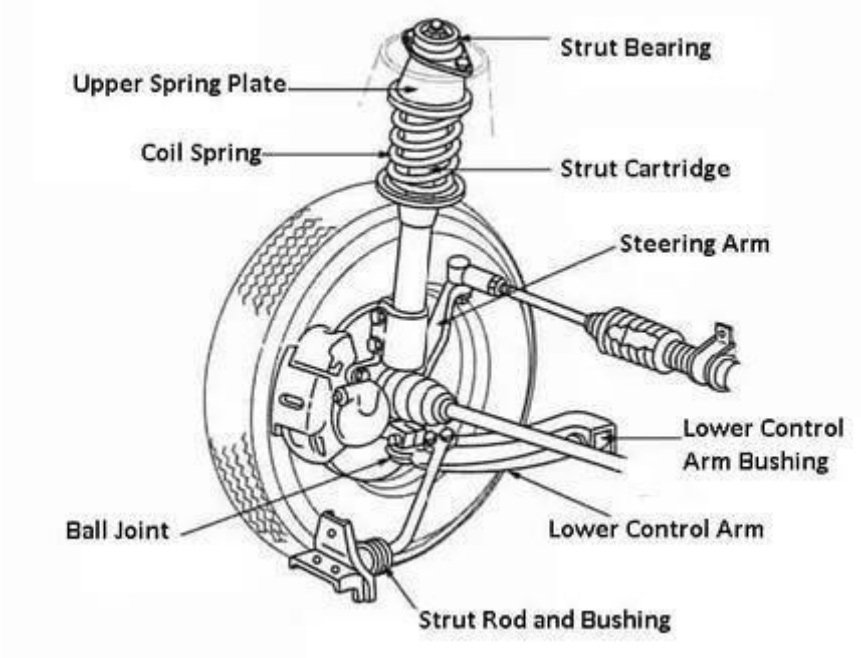
1. In the first type, the coil springislocated between the upper andlower control arms. The lower control arm has one point of attachment to the car frame.




2. In the second type, the coil spring is located between the upper and lower control arms. The lower control arms have two points to the attachment to the car frame.




3. In the third type, the coil spring is between the upper control arm and spring tower or housing that is part of front end sheet metal work.



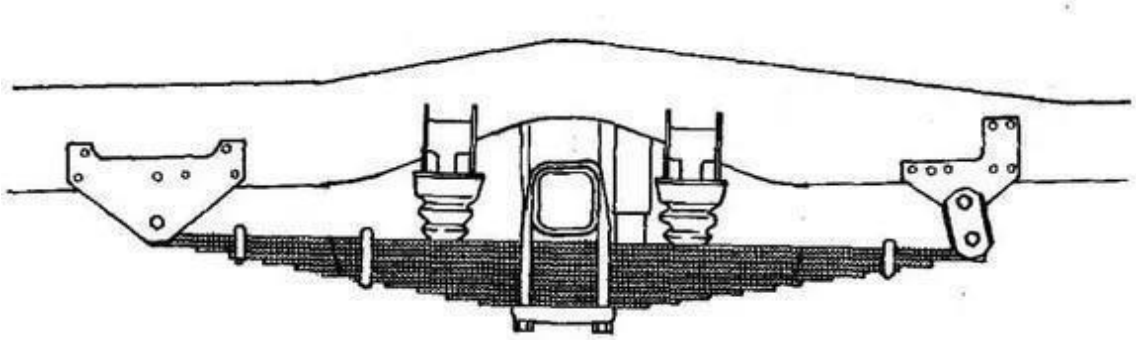

2. RearEndSuspensionSystem

Followingarethreetypesofrear-endsuspensionsgenerallyfoundinvehicles.

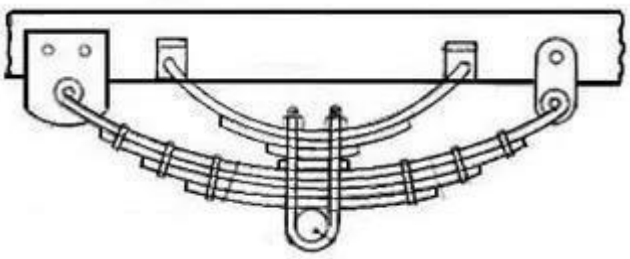
1. Longitudinalleafspringrearendsuspension
2. Transverseleafspringrearendsuspension
3. Coilspringrearendsuspension

LongitudinalandTransverseLeafSpringRearEndSuspension

Longitudinal leaf spring and coil spring rear end suspensions are widely used in modern vehicles. Transverse leaf spring rear end suspension is used in conjunction with the Hotchkiss drive, the leaf springs must be made strong and resilient enough to transmit the driving thrust and torque to resist sideways, in addition, to hold the spring weight of the body.

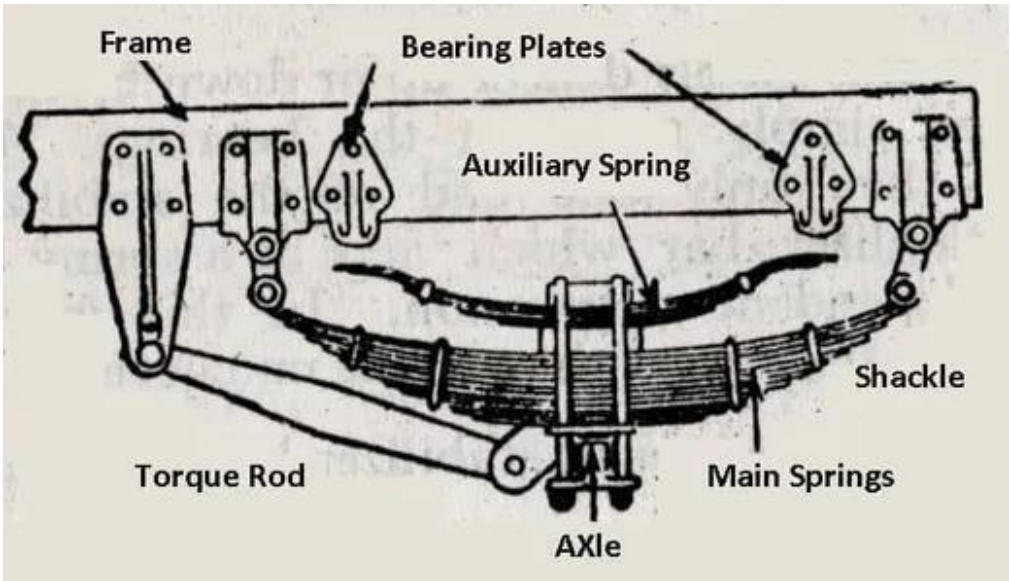


The spring weight is kept as less as possible, in order to improve the side of the vehicle. Because the springs do not generally support the wheels, rims, tyres, brakes and rear axles, the weight of these parts is called the spring weight. The spring is clamped the rear-axle housing by U-bolts, its every endispivoted to the frame, by meansofeyesformed in the endsof the longest leaf.



One end of the long leaf is secured to the front hanger by a bolt and the other end to the rear hanger by spring shackles. Both the hangers are bolted to the frame. The spring elongates in compression and shortens in expansion. This change in length of the spring is compensated by a shackle.

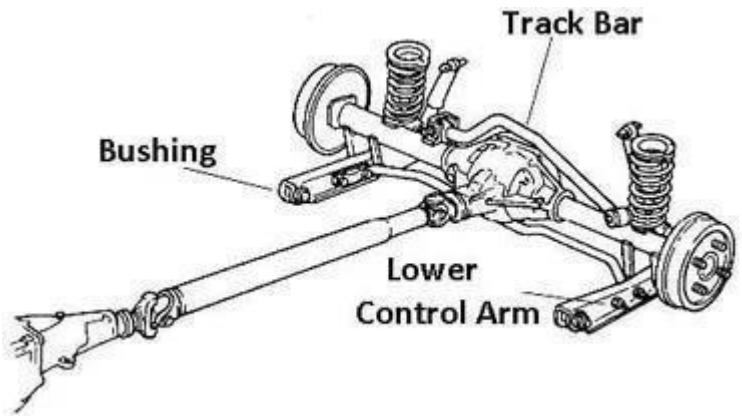
At the middle position of the spring length, the rebound clips are placed. They are loose enough to permit the leaves to slide on the other, and yet tightenoughtopermit theleavestogether whenthespringrebounds.The spring eyes are usually provided with bushings or some anti-friction material, such as bronze or rubber.



The figure shows a heavy-duty truck rear end suspension with leaf type auxiliary springs and torque rods. This type of suspension is used in truck intended for moresevere operations and withrear axleloadingexceeding 10000 kg. The figure shows rear-end suspension of a car with Hotchkiss drive.

CoilSpringRearEndSuspension

The figure shows coil spring rear end suspension. This type of suspension is always used in conjunction with torque tube, torque reaction link, or torque rod drive. Therefore the coil springs are not subjected to driving thrust or twist.

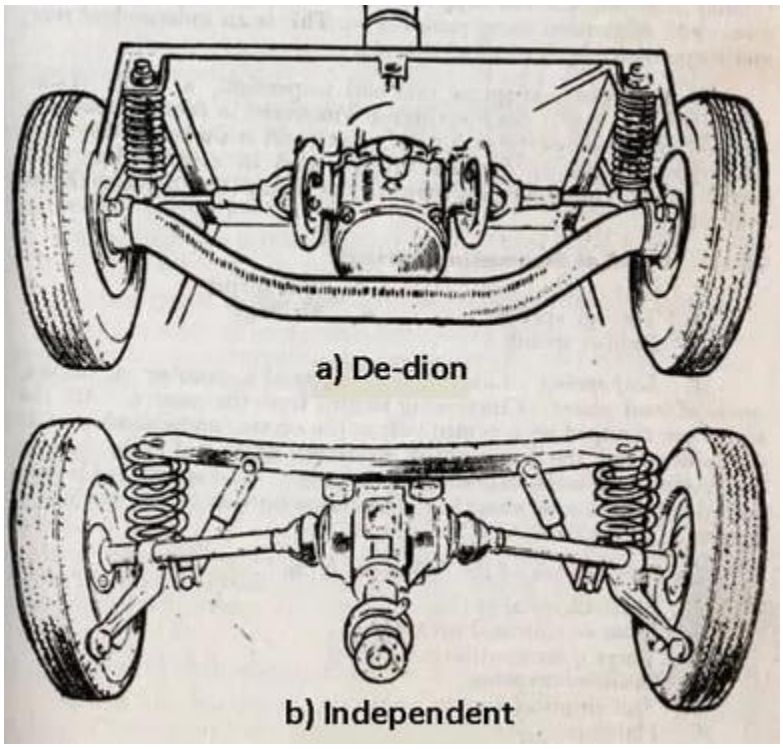



Stabilizers and radius rods are also used which relieve the coil springs of all stresses except those acting in a vertical direction. The stabilizer prevents excessive roll or sideways when the car is concerning.

Theradiusrodkeepstherearaxleandframeinlateral alignment.Thecoil springsareseatedinpan-shapedbracketsspringseatsattachedtothe rear axle.

De-DionandIndependentTypeCoilSpringRearEndSuspensions

The figure shows De-Dion and independent type coil spring rear end suspensions.At(A),the rigidDe-Diontubeislocatedlongitudinallyby two parallel links and laterally by a watt linkage. The tube maintains the track at a constant width.




It is to be noted that De-Dion suspension is not an independent suspension because a tubular axle connects and supports both the wheels.At (B)is shown a rear-end suspension using the radius arm. Thisis an independent rear end suspension.

In traverse leaf spring rear end suspension, a single transverse spring is used. Such springs are mounted in an inverted position parallel to and above the rear axle. Each end is shaken to the axle.

The transverse rear springs are always used in combination with torque-tube drive, and hence they do not carry the driving thrust and torque.

# Constructionalfeaturesandworkingofatelescopicshock absorber

## Functionofshockabsorber:

The shock absorber is a part of suspension system used as springing devicetocompromisebetweenflexibilityandstiffness.Itabsorbsthe energy of shock converted into the vertical movement of the axle by providing damping and dissipating the same into heat.

## Purposeofshockabsorber:

(i) Tocontrolthevibrationsonsprings.
(ii) Toprovideacomfortableride.
(iii) Toactflexibleandtoberigidenough.
(iv) Toresisttheunnecessarymotionofthespring.

## ConstructionofShockAbsorber:

Theuppereyeofthetelescopicshockabsorberisattachedtotheaxle andthe lower eye isattached to the chassis frame asshown in Figure 4.55. A two-way valve V1 is connected to a rod. Another one two-way valveV2isconnectedtothelowerendofthecylinder.Thefluidoccupies inthe space between above andbelow the valve VIand alsothe annular space between the cylinder and tube. A gland is provided on the head. Fluid scrappedoutbytherodisbroughtdownintotheannularspacethrough the inclined passage.

## WorkingofShockAbsorber:

Whenthevehiclecomesacrossabump,thelowereyewillmoveup.So,the fluid follows from the lower side of the valve V1 to the upper side. Due to less volume of the space above valve V1 than the volume of the rod, the pressure is exerted on valve V2 Thus, the damping force is producedbythispressureofthefluid.Thefluidwillflowfromtheupper side of thevalveV1tothelowersidewhenthelowereyemovesdownandfrom the lower side of the valve V2 to its upper side.
Whenacarabsorbsshocksfromtheroadsurface,thesuspensionspringswill compress and expand because the spring has the characteristic of continuing to oscillate for a long time of oscillation to stop. So, a riding comfort will be poor even the damp oscillation is supplied. Shock absorbers provide better road-holding characteristics and improved steering stability to tires.

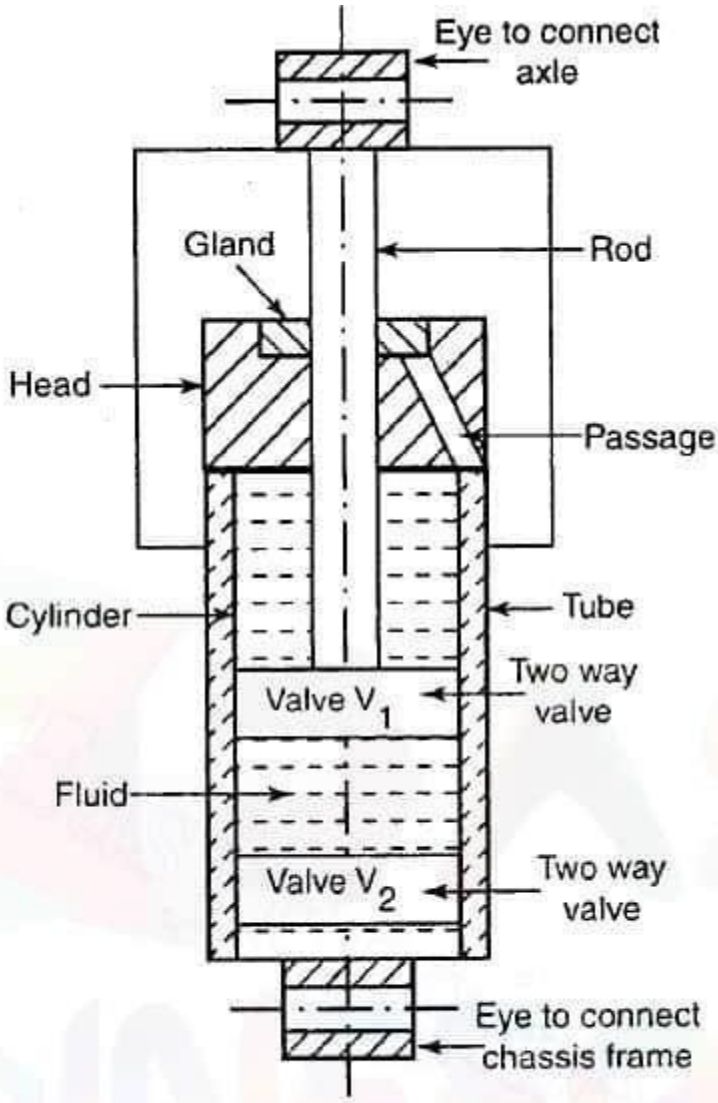



***Figure 4.55 Telescopic shock absorber***

telesco picshockabsorberdiagram

Thestrongeristhedampingforce,themorewillbetheoscillationsofthebody. But, the shock from the damping effect becomes greater than the strength of the stronger damping force. The damping force varies with the speed of the piston.

Typesofshockabsorbers:

1. Mechanicalshockabsorber(frictiontype)
2. Hydraulicshockabsorber.

Againthehydraulicshockabsorbersarefurtherdividedintovarioustypes.

1. Vantype
2. Pistontype

a. Single-acting
b. Doubleacting

3. Telescopictype.

Shockabsorber

## Advantagesoftelescopicshockabsorber:

1. Alargeamountofenergyisdissipatedduetoalargevolumeoffluid displaced without causing a high-temperature rise.
2. Thereisnowear development inthedamperwiththeabsenceof connecting arm pivots.
3. Theappliedforceisincreasedwhencomparedtotheindirect-acting type.Lowfluidpressureduetothefairlylarge pistonareaoccurswith reduced levers.
4. Theleakageisverylessduetolowerpressureandabsenceofthe rotating shaft entering the reservoir.
5. Thecostislessthansprings.
6. Noneedoftoppingupisnecessaryformostofthetelescopicdampers.

# 4.0 COOLING AND LUBRICATION:

## Enginecooling:Needandclassification

**TheEnginecooling system is one ofthenecessary thing that is present in the Internal Combustion Engine to reduce the temperatureofthecomponentsinsidetheengine.Italsohelpsto reduce the wear out of the component and provide smooth functioning and long life of the components.**
**WhataretheTypesofEngineCoolingSystems?**

Generally,therearetwotypesofthecoolingsystem,andthoseare:

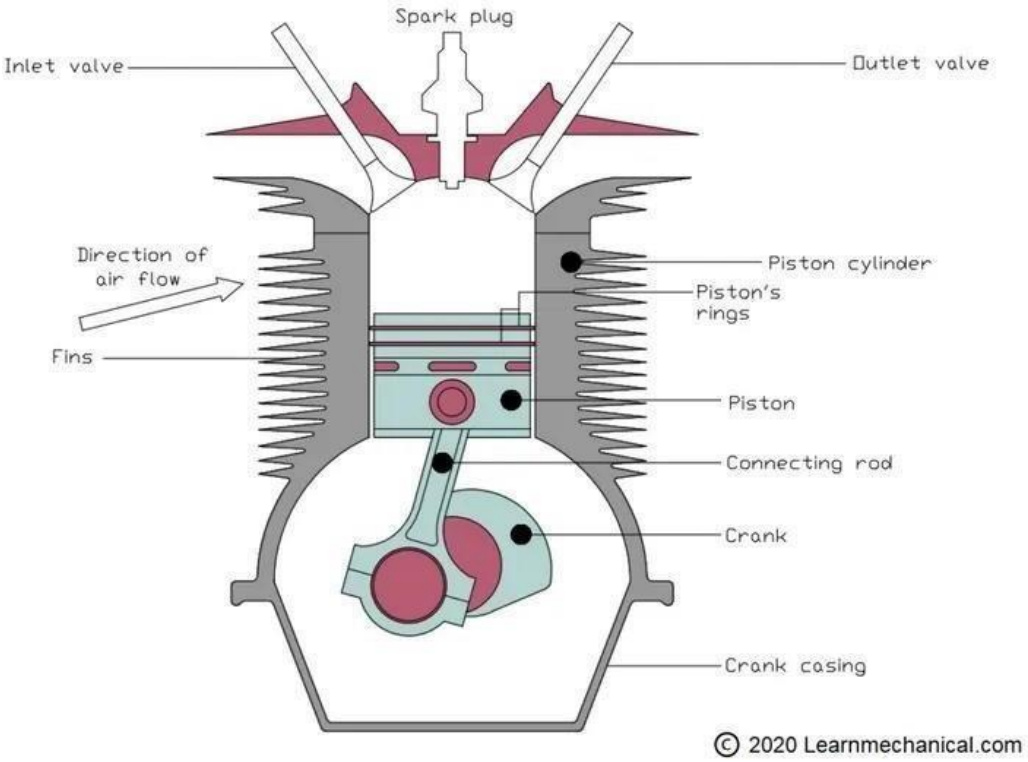
- AirCoolingSystem
- WaterCoolingSystem

**AirCoolingsystem:**

Inthissystem,theheatfromtheengineisdirectlydissipatedtothe atmosphere.

The Basic Principle of this type of system is to allow a flow of current through the parts from which heat is to be dissipated, whichdependsuponthesurfaceareaofmetalincontactrateof flowofair,atemperaturedifferencebetweenhotsurfaceandair.

AndSurfaceareaofmetalwillbeincreasedbyprovidingthefinsaround the cylinder which is made of copper or steel.




*Air-CoolingSystem*

**AdvantagesofAirCoolingSystem:**

ThesearesomeadvantagesofusingAirCoolingSystem:

- Lightinweight
- Noantifreezeisrequired
- Thissystemcanbeusedwherewaterscarcityisthere
- Simpleindesign
- Requirelessspace
- Notappingupofwater,etc.

**DisadvantagesofAirCoolingSystem:**

AirCoolingSystemalsohassomedisadvantages,andthoseare:

- Morenoiseinoperation.
- Thecoefficientofheattransferofairisless,henceless efficient in working.

**ExamplesofAirCooledEngine:**

- Itisusedinscooters,motorcycles,andtractor.

**WaterCoolingSystem:**

Thistypeisthemostcommonlyusedtypeofsystem.

In this system dissipation of heat is doneby the circulation of waterthroughthejacketsaroundthecylinderandpassesthishot waterthroughtheradiatorwhereairabsorbsheatfromthewater.

Therearetwotypesofwatercoolingsystem.

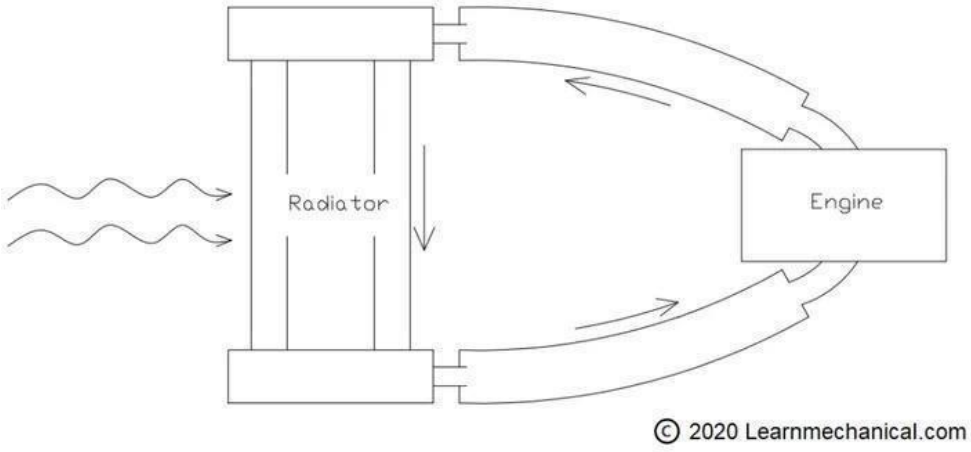
1. Thermosyphon
2. Pumpcirculationsystem

**ThermosyphonSystem:**

Thepumpisnotfittedinthissystem.

Circulationofwaterisdoneduetothedifferenceindensitiesbetween hot and cold water.

However, in this cooling system, the rate of cooling is low. Nowadaysitsusageislimitedbecauseweneedtomaintainthewaterto a certain level.It is simple in construction and cheap.




*diagramofThermosyphonSystem*

**WorkingofThermosyphonSystem:**

Thethermosyphoncoolingsystemoperatesontheprincipleofnatural convection.

Thermo-syphonwatercoolingsystemisbasedonthefactthatwater becomes light on heating and,

Thetopandbottomoftheradiatorareconnectedtothetopand bottom of the cylinder water jacket respectively with the help of pipes.

Theradiatoriscooledbycausingairtoflowoverit.Airflowisachievedby vehicle motion or a fan provided.

The heated water inside the cylinder water jacket becomes light andmovesoutoftheupperconnectionpipeintotheradiatorand travels downfromtheuppertanktothelower tank, andrejectingheat as it travels.

Thiscooledwaterfromthelowertankispassedintothecylinderwater jacket and hence circulated again for the process.

Thelimitationofthissystemisthatthiscoolingdependsonlyon temperature and is independent of engine speed.

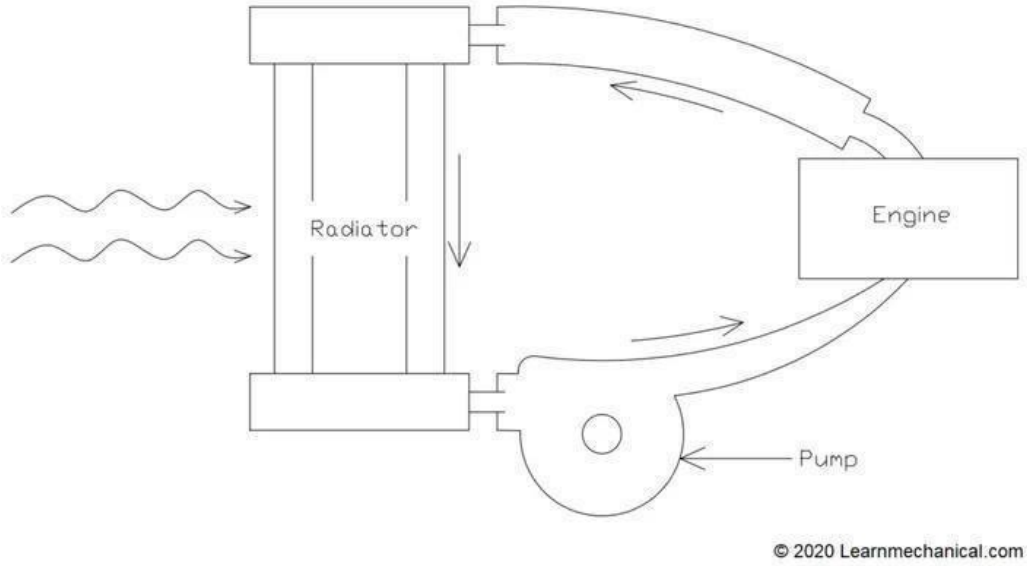
**PumpCirculationSystem:**

Inthiscoolingsystem,thecirculationofwaterisdonebyprovidinga centrifugal pump.

Duetothispump,therateofflowofwaterismore.

Hereradiatormaybefittedatanyplaceconvenienttothedesigner.The

pump is driven by a belt from a crankshaft.




*DiagramofPumpCirculationCoolingSystem*

**WorkingofPumpCirculationSystem:**

Inthissystem,thedirection ofcoolingwaterflowis upwardfrom the cylinderheadtothetoptankoftheradiator,thendownthrough the radiator core to the bottom tank.

Fromthe bottomtank,itmovesthroughthelower radiatorhose tothecylinderblockwaterjacketsbythehelpofthewaterpump,which circulates the water.

Waterenterstheengineatthecenteroftheinletsideofthepump.The

circulating pump is driven by a belt from the crankshaft.

Asenginespeedincreases,theflowofcoolantincreases.

**PartsoftheWaterCoolingSystem:**

Thesearesomemajorpartsofwatercoolingsystem:

- Radiator
- WaterPump
- Fan
- WaterJacketsaroundtheCylinders

- HosePipe
- ThermostatValve

**Radiator:**

RadiatorisaheatexchangerusedinaICEngine,itconsistoftwo tanks[oneriscalled uppertank,andotheroneislower tank]and buch of tubes connected to the both tanks.

Theuppertankisconnectedwiththeexitchannelof enginejackets viahosepipe,andbottomtankisconnectedwiththeentrychannelofthe cooling jacket via a water pump.

Thehotwatercomesfromtheenginecylinderfilledtheuppertank,from theuppertankwiththehelpofradiatortubesthehotwatercomes to the lower tank. By the time of following through thetubes the hot water is cooled by the flow of atmospheric air or sometimes a fan is fitted at the backside of the radiator.

Ingeneralradiatorsaremadeofthesemetarials:

- Castiron
- Mildsteel
- Stainlesssteel
- Aluminium
- Copper
- Brass

**WaterPump:**

Waterpump isusedfortheforcecirculationofwaterinsidethe engine. Thewaterpumpisdriven byabeltwhichisconnectedto the crankshaft.

**Fan:**

Fanisusedforblowingtheairthroughtheradiatortubes.Itisdrivenby the same belt which drive the pump.

**WaterJackets:**

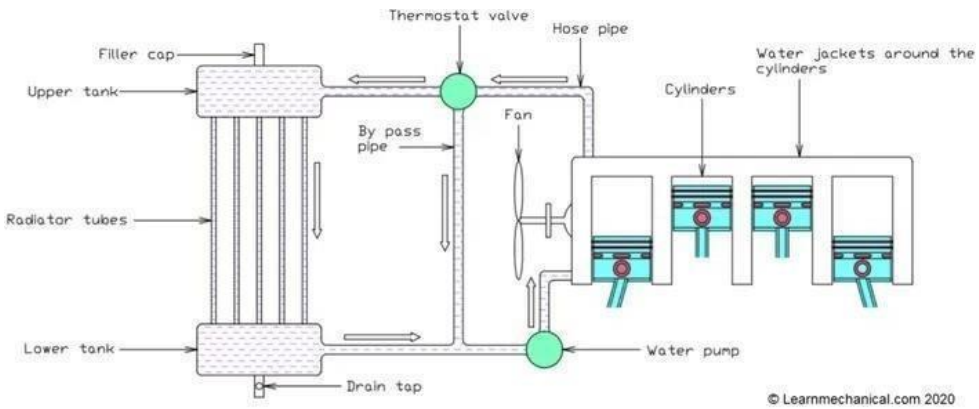
Itisfittedoutsidetheenginecylinder.Thesejacketsareusedfor trasffering the heat fromt he engine cylinder.

**HosePipe:**

Itisthepipeconnectedbetweentheengine'swaterjacketsand radiator.

ThermostatValve:

Thefunctionofthisvalveistorestricttheflowofwaterfromtheengine to the radiator. This valve design aswhen the water temperature inside the engine cylinder exceeds a certain value (Generally 70-degree centigrade)thenthevalveallowstheflowofwater,ifthetemperatureof the water inside the cylinder is below 70-degree centigrade then the valve restrict the flow of water.




*PartsofWaterCoolingSystem*

AdvantagesofWaterCoolingSystem:

ThesearesomeadvantagesofWaterCoolingSystem:

- Inthesetypesofcooling,weseeahighheattransferrate.
- Thistypeofcoolingsystemisusedwherethesizeorpowerofthe engine is more.
- ThermalConductivityismore
- Wateriseasilyavailable

- Liquidhasahighenthalpyofvapourizationsothate=theefficiency of water cooling is more.

DisadvantagesofWaterCoolingSystem:

ThedisadvantagesofWaterCoolingSystemismentionedbelow:

- Sometimecorrosionoccursinsidetheradiatororpipeorstorage.
- Duetoscalingheattransferrateisgoesdownafterthelongrun,so it needs regular cleaning and maintenance.

ExamplesofWaterCooledEngine:

- Allthemodernengines(Cars,Bus,Trucks,etc.)arenowadaysusethistype of cooling system.

# NecessityofCoolingSystem:

TheneedofcoolingsysteminanICEnginebecauseofthefollowingreason:

- During the operation of an engine, the temperature inside the engine cangoupto2500degreecentigrade(Source: HowStuffWorks),which isabovethemeltingpointofthecomponents usedtomake theengine. So we need to use the cooling system to dissipate the heat as much as possible.
- Asweknow,wealsoneedlubricationsystemtotheproperfunctioningofthe engine,butduetothehighheat,theproperty of lubricatingoilcanbe changed. That result seized of the engine. So to avoidthat we need to use a cooling system.
- Sometimesduetotheenormousheat,thermalstressinbuilt-upinsidethe engine, so to minimize the stress we need to keep the engine temperature as low as possible.

# Describedefectsofcoolingandtheirremedialmeasures

ExternalLeakage

1. Loosehoseclips.
2. Defectiverubberhose.
3. Damagedradiatorseams.
4. Excessivewearinthewaterpump.
5. Loosecoreplugs.

6. Damagedgaskets.
7. Leaksintheheaterconnectionorplugs.
8. Leakatthewatertemperaturegaugeplugs.

Internal Leakage

1. Defectivecylinderheadgasket.
2. Crackedcylinderwall.
3. Loosecylinderheadbolt.

Water Loss

1. Boiling.
2. Externalorinternalleakage.
3. Restrictedradiatororinoperativethermostat.

Poor Circulation

1. Restrictedinthesystem.
2. Insufficientcoolant.
3. Inoperativewaterpump.
4. Loosefanbelt.
5. Inoperativethermostat.

Corrosion

1. Excessiveimpurityinthewater.
2. Infrequentflushinganddrainingofthesystem.
3. Incorrectanti-freezemixture.

Overheating

1. Poorcirculationduetoanyreason.
2. Dirtyoilandsludgeinthesystem.
3. Radiatorfinschoked.
4. Incorrectignitionsystem.
5. Incorrectvalvetiming.
6. Lowoillevel.
7. Tightengine.
8. Engineoiltoothick.
9. Cloggedexhaustsystem.
10. Draggingbrakes.

Overcooling

1. Defectivethermostat.
2. Inaccuratetemperaturegauge.

# CoolingSystem:

If the middle combustion of the cylinder is not controlled, it will be impossibletoruntheengine.Receivesupto40%oftheheatandhelps the engineto run normally.
Therearetwomaintypesofcallingmethodusedtokeeptheenginecool.Such as

1. methodofcoolingwiththehelpofair
2. methodofcoolingwiththehelpofwater.

Coolingmethodwiththehelpofair:
Aircoolingenginesarecarsthatuseairtocooltheirengines.Suchas motorcycles, small engines, airplanes, etc.

Coolingmethodwiththehelpofwater:
Thewatercoolingsystemisusedincarsthatusewatertocooltheengine. The water cooling system is used in most of the cars in the world.

1. Radiator
2. Radiatorcap
3. Overflowline
4. Waterpump
5. Thermostatvalve
6. Reservebottle
7. Bypassline
8. Hosepipewater
9. Jacketreturnline

10. Cylinderhead

11. Crankcase

.

SomeimportantcomponentsofcoolingsystemarediscussedRadiator:


Radiator

It contains about 10 liters to 13 liters of water. This water should be completely clean. For example, rivers, rain, or mineral water should be given. tubewell water cannot be given because it contains a lot of iron. Tubewellwaterdestroystheradiatorcoreortubesinashorttime.Never drive withoutopeningtheradiatorcap.Theopeningpressure ofthiscapis0.5 to 0.9 bar.

Thermostatvalve:

It works a lot like a switch gate, meaning that the engineer controls the flowofwateraccordingtothetemperatureofthewaterflowingthrough thewaterjacket.Ifitisnotallowedtodrivethecar,thelifeoftheenginewillbe reduced. It starts at 74 degrees Celsius and opens completely at 90 degrees.

CoolingSystemProblemsAndSolutions

| S.N | Problems | Problems | Solutions |
|---|---|---|---|
| 01. | Theengineis overheated. | Firstofallyou have to test the cooling method.<br>Radiatorsare dirty or the tubes are jammed with dirt.<br>Thewater jacketisjammed with rusty dirt.<br>Thefanis broken or not working.<br>Loosenor loosenthepump | Cleaningor repair.<br>Needtobe cleaned.<br>Needto change.<br>Changeor tighten.<br>Needtoclean or change.<br>Clearor change.<br>Oilshouldbe given as required. |

| | | | |
|---|---|---|---|
| | | belt.<br>Hosepipe closed or bad.<br>The thermostatvalveis not working properly.<br>Theimpeller orshaftofthewater pump is broken.<br>The air cleanerisdirtyor obstructed.<br>Thereismoreor less engine oil.<br>Iftheinjector or nozzle is damaged.<br>Ifthetiming ofthefuelpumpis not correct.<br>Ifthecylinderga s kit leaks.<br>If the valve timingisnotcorrect. | Repairor replacement.<br>Thetiming needstoberight<br>Thehead bolts should be tightened well.<br>Andgasket timing must be correct. |
| 02. | Leakageand noise are created atthebaseof the water pump. | The seal on thewaterpumpmay be damaged.<br>Theshaftof the pump may break.<br>The pump bearingsmaybreak.<br>Pulihasloston e line. | Theseal needs to be changed.<br>Theshaft needs to be changed.<br>Thebearings needtobechanged.<br>Repairor replacement.<br>Repairor replacement. |

| | | | |
|---|---|---|---|
| 03. | Water leakage or water is reduced. | The radiator may have a top-downholeoracoreor tube hole.<br>Hose pipe holesorconnections may be loose.<br>Drain plug leakedordamaged.<br>Iftheradiatorcap is damaged or not.<br>Ifthehead gasket is bad.<br>Iftheenginebl ock is cracked. | The hole needstoberepaired or replaced.<br>Need to changeortighten well.<br>Need to repairorchange. Needtochange.<br>Needto change.<br>Need to repairorchange. |

# DescribetheFunctionoflubrication

Functionoflubrication:
Lubricationproducesthefollowingeffects:

(a) Reducingfrictioneffect
(b) Coolingeffect
(c) Sealingeffectand
(d) Cleaningeffect.

(a) Reducingfrictionaleffect:

The primary purpose of the lubrication is to reduce friction and wear between two rubbing surfaces. Two rubbing surfaces always produce friction. The continuous friction produce heat which causes wearing of parts and loss of power. In order to avoid friction, the contact of two slidingsurfacesmustbereducedasfar aspossible.Thiscanbedoneby properlubricationonly.Lubricationformsanoilfilmbetweentwomoving

surfaces.Lubricationalsoreducesnoiseproducedbythemovementof two metal surfaces over each other.

(b) Coolingeffect:

The heat, generated by piston, cylinder, and bearings is removed by lubricationtoagreatextent.Lubricationcreatescoolingeffectonthe engine parts.

(c) Sealingeffect:

Thelubricantentersintothegapbetweenthecylinderliner,pistonand pistonrings.Thus,itpreventsleakageofgasesfromtheenginecylinder.

(d) Cleaningeffect:

Lubricationkeepstheenginecleanbyremovingdirtorcarbonfrom inside of the engine along with the oil.

[1] Itshouldhaveahighviscosityindex.

[2] Itshouldhaveflashandfirepointshigherthantheoperating temperature of the machine.

[3] Itshouldhavehighoiliness.

[4] Thecloudandpourpointsofagoodlubricantshouldalwaysbelowerthan the operating temperature of the machine.

[5] Thevolatilityofthelubricatingoilshouldbelow.

[6] Itshoulddepositleastamountofcarbonduringuse.

[7] Itshouldhavehigheranilinepoint.

[8] Itshouldpossessahigherresistancetowardsoxidationandcorrosion.

[9] Itshouldhavegooddetergentquality.

*Lubricationtheory:*

Therearetwotheoriesinexistenceregardingtheapplicationoflubricants on a surface:

(i) Fluidfilmtheoryand
(ii) Boundarylayertheory.

(i) Fluidfilmtheory:

Accordingtothistheory,thelubricantis,supposedtoactlikemassof globules,rollinginbetween twosurfaces.Itproduces a rolling effect, which reduces friction.

(ii) Boundarylayertheory:

Accordingtothistheory,thelubricantissoakedinrubbingsurfacesand forms oily surface over it. Thus the sliding surfaces are kept apart from each other, thereby reducing friction.

# DescribethelubricationSystemofI.C.engine

**variouslubricationsystemusedforICenginesare,**

**(a) Mistlubricationsystem**
**(b) Wetsumplubricationsystem**
**(c) Drysumplubricationsystem**

### *(a) Mistlubricationsystem:*

-Usedwherecrankcaselubricationisnotsuitable– Generallyadoptedintwostrokepetrolengineline scooterandmotorcycle.Itisthesimplestformof lubricating system.
– It is thesimplest form of lubricating system. It does not consist ofanyseparatepart likeoilpumpforthepurpose of lubrication.
– Inthissystemthelubricatingoil ismixedintothefuel (petrol) while fillinginthe petroltank ofthevehiclein a specifiedratio(ratiooffuelandlubricatingoilisfrom12:1 to 50:10 as per manufacturers specifications or recommendations.
– Whenthefuelgoes intothecrankchamberduringthe engineoperation,theoilparticlesgodeepintothebearing surfaces due to gravity and lubricate then. The piston rings, cylinder walls, pistonpin etc. are lubricatedinthe

same way.
-If the engine is allowed to remain unused for a considerabletime, thelubricatingoil separates oil from petrol&leadstoclogging(blocking)ofpassages inthe carburettor,resultsintheenginestartingtrouble.Thisis the main disadvantage of this system.
-Itcausesheavyexhaustsmokeduetoburningoflubricating oil partially or fully
-Increasedepositsonpistoncrownandexhaustportswhich affect engine efficiency
-Corrosionofbearingsurfacesduetoacidsformation
-thoroughmixingcanfetcheffectivelubrication
-Enginesuffersinsufficientlubricationduringclosed throttle i.e. vehicle moving down the hill.

### *(b) Wetsumplubricationsystem:*

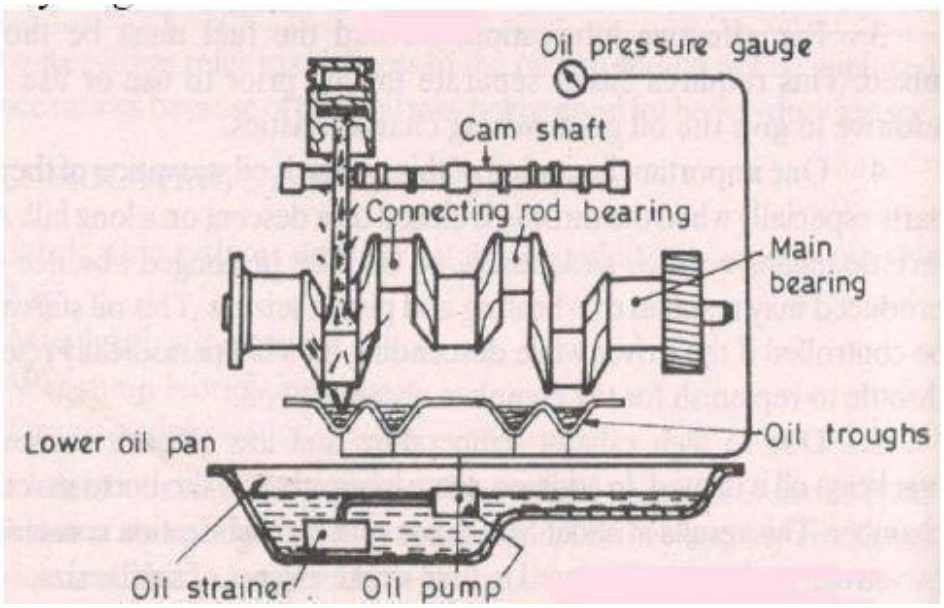
Bottom of the crankcase contains oil pan or sump from which the lubricating oil is pumped to various engine componentsbyapump.Afterlubrication,oilflowsbacktothe sump by gravity. Three types of wet sump lubrication system,

**(i) Splashsystem**
**(ii) Splashandpressuresystem**
**(iii) Pressurefeedsystem**

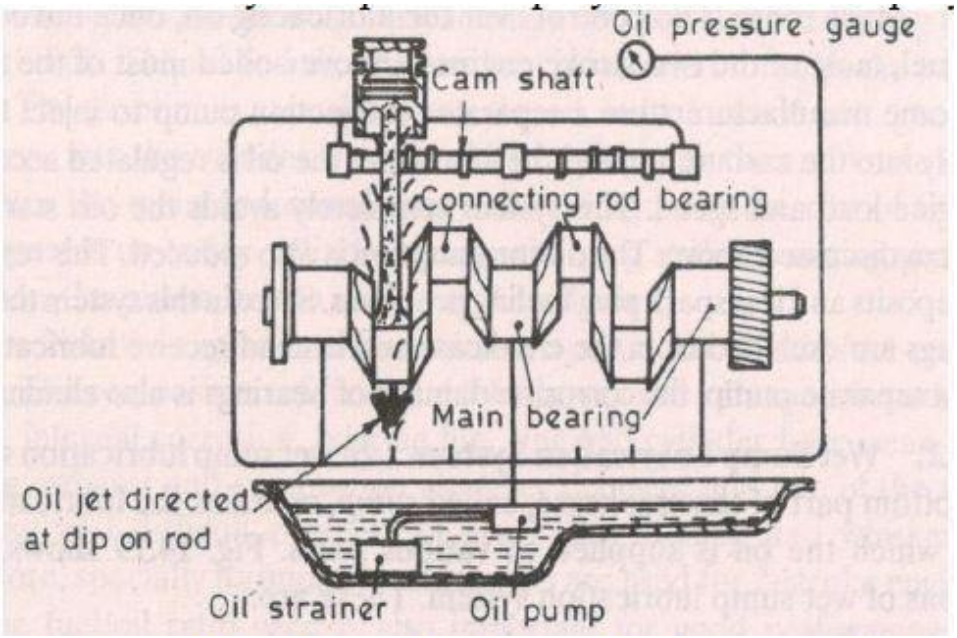
***(i) Splashsystem:***

-Inthissystemoflubricationthelubricatingoilisstoredin anoilsump.Ascoopordipperismadeinthelowerpart of the connecting rod.When theengine runs, the dipper dips in the oil onceineveryrevolutionof thecrankshaft,theoil is splashed on the cylinder wall. Due to this action engine walls, piston ring, crank shaft bearings are lubricated.

-Itisusedforlightdutyengine

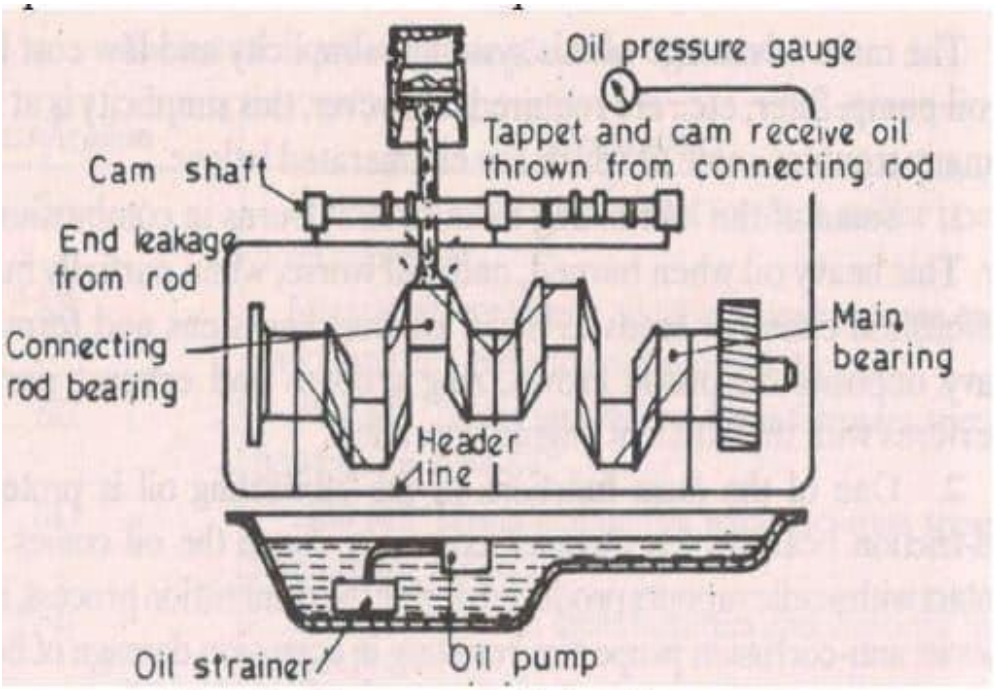


***(ii) Splashandpressuresystem:***
Lubricating oil is supplied under pressure to main, camshaftbearingsandpipeswhichdirectastreamofoil against the dippers on the big end of connecting rod bearingcupandthuscrankpinbearingsarelubricatedbythe splash or spray of oil thrown up by the dipper.



***(iii) Pressurefeedsystem:***

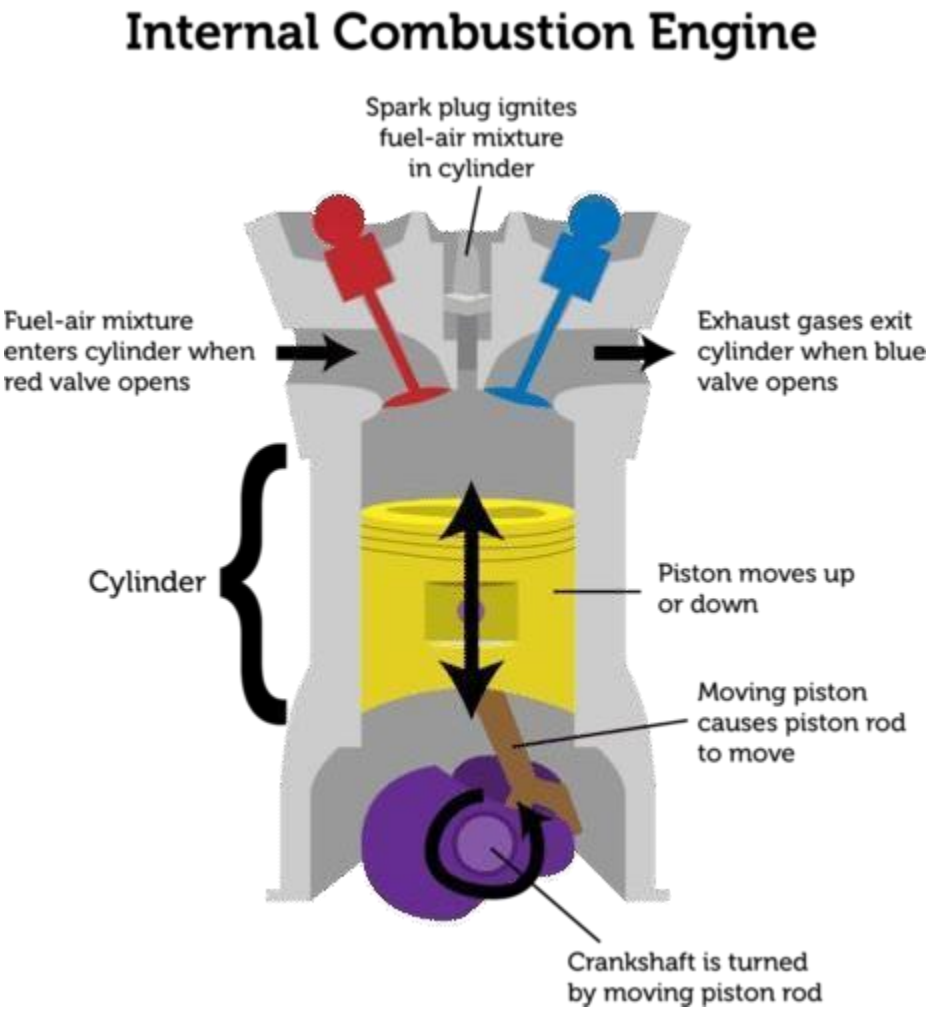
In this system of lubrication, the engine parts are lubricatedunderpressurefeed.Thelubricatingoilisstored in a separate tank (in case of dry sump system) or in the sump (in case of wet sump system), from where an oil pump(gearpump)deliverstheoil tothemainoil gallery at a pressure of 2-4 kg/cm2 through an oil filter. The oil from the main gallery goes to main bearing, from where some of it falls back to the sump after lubricating the main bearing and some is splashed to lubricate the cylinder walls and remaining goes through a hole to the crank pin. From thecrank pinthelubricatingoil goestothepistonpin through a hole in the connecting rod, where it lubricates thepistonrings.Forlubricatingcamshaftandgearstheoil is led through a separate oil line from the oil gallery. Theoilpressuregaugeusedinthesystemindicatestheoil pressure in the system. Oil filter & strainer in thesystemclearofftheoilfromdust,metal particlesandother harmful particles.



# 5.0 FUEL SYSTEM:

## DescribeAirfuelratio

AirFuelRatioinInternalCombustionEngine




Higher compression ratio and larger piston bore in an engine producehigherpowerandtorque.Thehighercompressionina combustion chamber makes the air and fuel particles compressedinlargerdensityandinhighpressure.Largerpiston geometry (bore) will let more air passing through the combustion chamber. Both of these variables will create powerful explosion and burns fuel more efficiently. The

modification will generate fuel economy and will deliver peak performance.However,thesemodificationshaveitsdrawbacks too. High octane gas is needed to keep the engine running in good condition which is more expensive than regular unleaded gas. Using low octane will develop engine knock. Engine knockinghappenswhentheair-fuelcombustiondoesn'thappen at the exact time of spark ignition in the piston's stroke. Furthermore, larger explosion actually create more power and will make the engine runs hotter than normal. Larger piston borealsorequiremorefueltoburntocompensatethelargerairflow through combustion chamber [1].

Asweknowngasolineenginesburnfueltocreatemotions.The reaction of mixture of fuel with oxygen in the air is cause from burningoffuel.Thisiscalledair-fuelratio(AFR).AFRisthemass ratio of air to fuelpresent inan internal combustion engine.For gasoline engines, the stoichiometric, A/F ratio is 14.7:1, which means 14.7 parts of air to one part of fuel [2]. It depends on type of fuel. Different fuel gives different AFR. The AFR is necessary for controlling emission and performance-tuning reasons [3]. The mixture combust and produce the product of carbon dioxide, water and nitrogen [4]. The AFR calculation is based on Lambda Oxygen ($O^2$) sensor in gasoline engine. The AFR are defined below [5]:

$$AFR = \frac{m_{air}}{m_{fuel}}$$

The AFR is related to mixture of air and fuel. The AFR is importantmeasureforanti-pollutionandperformancetuning reasons.Furthermore,itisimportanttoknowtheAFRatwhich exactly all the available oxygen is used to burn the fuel completely or at least to the best possible value. This ratio is called stoichiometric AFR. However, standard stoichiometric

AFR is not giving best performance when modification of modifiedpistongeometryandcompressionratioisdone.The stoichiometricmixtureingasolineengineanditsproductsare defined below:

$$C_xH_y + zO_2 + 3.71zN_2 \rightarrow xCO_2 + \frac{y}{2}H_2O + 3.71zN_2$$

wherethemixtureoffuel,oxygenandnitrogenproducetheproducts of water, carbon dioxide and nitrogen.

Relatively richmixtureofairfuelratioof12:1isrequiredby the engine while accelerating or running at high speeds. A leaner mixture of air-fuel ratio of 16:1 is sufficient while running on levelled roads. For idling, a richer mixture of about 14:I is needed.Similarly,anextremely richmixturehavinga ratioof9:1 is required during cold starting.

# DescribeCarburetionprocessforPetrolEngine

Workingofa Carburetor:

Aswealreadyknew,theSimplecarburetormainlyconsistsof

1. ThrottleValve
2. Strainer
3. Venturi
4. Meteringsystem
5. Idlingsystem
6. FloatChamber
7. MixingChamber
8. IdleandTransferport
9. ChokeValve

TheFloatandneedlevalvesystemmaintainsaconstantlevelof gasoline in the float chamber.

If the amount of the fuel in the float chamber falls below the designedlevel,thefloatgoesdown,therebyopeningthefuel supply valve and admitting fuel.

Whenthedesignedlevelhasbeenreached,thefloatclosesthefuel supply valve thus stoping additional fuel flow from the supply system.

Thefloatchamberisventedeithertotheatmosphereortothe upstream side of the venturi.

Duringthesuctionstroke,theairisdrawnthroughtheventuri. Venturiisatubeofdecreasingcross-sectionwithaminimum area at the throat.

Venturitubeisalsoknownasachoketubeandissoshapedthatit offers minimum resistance to theairflow. As theair passes

throughtheventurithevelocityincreasereachingamaximumat the venturi throat.

Correspondingly,thepressuredecreasesreachingaminimum.

Fromthefloatchamber,thefuelisfedtoadischargejet,thetipof which is located in the throat of the venturi.

Becauseofthedifferentialpressurebetweenthefloatchamberand the throat of the venturi,known as carburetordepression, fuel is discharged into the air stream.

Thefueldischargedisaffectedbythesizeofthedischargejetanditis chosen to give the required Air fuel ratio.

## Functionsofacarburetor:

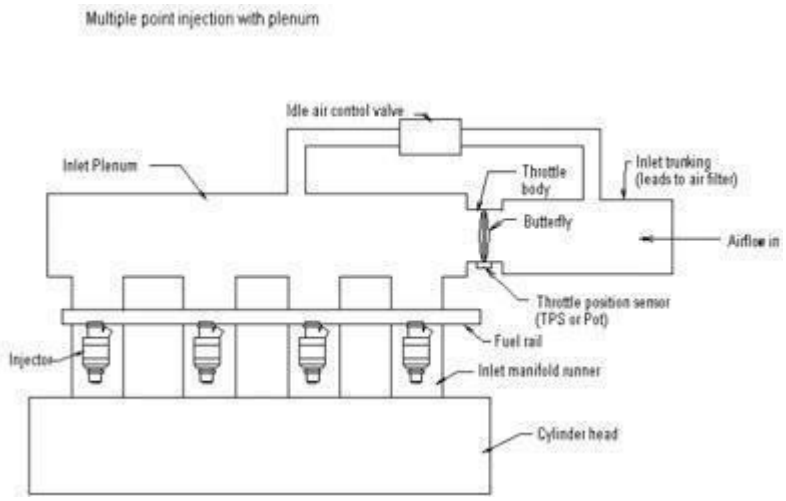
Themainfunctionsofacarburetorare

1. Themainfunctionofcarburetorstomixairandgasolineand provides a high combustion mixture.
2. Itcontrolstheenginespeed.
3. Italsoregulatestheair-fuelratio.
4. Increaseordecreasetheamountofmixtureaccordingtothe engine speed and load changing.
5. Tokeepcertainheadoffuelinthefloatchamberallthe time.
6. Vaporizethefuelandmixtoairtoahomogeneousair-fuel mixture.
7. To supply the correct amount of air-fuel mixture at the correctstrengthunderallconditionsofloadandspeedofthe engine.

# DescribeMultipointfuelinjectionsystemforPetrol Engine(MRFI)

The MPFI is a system or method of injecting fuel into internal combustion engine through multi ports situated on intake valve of each cylinder. It delivers an exact quantity of fuel in each cylinderatthe right time.Therearethree types ofMPFI systems – Batched, Simultaneous and Sequential.

In the batched MPFI system fuel is injected to the groups or batches of the cylinders without bringing their intake stroke together. In the simultaneous system, fuel is inserted to all cylindersatthesametime,whilethesequentialsysteminjection is timed to overlap with intake stroke of each cylinder.




WorkingofMRFI

MPFI includes a fuel pressure regulator, fuel injectors, cylinders, pressurespringandacontroldiaphragm.Itusesmultipleindividual injectors to insert fuel in each cylinder through intake portsituatedupstreamofcylinder'sintakevalue.Thefuelpressureregulator,connectedtothefuelrailbymeansofan inletandoutlet,directsthe flowofthefuel. Whilethe control diaphragmandpressurespringcontrolstheoutletvalveopening andtheamountoffuelthatcanreturn.Thepressureinthe

intake manifold significantly changes with the engine speed and load.

## Advantagesofmultipointfuelinjectionsystem?

- The multi-point fuel injection technology improves fuel efficiency of the vehicles. MPFI uses individual fuel injector foreach cylinder,thus thereis no gaswastageovertime.It reduces the fuel consumption and makes the vehicle more efficient and economical.
- The vehicles with MPFI automobile technology have lower carbon emissions than a few decades old vehicles. It reduces the emission ofthehazardous chemicals orsmoke, released when fuel is burned. The more precise fuel delivery cleans the exhaust and produces less toxic byproducts. Therefore, the engine and the air remain cleaner.
- MPFI system improves the engine performance. It atomizes the air in small tube instead additional air intake, andenhancesthecylinder-to-cylinderfueldistributionthataid to the engine performance.
- It encouragesdistributionof more uniform air-fuel mixture to each cylinder that reduces the power difference developed in individual cylinder.
- The MPFI automobile technology improves the engine response during sudden acceleration and deceleration.
- TheMPFIenginesvibratelessanddon’trequiretobecranked twice or thrice in cold weather.
- Itimprovesfunctionalityanddurabilityoftheenginecompone nts.
- TheMPFIsystemencourageseffectivefuelutilizationand distribution. .

## Otherbenefits

- Smoothoperationsanddrivability
- Reliability
- Competenttoaccommodatealternativefuels
- Easyenginetuning

- Diagnosticcapability
- Initialandmaintenancecost

## Describe the working principle of fuelinjectionsystemformulticylinderEngine

#afuelinjectionsystemforamulti-cylinderendothermicengine is provided which comprises:

apluralityoffirstcylindersprovidedalongafirstaxis;

apluralityofsecondcylindersprovidedalongasecond axiswhichisparalleltothefirstaxis;

apluralityofintakevalves,eachofwhichismountedin the head of a respective cylinder;

afuelmanifoldwithalongitudinalaxiswhichisparallelto the first and second axis;

apluralityoffuelsupplypipeswhichleadtotheheadofa respectivecylinder;

a plurality of fuel injectors, one for each cylinder, the longitudinal axis of which converges towards a median areadefinedbetweenthefirstandsecondaxis,andwhich can collectfuelfromthefuelmanifoldandinjectthisfuelinto a respective fuel supply pipe; and

anairintakemanifoldwhichcanconveyairintothefuel supply pipes;

characterizedinthattheinjectorscomprisea nozzlein which there is providedaninjectionhole which is defined along an axis which converges on the longitudinal axis of theinjector,accordingtoarespectiveandpredetermined angle, and characterized in that the axis of the injection hole of the injectors which supply the first cylinders converges on the intake valve of the first cylinders, whereas the axis of the injection hole of the injectors whichsupplythesecondcylindersconvergesontheintake valve of the second cylinders.

# For improved understanding of the present invention,apreferredembodimentisnowdescribed, purely by way of non-limiting example, with reference to the attached drawings, in which:

- Figure1isaschematicplanviewofaninjection systemaccordingtothepresentinvention;
- Figure2isanenlargedcross-sectionalonglineII-II in Figure 1; and
- Figure3isapartialenlargedcross-sectionofa detail of the system in Figure 2.

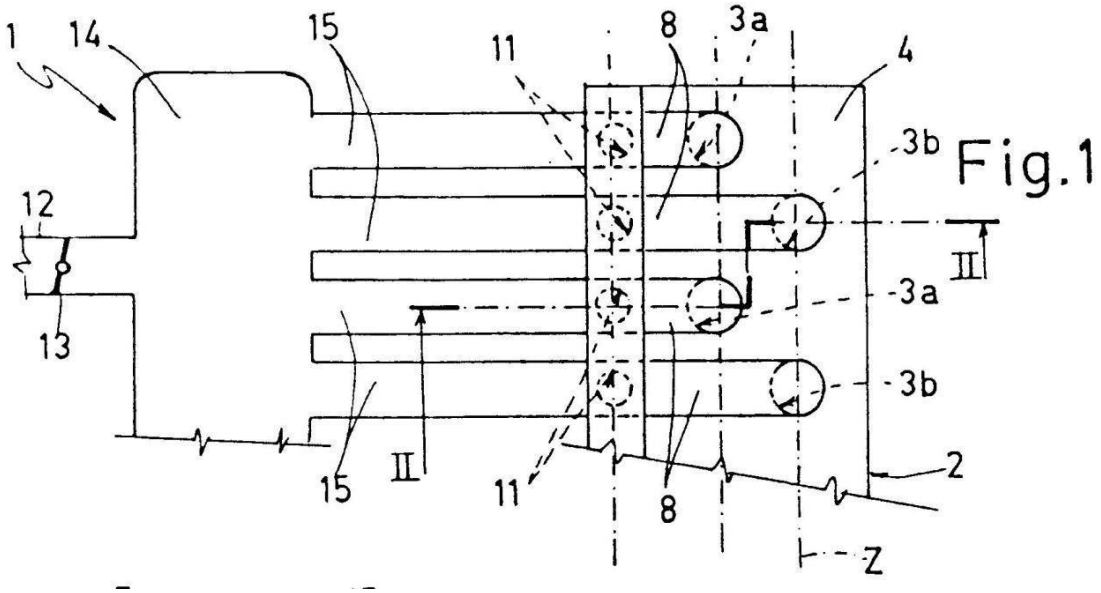



Fig.1

#AsFigure1illustrates,1indicatesasawholea fuel injection system for an endothermic engine 2 of the type which has a plurality of cylinders distributed in two rows. The engine 2comprises a base 4 in which therearedefinedtwoparallelaxesYandZ;alongthe

axisYthereisprovidedafirstpluralityofcylinders3a,and alongtheaxis Zthereis provideda second plurality of cylinders 3b. Each cylinder 3a and 3b (Figure 2) accommodates a respective piston 5, and has in its head a respective intake valve 6.

#WithreferencetoFigures1and2,thesystem1 comprises:

afuelmanifold7withlongitudinalaxisXwhichis parallel to the axes Y and Z;

apluralityoffuelsupplypipes8(oneforeach cylinder 3a and 3b) which lead to the head of the respective cylinder 3a and 3b;

apluralityoffuelinjectors11,oneforeach cylinder 3a and 3b;

anairintakemanifold12,alongwhichthereactsa regulation valve 13 which is preferably of the throttle type;

anexpansionbox14intowhichthemanifold12leads; and

apluralityofairsupplypipes15whichoriginate fromtheexpansionbox14,andwhichareofthe same number as the fuel supply pipes 8.

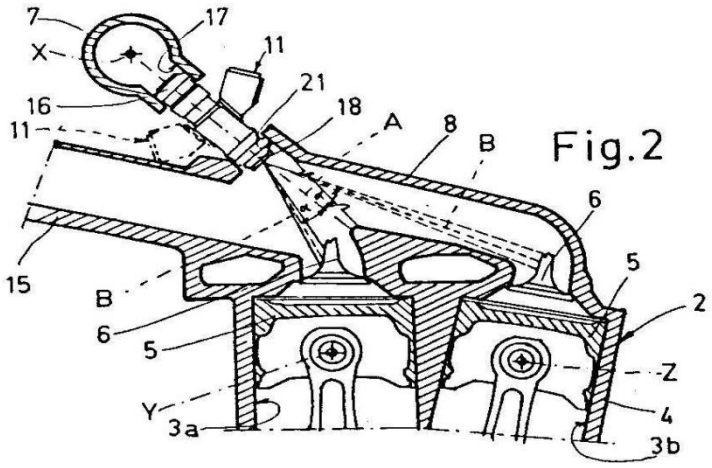


Fig.2

# With reference to Figure 2, theinjectors 11 have a head 16, in which there is recessed the fuel inlet mouth, which is accommodated in a respective seat 17 recessed in the fuel manifold 7, and a nozzle 18 (Figure 3) which is accommodated in a seat 21 recessedalongtherespectivefuelsupplypipe8.The fuel manifold 7is mounted to the sideof the base 4, andin particularinthevicinityoftheaxis Y,suchthat the pipes 8 which supply the cylinders 3a have a lengthwhichisshorterthanthatofthepipes8which supply the cylinders 3b. The injectors 11 have a respective longitudinal axis A which converges towards an area of the base 4 in a median position between the axes Y and Z. The axes A of all the injectors 11 are defined on a single plane, i.e. all the injectors 11 have the same angle relative to the longitudinal axis X of the fuel manifold 7. The air supply pipes 15 lead to a respective fuel supply pipe 8, insidewhichthe air and fuel aremixed in order to obtain the air-fuel mixture which the cylinder 3a, 3b will takeinby means of thevalve6 duringtheintake stage.

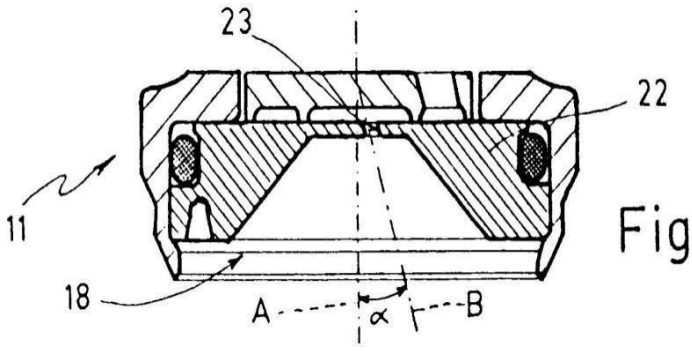


Fig.3

#With reference toFigure 3,thenozzle 18 of the injector11 hasaplate22in which thereis provided aninjectionhole23definedalonganaxisBwhich convergesontheaxisAaccordingtoanangleα;the

fueljetisthusnotinlinewiththeaxisAbutisatanangleα relative to the latter.

# With reference to Figure 2, the injectors 11 which supply the cylinders 3a are oriented differently, and in particular are rotated around the axis A by 180° relativetotheinjectors11whichsupplythecylinders3b. The orientation of the injectors 11 which supply the cylinders 3a, and the angle α of the fuel jet relative to the axis A, cause the fuel jet to strike fully the valve 6 of the cylinders 3a. Whereas the orientation of the injectors 11 which supply the cylinders3bandtheangleαofthefueljetrelativeto theaxisA,causethefueljettostrikefully thevalve6 of thecylinders3b,thislattersolutionbeingillustrated in broken lines in Figure 3.

#Accordingtotheabovedescription,theadvantages obtainedbyimplementingthepresentinventionare clear.

# In particular, an injection system is provided according to which all the cylinders use the same injectors, in which the injection hole is at an angle relative to the axis of the injector. If the injector is now positioned according to a predetermined orientationoftheinjectionholeaxis,thefueljetcanbe directed against the intake valve of the closer cylinder or of the further cylinder. This aimed direction of the fuel jet does not give rise to the depositingofparticlesonthewallsofthefuelsupplypipe, since these walls are not along the axis of the jet. Consequently,all thequantityoffuelinjectedis thentakeninbythecylinder,andinadditionthereis

nodistortionofthestoichiometryprescribedfortheair-fuel mixture.

#Finally,itisclearthatmodificationsandvariants may be applied to thesystem 1 describedandillustrated here,withoutdepartingfromtheprotectivecontext of the present invention.

# In particular, the system 1 can contain any numberofcylindersdistributedintworows,andcan includeinjectors ofa type otherthanthat described. Thecylindersofonerowcanhavetheirlongitudinal axisparallel orconverging with the longitudinal axis of the cylinders of the other row. In addition, the injectors which supply the cylinders 3a could have theirinjectionholesdefinedalongangledaxes,with an angle which differs from that of the injection holes of the injectorswhichsupply thecylinders 3b.

# According to a different embodiment, all the injectors could have the same orientation, and includeaplate22whichcanbepivotedaroundthe axis A in order to determine the injection hole 23 definedonanaxiswhichconvergesontherespective intake valve 6.

Claims(4)
HideDependent

1.

Fuelinjectionsystemforamulti-cylinderendothermicengine (2) comprising;

apluralityoffirstcylinders(3a)providedalongafirstaxis (Y);

apluralityofsecondcylinders(3b)providedalongasecond axis(Z)whichisparalleltothefirstaxis(Y);

apluralityofintakevalves(6)eachofwhichis mountedintheheadofarespectivecylinder(3a,3b);

afuelmanifold(7)withalongitudinalaxis(X)whichis parallel to the first and second axis (Y and Z);

apluralityoffuelsupplypipes(8)whichleadtotheheadof a respective cylinder (3a, 3b);

a plurality offuelinjectors(11),oneforeachcylinder (3a, 3b), the longitudinalaxis (A) of whichconverges towardsa median area defined between the first and secondaxis(YandZ),andwhichcancollectfuelfromthe fuelmanifold(7)andinjectthisfuelintoarespectivefuelsupply pipe (8); and

anairintakemanifold(12)whichcanconveyairintothe fuel supply pipes (8);

characterized in that the injectors (11) comprise a nozzle(18)inwhichthereisprovidedaninjectionhole(23) which is defined along an axis (B) which converges on the longitudinal axis (A) of the injector (11) according to a respectiveandpredeterminedangle(α),andcharacterizedin that the axis (B) of the injection hole (23) of theinjectors (11)whichsupplythefirstcylinders(3a)convergesonthe intakevalve(6) ofthe firstcylinders (3a), whereas the axis (B) of the injection hole (23) of the injectors (11) which supplythesecondcylinders(3b)convergesontheintake valve (6) of the second cylinders (3b).

2. SystemaccordingtoClaim1,characterizedinthatall theinjectors(11)havethesameanglebetweentheir

ownlongitudinalaxis(A)andtheaxis(B)oftheirown injection hole (23).

3. System according to Claim 2, characterized in that theinjectors(11)whichsupplythefirstcylinders(3a)are oriented differently,andin particularare rotated around their own longitudinal axis (A) by 180° relativetotheinjectors(11)whichsupplythesecond cylinders (3b).
4. SystemaccordingtoClaim2,characterizedinthatall the injectors (11) have the same orientation, and in that the nozzles (18) of the injectors (11) which supplythefirstcylinders(3a)areorienteddifferently,and in particular are rotated around the longitudinal axis (A) by 180° relative to the nozzles (18) of the injectors (11)which supply thesecond cylinders (3b).

# FilterforDieselengine

The fuel filter of diesel engine can filter out the harmful impuritiesandmoistureinthefuelsystem,protectthenormalwork of the engine, reduce wear and tear, avoid clogging and improve diesel engine life. Here, we are willing to share the basic working principle of diesel engine fuel filter.

BasicWorkingPrincipleofDieselFuelFilter

The purpose of any diesel fuel filter is to remove foreign particlesaswellaswater.Theuseofasuitablefiltrationsystemon diesel engines is a must to avoid damage to closely fitted

injection pump and injector components. Filter's ability varies betweenthetypeandmanufacturer.Ondieselenginesprimaryand secondary filters are used. The primary filter is capable of removing dirt particles down to 30 microns and the secondary filter between 10 to 12 microns. Secondary filters are available between 3 and 5 microns, which are used in severe service operations. The primary filter is usually located between the tank and the supply pump, the FWS is one type of the primary filters. The secondary filter between the supply pump and the injection pump.

Dieselfuelfilterisreferredtoasfull-flowfilter,becauseallthe fuel mustpassthroughitbeforereachingtheinjectionpump.Some filters use internal replaceable element inside a bowl or shell. These arecommonly referred to as ashelland element design. Mostfuelfiltersusedtoday areofthespin-ontype,whichallow for fasterchange out since the complete filter is a throwaway.

Besides,if the filter is installed on thepressureside ofthe boost pump it must have sufficient strength to handle pump pressure withoutburstingorleaking.Thefiltermustbelocatedwellawayfrom sources of heat, preferably outside ofthe engine compartment.

Components

Thefuelfilterofdieselengineis mainlycomposedof threeparts: filter element, the shell and filterbase (As shown in Figure 1). All modelsareuniversalexceptfortheoverflowvalve8thathastwo structures. Choosing C0810A or C0810B filter should be on the basis of different models. For the 12 cylinder V type diesel genset, it shouldbe installed in parallel with each one of C0810A and C0810B.

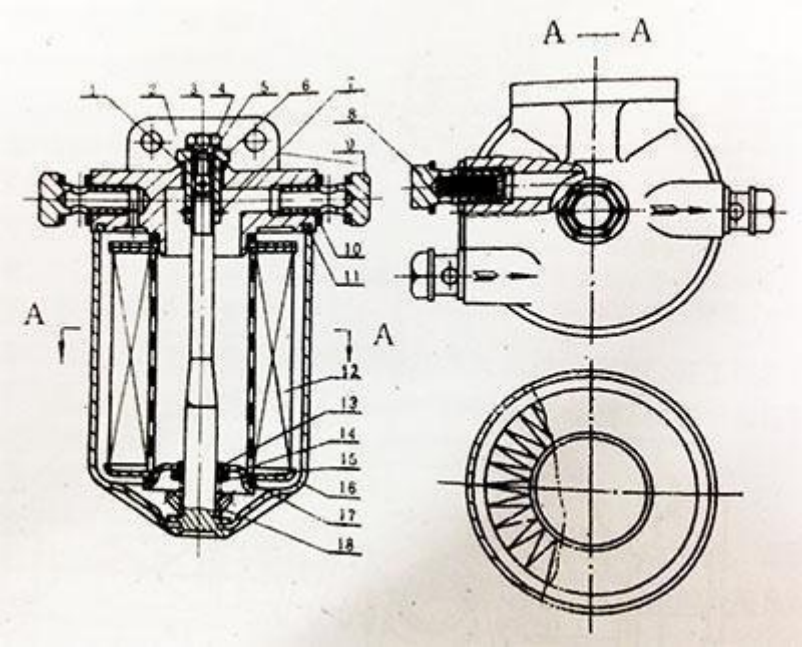


Figure1:Fuelfilterassemblysection

1.Gasket2.Baseoffilter3.Pullrod4.Bleedscrew5. Gasket6. Pull-rod nut7. Jump ring8. Overflow valve 9.Oil pipe connection 10. Seal ring 11. Sealing washer 12. Filter element 13. Seal ring 14. Tray 15. Spring seat 16. Shell 17. Sealring18.Spring

The fuel is sent to the fuel filter mainly by the fuel pump. The impurities in the fuel will be cleared through the paper filter element. And then the fuel can enter the inner cavity of the filter cylinder. Through thecollection chamberof the filter sea, itleads tothefuelinjectionpump.Thefilterholderisequipped with fuel return fittingand theoverflow valveis alsoinstalled inside. When the fuel pressure in the fuel filter is more than 78kPa(0.8kgf/C ㎡), the excess fuel will return back to the fuel tank from the fuel return fitting. When connecting the low pressurefuelline,youshouldconnectitaccordingtothearrow pointing direction on the socket toavoid connection error. The filter seat and the shell are connected by pull rod, and it is sealedbyrubberring. Duetothereisableederplugonthetopof filter seat, users can release the screw to clear the air of the fuel filter in use.

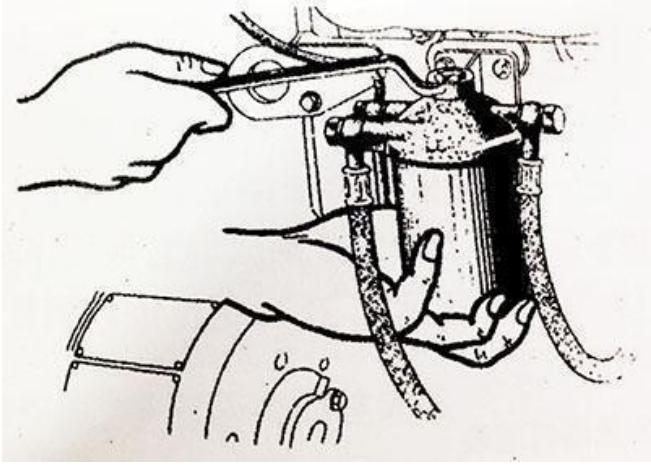


Figure2:Fuelfilteroverhauling

The fuel filter of the diesel engine is fixed on the engine body and bracket with two M8-6H screws. If users find that the fuel supply is not smooth, it is possible that the filter element is pluged. At the moment, you should dump the fuel oil. You can directlyloosen thepull rod nut of diesel generator set, remove the shell,and takeout the filtercartridge(As shownin Figure 2). Afterthefilterelementisdippedintogasolineordiesel oil,you cangentlywashthedirtoffwithbrush(AsshowninFigure3).If the filter cartridge is broken or hard to clean, it must be renewed.TheninstallitasshowninFigure1andinjecttheclean fuel.

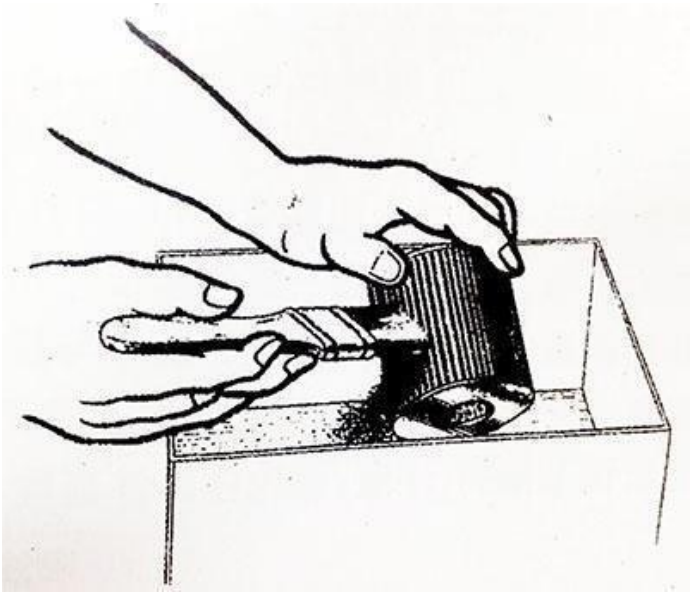


Figure3:Cleaningfuelfilterelement

# DescribetheworkingprincipleofFuelfeedpumpand Fuel Injector for Diesel engine

Fuelfeedpumpdieselengineconstructionandworking
Fuel *feed pump diesel engine* is a mechanical device which works for supplyingthe fuel.Thefuel feedpumpdieselenginebringsfuelfromfuel tankandsendstothefilters,FIPandinjectors.Fuelfeedpumphasdriven by engine cam shaft.

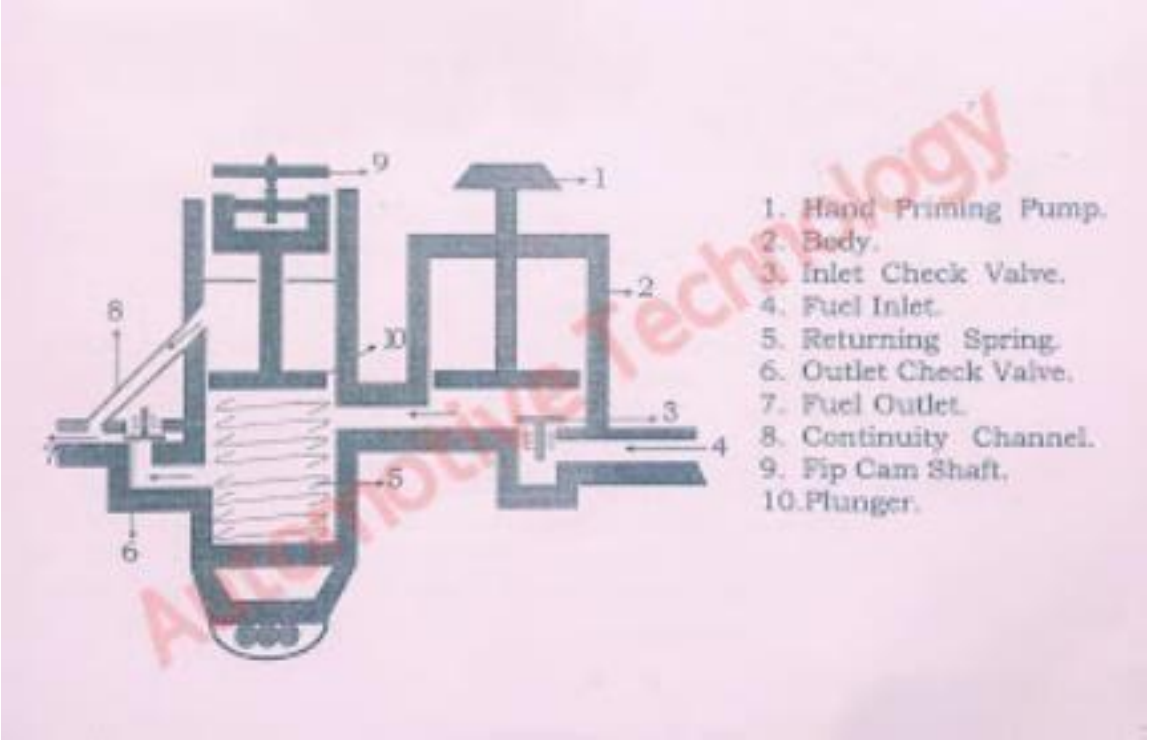
Constructionoffuelfeedpumpdieselengine;
The*fuelfeedpumpdieselengine*haveafuelinletwhichisconnectedwithfuel tank by the fuel feed pump pipe line. It also have a fuel outlet which is connected with filter and FIP by the low pressure pipeline

The fuel feed pump diesel engine have two check valve namely inlet checkvalveandoutletcheckvalve,botharefittedinsidethepumpbodyatinlet and outlet ofthe fuel

Forairlockremovingoperationthefuelfeedpumpdieselenginehavea manual operatinglever.Fornormalcleaningofthe fuelithasagauge filterinside the body.

There is a plunger fitted inside the fuel feedpump diesel engine body andtokeepininitial positionofthe plungerthereisareturningspeed provided.
Thereisacontinuitychannelcastedinsidethebody whichmakes continuity of fuel supply f or the system.

WORKINGOFFUELFEEDPUMPDIESELENGINE
Therearetwodifferentworkings:




1. Manualoperationwhileremovingairlock:
Whenvehicleisgettingoff becauseoftheairlockinthefuelsupply system. Nowtheuserhastoopenthemanualprimingleverandstartprimingby pulling and pushing this lever
Continuousprimingofthelieverthereisasuctionbeingcreatedandtakes fuel from fuel tank and supply to the system.

2. Fuelsupplywhiletheengineisstarting

During startingthe engine the cam shaft of the engine gives drive tothe fuelfeed pump diesel engine. Theplunger starts moving front and back. When the plunger comes back then suction takes place inside the body. Becauseofthissuctionfuelflowsfromfueltankandfilledintothepump body by opening the inlet check valve.
Whentheplungergoesfrontthenitmakespressureonthefuelandfuel flowstothesystembyopeningtheoutletcheckvalve.Duringfueloutlet some fuelgoesbehindtheplungerthrough thecontinuitychannel,while plunger goes back again the fuel comes from fuel tank intothe pump bodybutthefluidbehindtheplungerflowstothesystemandthenthere is continuity of fuel supply.

# 6.0 ELECTRIC AND HYBRID VEHICLES:

## Introduction,SocialandEnvironmentalimportanceofHybrid and Electric Vehicles

Sincethedawnofthemodernera,consumptionand distribution of energy has quickly become mankind's highest priority. However, the continued apathetic attitude that was initially taken toward energy and its side effects can no longer beused.Anewmoreenvironmentallyfriendlysourceofenergy has tobe utilizedin order to fulfillourown needs otherwise we selfdestruction while relying on non-renewable oil based methods. In the last few decades two new technologies have emerged; the development and implementation of Hybrid Electric Vehicles (HEVs) and more recently the Plug-in Hybrid Electric Vehicles (PHEVs). These emerging technologies may make it possible for the United States to adapt these technologies on a larger scale to reduce harmful emissions and cut our dependence on foreign oil dramatically. However, the future of the technologies will heavily depend on the everyday American consumer's willingness to forgo the 'tried and true' combustionengineforthe infantiletechnologiesoftheHEVand PHEV. With the introduction and continued popularity of HEVs and as well as the recent hype over the PHEVs, the future of transportation in the United States is on the brink of change.

First, verify if independence of foreign oil is truly a possibility and how to accomplish this feat. Second, identify the major motivators for the American consumers who purchase these vehiclesandhow thatcanbeusedtoincreasethesalesofHEVs and PHEVsrespectively.Thethirdandlastobjectiveistodetermine the future impact of the all electric vehicle (EV). Earliercivilizationsreliedonanumberofpowersourcessuchas

water to turn wheels, to run mills, fire to heat water and create steam, or windmills to turn grinding stones. Since roughly Environmental and Social Issues Concerned with Hybrid Cars 5 the 17th century various forms of oil have been used, such as kerosene, as fuel for lanterns. Even into the 18th , 19th , and early 20thcenturieswhaleswerehuntedfortheirblubberwhich could be converted into oil among other things. In the more recentyearswiththeinventionofthecombustionengine,which has not only increased the shear amount of oil consumed annually butalsodrasticallyaugmentedourdependenceuponitinourdaily lives.

Our oil 'addiction' has lead us to the realization that ourusage has its limits, not only does the environment suffer adverse effectsbecauseofitsusebutoursocietyissodependentupon thatifitweresuddenlyremoved,mostofmodernsocietywould cease to function properly if it all. Without a reasonable alternative this fate isalltoo possibleand thishascaused huge concerns over how, on a large scale, we can change our consumption habits and create a cleaner energy for our use.

Hybridcarshavecomea longwayinthepast20years,butmost peopleareunawaretheyhavebeenaroundsincethemid1800s.The early electric vehicles at the turn of the 20th century were expensive, problematic and not very powerful. Given certain weather conditions or too steep a hill the electric vehicle of yesteryearwas simply unableto perform up to our expectations.

With the introduction of the Ford Model T, a revolution in vehicles was made. The Model T was cheaper and more powerfulandwasmaderelatively simplistic,italsoranona then abundantsourceofgasoline,andtheUnitedStatescouldmeet its own internal demand enough so that itactually exported its excess to European countries such as France and Britain. Ultimately,theModelTmadetheearlyEVsdefunctandassuch

fell off the radar until events like the 1973 oilcrisis and 1979 energycrisiswheretheelectric technologieswereeventually reconsidered.

Thefirstelectriccarisclaimedtohavebeenbuiltbetween1832 and 1893 by Robert Anderson of Scotland. From then until the late 1800s,whentheybecameefficientenoughtouseastaxicabsin England, the cars were heavy, slow and impractical. Modernbatteriesdevelopmentintheearly1900spushedthe development of more efficient, reliable, and practical electric cars in that period.

The Hybrid came about in 1900 in Belgium, when a small gasoline engine was paired with an electric motor. During normal operation the electric motorcharged onboardbatteries, but during acceleration and uphill stints the electric motor provideda boost to the 3.5 horsepower motor.In 1905 H Piper patented the first hybrid in America.In 1910a hybrid truckwas manufacturedinPennsylvania,whichuseda4cylindertopower a generator and an electric motor. 1916 saw the production of hybridcarsclaiming35mphand48mpg,howeverthisalsosaw the end of the electric car era due to the advances in combustion engine technology.

Untilthemidtolate1960s,thereislittlecommercialadvancein hybrid or electric cars. As early as the mid 1960s congress recognizedtheimportanceofreducingemissionstoimproveair quality, and that the use of electric cars was a possible way to achieve this. In the late 60s and early 70s the oil embargo sparkeda renewed interestin hybridand electric vehicles.Afew hybrids were released by major manufacturers, but most were underpowered and small. More importantly, three scientists patentedthefirstmodernhybridsystemin1971,muchofwhich closely resemble the hybrids of today.

The next big push from congress come s with the 1976 Electric andHybridVehicleResearch,Development,andDemonstration Act which encouraged the commercial improvement of electric motorsandotherhybridcomponents.Theresearchleadtowardnew developments and new vehicle released in the United States, including all electrics from GM and Honda, even including an electric truck, the Chevrolet S-10. These vehicles reached a niche group, but still did not receive the sales numbers Environmental and Social Issues Concerned with HybridCars 7 to be feasible. This all changed with the releaseof the Toyota Prius in Japan in 1997.

With 18000 sold in the first year it becomes the first economically feasible hybrid produced. With its import to the united stated in 2000 and the release of Hondas Insight to the US in 1999 the hybrid age had finally arrived. However, PHEVs and HEVs are not without limitations, which are mainly caused bythecurrentstateofbatterytechnology.Withfutureresearchand development into creating improvements on battery technologymanyofthelimitationswillbegreatlyreducedifnot expunged completely.

Wehavecomealongwaysincethenickelandleadbatteriesofthe 1960s, more recently theNickelMetalHydrideand Lithium Ion battery technologieshavebeendevelopedandsuccessfully implemented. Today's HEVs are a far cry from the small four horse power models of the 1800s, modern HEVs include the same power, acceleration, comfort, and price of their counterpartconventionalcars(CVs),butcanreachupwardsof 50 miles per gallon depending on the model

# Impact of Hybrid Cars on the Environment

Oneofthemajortechnologiesfoundtohaveasignificant contributiontowardscarbonemissionreductionistheHybrid Electric VehiclesorHEVs.Thisnewtypeofvehicleisbeing praisedforfuelefficiencyandultimatelybeingenvironmental friendly.

On the other hand, there arecontradictingarguments regarding the impact of HEVs on the environment, which needs to be examined further. The environmental implications of HEVs can bebetterexploredwhenobservedinasmallerregionwherethe data ismorespecific.FuelpricesinOmanareatarecordhighdespite the fact that the country is a major global producer of petroleum products. As a result, a significant number of car owners in the country are shifting to HEVs.

However,theshifttowardsHEVsismoreontheeconomicthan environmental position. In this regard, the discussion will explore how the shift towards HEVs impacts the environment specifically in Oman. Hybrid Cars vs. Traditional Cars There are two major questions that car consumers in Oman asks today whenpurchasingnew vehicle,and thatiswhetherthecarisfuel efficient and environment friendly. Only HEVs have the highest potential for meeting the aforementioned two conditions. However,tocompareconventionalversusHEVsitisimportant tonoteprosandconsofeachtype.ForHEVs,theadvantageishigher mileage,highresalevalue,usescleanerenergy,butthe tradeoffwould beahigherpricetag,highermaintenancecost, and no sport-tuned suspensions (Lexus, N.D.).

On the other hand, conventional fuel cars command a lower pricetag,betterenginepower,and low maintenancecost,but thedrawbackswouldbeharmfulemissionsandlowmileage.Areport published by Argonne in 2009 suggests that HEVs offer

90%reductiononpetroleumenergyuseand40-80%reduction on greenhouse gas emission (Elgowainy et al., 2009). Carbon Footprint and Environmental Impact in Oman In the case of Oman,thecurrentenvironmentalstatisticssuggeststhatcarbon emission in the country is on a steady increase since the early discovery and production of oil and gas.

From1972to2011therehasbeensteepclimbonthetotalCO2 emissionsinOmanfrom2,000Ggto40,000Gg(Abdul-Wahab et al., 2015). Similarly, the study conducted by Yousif et al. (2017) shows a forecasted further increase in CO2 and greenhouse gas emissions of nearly 60 million tons in the country in the next decade. The major contributors of these emissions are continuous fuel combustion at 57.9, manufacturing at 24.2 and transportation at 12.3 .

TheCO2emittedbyconventionalcarsinthecountryareaddedon both transportation and fuel combustion segments, which encompasses a much higher statistic when combined. In this regard,theSultanateofOmanisseeingthepotentialof HEVsto counterthecontinuouslyincreasingCO2 and GHGemissions in the country .

In 2015, major car brands introduced HEVs in Oman such as ToyotaPrius,whichisspearheadingtheshifttoHEVsacrossthe Middle East (Times of Oman, 2016). Expectations of the car model 3 / 14 Journal of Student Research Fourth Middle East College Student Research Conference, Muscat, Sultanate of Oman(2019)ISSN: 2167-1907(www.jofsr.org)suggestthatitis likelytoreduceapproximately67milliontonsofCO2emission over the span of 20 years (Times of Oman, 2016). To date it is not certain how many of the HEVs were deployed in Oman, hence,theexactmeasureofitsimpacttowardsthecountry'sCO2 emission reduction is still undetermined (CMS, 2018). Therearesevеralchallengesobservedintermsoffurther

deployment of HEVs in Oman and one of them is the establishment of regulators that will oversee the operations encompassedbytheintroductionofHEVsinthecountry.Oneofthe primary considerations is who would be responsible for the implementation and regulation of facilities such as charging stations, tariff fixing, and government registration and requirements (CMS, 2018).

RESULTS

Thetopicofhybridcarswaskeenlyinspected.Themajorpartsof it were broken down and critically analyzed. The study producedresultsthatcouldpositivelyaffecteveryoneinvolved. Withrespecttodifferentaspects,theresultsreviewedareas produced below:

Environmental Impact The first and one of the most important result ofimplementing hybrid cars usage,is the environmental factor. According to the survey conducted among 36 people, 88%oftherespondentsagreedthatairpollutionhasincreased due to the automobiles on road. Cars driven in the city, when they runonlowspeeds,orarestuck inheavy traffic,theregular gasoline cars keep the engine running which at the same time exhalesfumescausingincreasingairpollutiononextremelevels.

The same situation when applied to hybrid cars, they smartly switchtotheelectricmotor,causingzerofuelconsumptionand zero air pollution. This notonly contributes tosaving money but also to a greenerand healthier environment.. Money Saver The survey shows that on an average around 66% of people agreed to spending between 50 – 60 10 / 14 Journal of Student Research Fourth Middle East College Student Research Conference,Muscat,SultanateofOman(2019)ISSN:2167-1907 OMR per month just on petrol/diesel. Going by the figure 60, that is 720 OMR per year. And people that fall into the more

than70category;thatwouldsumuptoawhopping960OMRper year.

For most of the people, 960 to 1000 OMR per year is a huge amount to be wasted just for refilling cars. With hybrid vehicles in place, this number is sure to come down by a few hundreds, saving money in the long term. Safety Referring to the report issued by Insurance Institute for Highway Safety, it claimed that in crashtests,hybridcarsperformedbetterthantheregulargas cars. The data showed that the people within a hybrid vehicle wouldbe25%lessinjuredthanasamestandardgasolinevehicle, as wellasthedriver'sdeathrateshowedareductionwhenitcame tohybridmodels.Thereasonthehybridmodelsexecutedwellin the crash tests was due to the heavy weight they carry.

According to the reports, these models are 10% more heavier thantheregulargasolinecars,andhencewhentheycrash,the heavier vehicle tends to have a greater impact on the light weighted gasoline counterparts and pushes it backwards. (Edgerton, 2011) For example, the hybrid variant of Accord is 217 kg's more than the standard Accord. A lot of news is surroundedaroundthetopicofhowLithiumIonbatteryusedin thesevehiclescouldprovedangerousby gettingoverheatedand may also catch fire. Companies manufacturing and producing hybrid cars have stated that it takes a long process to modify and tame the li-ion batteries to make it safer and runnable for years (Tajitsu, 2016).

Alongwiththenewlymodifiedandnowmuchsaferlithiumion batteries, Tesla Motors mentioned that they developed a cooling system and have also created sensors and fuses up to three layers of protection to safeguard the batteries from overcharging. The role of the fuses and the sensors is to immediatelydisengagethebatteryinuse,whenthereisarisein the temperature, a roll-over or an unexpected impact. From a

safety point of view, the makers decided to use a number of smaller batteries in comparison to a few large ones, since the energystoredwillalsobeinsmallamountsandenclosedwithin its own steel cases, it will also prove safer.(Bullis, 2006)
DISCUSSION The main objective of this research is to analyze Hybrid-Electric Vehicles(HEV)and theircomponentsand justify how these vehicles are less harmful than gasoline cars to the environment. This is done by analyzing and conspicuously explaining how an HEV works, its characteristics and the componentsthatdifferentiateitbetweentraditionalgasoline.

The result after testing the vehicles and researching and understanding its components is that HEV does is indeed less harmful to the environment due to it consuming less gasoline and because the components; mainly the battery and motor, arenaturallybuilttobelessimpactfultotheenvironment.This researchalsoaims to encourageconsumers into buying HEV.If the number of total hybrid vehicles increase and the total number of gasoline vehicle decrease, the total amount of pollutioncausedbyvehicleswoulddrasticallydecreasedueto thetotalconsumptionofgasolinedecreasingaslargeamounts of gasoline won't be needed to fulfill the needs of hybrid vehicles.

Thisultimatelyreducesenvironmentalpollutioncausedby vehicles.Alongwiththereductionofpollution,theamountof moneysavedoffuelrefilling'scouldbeturnouttobehelpfulformost of the individuals, who are struggling with balancing their budget.

CONCLUSION

Alltheabovetopics,whichhavebeenanalytically studied,it concludesthatthehybridvehiclesprovetobemoreeco-friendlyandsaferfortheenvironmentthantheICengine

vehicles.Withincreasingproductionofhybridvariants,batteriesare being planned and designed in way that extends its life as well as provides the ability of recycling.

This all in all, turns to be safer, healthier 11 / 14 Journal of StudentResearchFourthMiddleEastCollegeStudentResearch Conference,Muscat,SultanateofOman(2019)ISSN:2167-1907 (www.jofsr.org) and also a money saver package, saving you a fine amount spent on fuel. Investigation into other vitality sources, for example, power devices and sustainable powers make the future look more splendid for hybrid vehicles.

RECCOMENDATIONS

Manypeoplehavetheconceptionofhybridvehiclesbeingalotmore expensive than the regular gasoline vehicles.

The truth in fact, is that the hybrid types cost only a very few morethousandsthanthegasolinetypesofthesamemodel.For example;theHyundaiSonataHybridcosts$26,000,whereasthe gasoline counterpart costs $22,000. In the long run, these few extra thousands will cover up the huge amount spent on fuel yearly. It was also witnessed that the EU is providing incentives for people who use fully electric cars,such as reduced taxesand other similar traits. A similar trait can be introduced and implemented in GCC counties to encourage the purchase of hybrid vehicles, like for example reduced gas rates per liters for certified hybrid cars.

Duetothenatureof electriccars,itdoesn’tseemlikea viable solution; atleastin GCC toimplementthemsincetheyarethe mostenvironmentallyfriendlyvehiclesduetotheexclusionofanIC engine. The reasons behind this are: electric cars don’t cover enough millagewithout needingto be recharged.Based on experiments conducted, the most distance that an electric

car was able to attain by driving in specific conditions was approximately300kilometerswithoutneedingtochargethecar. Another reason is that there are not enough charging stations. Untilthatrealitycomesintofruition,hybridvehiclesaredeemed to be the most viablesolution toreduce pollution;atleast inthe GCC.

## DescriptionofElectricVehicles,operationaladvantages, present performance andapplications of Electric Vehicles

The electric car(EV) is a relatively new concept in the world of the automotiveindustry.Althoughsomecompanieshavebased theirentire modelofcarsaroundbeingproactiveand usingelectricity,somealso offer hybrid vehiclesthat work off both electricity and gas.

AnelectriccarsuchasNissan Leaf,FordFocusElectricorTeslaModelS, ChevroletVoltisagreatwayforyoutonotonlysavemoneybutalso help contribute towards a healthy and stable environment.

Carsproducealotofcarbonemissionsthatareejectedintoournatural atmosphere, leaving us vulnerable to things likepollutionandgreenhousegases.Inordertopositivelyhelpthe environment we live in, an electric car is a great step forward.

By buying an electric car, you can also receive government subsidies forbeingenvironmentallyconscious.Althoughyoumayenduppaying moreforyourvehicle,thepositivesgreatlyovershadowthenegatives. However, there are still two sides to consider when you're thinking about investing in an electric vehicle.

EV'sgettheirpowerfromrechargeablebatteriesinstalledinsidethecar. Thesebatteries arenotonlyused to powerthecar butalsoused forthe functioning of lights and wipers.

Electriccarshavemorebatteriesthanaregulargasolinecar.It'sthe samekindofbatteriesthatarecommonlyusedwhenstartingupa

gasolineengine.Theonlydifferencecomesinthefact thatinelectric vehicles,theyhavemoreofthem,whichareusedtopowertheengine.

## AdvantagesofanElectricCar

Anelectriccarcanbeagreatwayforyou,asaconsumer,tosavealot ofmoneyongas.However,therearesomany differentreasonswhyyou should invest in an electric car in the modern-day of technology.

### 1. NoGasRequired

Electriccarsareentirelychargedbytheelectricityyouprovide,meaning you don'tneedtobuyanygaseveragain.Drivingfuel-basedcarscanburn a hole in your pocket as prices of fuel have gone all-time high.

The average American pays about 15 cents a mile to drive a gas-poweredvehicle,whereasmanyelectriccarsrunonfivecentsamile.Electricity is largely less expensive than gasoline.

If most people charge their cars in the garage installing a few solar panels,thatpricecangetcutevenfurther,offeringsavingsonpoweringyour entirehome.Withelectriccars,thiscostof$2000 –$4000ongaseach year can be avoided.

### 2. MoreConvenient

Theelectricvehicleiseasy torecharge,andthebestpartisyouwillno longerneedtoruntothefuelstationtorechargeyourcarbeforehitting the road! Even a normal household socket could be used for charging an electric car.

### 3. Savings

These cars can be fuelled for very low prices, and many new cars will offergreatincentivesforyoutogetmoneybackfromthegovernment for goinggreen.Electriccarscanalsobeagreatwaytosavemoneyinyourown life.

### 4. NoEmissions

Thebiggestadvantageofan electricvehicleisitsgreen credential. Electriccarsare100percenteco-friendlyastheyrunonelectrically powered engines.

Itdoesnotemittoxicgasesorsmokeintheenvironmentasitrunson a clean energy source. They are even better than hybrid carsas hybrids running ongasproduceemissions.You'llbecontributingtoahealthyandgreen climate.

## 5. Popularity

EV'saregrowinginpopularity.Itisnearlythreetimesasefficientascarswithan internal combustion engine, according to Wikipedia. With popularitycomes allnewtypes of cars being puton themarketthatare unique, providing you with a wealth of choices moving forward.

## 6. SafetoDrive

Electric cars undergo the same fitness and testing procedures test as otherfuel-poweredcars.Anelectriccarissafertouse,giventheirlower center ofgravity,whichmakesthemmuchmorestableontheroadincaseofa collision.

In case an accident occurs, one can expect airbags to open up and electricitysupplytocutfromthebattery.Thiscanpreventyouandother passengersinthecarfromseriousinjuries.Theyareevenlesslikelyto explode in the absence of any combustible fuel or gas.

## 7. Cost-Effective

Earlier, owning an electric car would cost a bomb. But with more technologicaladvancements,bothcostandmaintenancehavegonedown.

Themassproductionofbatteriesandavailabletaxincentivesfurtherbrought down the cost, thus, making it much more cost-effective. Consultataxspecialisttolearnmoreaboutanytaxcreditsthatmightbe available to you on the state or federal level.

## 8. LowMaintenance

Electriccarsrunonelectricallypoweredengines,andhencethereisnoneed to lubricate the engines, anything related to the combustion engineoratonofmaintenancetasksthatareusuallyassociatedwitha gas engine.

Otherexpensiveengineworkisathingofthepast.Therefore,the maintenance cost of these cars has come down. You don'tneed to send ittotheservicestationoftenasyoudoforastandardgasoline-powered car.

## 9. ReducedNoisePollution

Electriccarsputacurbonnoisepollutionastheyaremuchquieter. Electric motors are capable of providing smooth drive with higher accelerationoverlongerdistances.Manyownersofelectriccarshave reportedpositivesavingsofuptotensofthousandsofdollarsayear.

## 10. BatteryLife&Cost

Batteriesareanintegralpartofanelectricvehicle.Mostelectricvehicle batteriesarelithiumones,andtheircostsareimprovingeveryyear.

The full capacity of a lithium-ion battery cell should be good for300 to 500 cycles. A good battery could last you up to ten years. With the improvingtechnologies,thecostofthesebatteriesisexpectedtocomedown even more.

## 11. EasyDriving

In the world of automobiles, electric cars have the simplest driving method.Commercialelectriccarscomewithatransmissioncomprising of onlyonereallylonggearandalsodon'tsufferfromthestallingproblem as petrol cars do.

This effectively eliminates the need to add a clutch mechanism to preventthatfromhappening.Therefore,youcanoperateanelectriccar with just the accelerator pedal, brake pedal and steering wheel.

Anotherreallyusefulfeatureisregenerativebraking.Innormalcars,the brakingprocessisatotalwastageofkineticenergythatgetsreleasedas

frictionalheat.However,inanelectricvehicle,thesameenergyisusedto charge the batteries.

Consideringthedemandforoilwillonlybegoingupasthesuppliesrunout,an electric car will most likely be the normal mode oftransportation in the coming future.

Companies like Nissan and Tesla offer great electric models with an outstandingamountofbenefitsforpeoplewhodecidetoinvest.You'll be savingnotonlyyourselfbutalsoyourfamilyahugeamountof money.

Theenvironmentalimpactofanelectriccariszero,aswell,meaning you're reducingyourcarbonfootprintandpositivelyaffectingtheeconomy.

APPLICATIONSOFELECTRICVEHICLE

.Consumerelectronics

.publictransportation

.aviation

.electricitygrid

.renewableenergystorage

.military

.spaceflight

.wearabletechnology

# 6.3 Battery for Electric Vehicles, Battery types and fuel cells

Anelectricvehiclebattery(EVB,alsoknownasatractionbattery)is a rechargeable batteryused to power the electric motorsof a battery electricvehicle(BEV)orhybridelectricvehicle(HEV).Typicallylithium-ion batteries,theyarespecificallydesignedfor highelectriccharge(orenergy) capacity.

Electric vehicle batteries differ from starting, lighting, and ignition(SLI) batteries as they are designed to give power over sustained periods of time and are deep-cycle batteries. Batteries for electric vehicles are characterized by their relatively high power-to-weight ratio, specific energy and energy density; smaller, lighter batteries are desirable becausetheyreducetheweightofthevehicleandthereforeimproveits performance. Compared to liquid fuels, most current battery technologieshavemuchlower specificenergy,andthisoftenimpactsthe maximum all-electric range of the vehicles.

Themostcommonbatterytypeinmodern electricvehiclesarelithium-ionandlithiumpolymer,becauseoftheirhighenergydensitycompared to their weight. Other types of rechargeable batteries used in electric vehicles include lead–acid("flooded", deep-cycle, and valve regulated lead acid), nickel-cadmium, nickel–metal hydride, and, less commonly,zinc–air,andsodiumnickelchloride ("zebra")batteries.[1]Theamountofelectricity(i.e.electriccharge) storedinbatteriesismeasuredinamperehoursorincoulombs,withthetotal energy often measured in kilowatt-hours.

Since the late 1990s, advances in lithium-ion battery technology have beendrivenbydemandsfromportableelectronics,laptopcomputers, mobile phones, and power tools. The BEV and HEV marketplace has reapedthebenefitsoftheseadvancesbothinperformanceandenergy density. Unlike earlier battery chemistries, notably nickel-cadmium,

lithium-ionbatteriescanbedischargedandrechargeddailyandatanystateof charge.

The battery pack makes up a significant cost of a BEV or a HEV. As of December2019,thecostofelectricvehiclebatterieshasfallen87%since 2010 on a per kilowatt-hour basis.[2]As of 2018, vehicles with over 250mi(400km)ofall-electricrange,suchasthe TeslaModel S,have been commercialized and are now available in numerous vehicle segments.

Intermsofoperating costs, thepriceofelectricitytorun aBEVisasmall fractionofthecostoffuelforequivalentinternalcombustionengines, reflecting higher energy efficiency.

TypesofElectricCarBatteries

Electric car batteries are different from SLI batteries (starting, lightning and ignition). SLI batteries are batteries that are usually installed in gasolineordieselcars.Thistypeofelectriccarsbatteryisdesignedasan energy storage system, capable of delivering power for long and sustainable periods.

Thereare5typesofelectricvehiclebatteriestobediscussedinthisarticle:

- Lithium-Ion(Li-On)
- Nickel-MetalHybrid(NiMH)
- LeadAcid(SLA)
- Ultracapacitor
- ZEBRA(ZeroEmissionsBatteriesResearchActivity)

Thecomparisonofthefirstfourtypesofelectriccarbatteriescanbe seen as

follows: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Lithium-IonBattery(Li-On)

This type of electric vehicle battery is most widelyappliedistheLi-Onbattery.Thisbatterymayalready befamiliarto us because it is also used in many portable electronic equipment such as cellphones and laptops. The main difference is a matter of scale. Its physicalcapacityandsizeonelectriccarsismuchgreater –thisisoften referred to as a traction battery pack.

Li-on batteries have a very high power to weight ratio. This type of electric car battery is high energy efficiency. Performance at high temperaturesisalsogood.Thebatteryhasagreaterenergyratioper weight– aparameterthatisveryimportantforelectriccarbatteries.The smallerthe batteryweight(samekWHcapacity)means thecarcantravel further with a single charge.

Thisbatteryalsohasalow“self-discharge”level,sothebatteryisbetter than any other battery in maintaining its ability to hold its full charge.

Inaddition,mostpartsofLi-onbatteriescanberecycled,makingitthe right choiceforthoseinterestedinenvironmentallyconsciouselectriccars.
BEV cars and PHEVs use the most lithium batteries.

Li-onbatteryTypes

- LithiumIronPhosphate(LiFePO4)—LFP
- LithiumNickelCobaltAluminumOxide(LiNiCoAlO2)—NCA
- LithiumNickelManganeseCobaltOxide(LiNiMnCoO2)—NMC
- LithiumTitanate(Li2TiO3)—LTO
- LithiumManganeseOxide(LiMn2O4)—LMO
- LithiumCobaltOxide(LiCoO2)—LCO

Li-ion battery
parameters

| | | | |
|---|---|---|---|
| Mass Energy Density | 100-180 Wh/kg | Self-Discharge Rate | 1-5% / month |
| Volume Energy Density | 200-300 Wh/L | Cycle Durability | 500-15000 cycles |
| Power Density | 1000-5000 W/kg | Typical Cost | $0.50-$2.50/Wh |
| Charge/Discharge Efficiency | 95-99% | Self-Discharge Rate | 1-5% / month |
| Mass Energy Density | 100-180 Wh/kg | | |

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HybridNickel-Metal(NiMH)Batteries

NiMH batteries are more widely used by hybrid-electricvehicles(HEV),butarealsousedsuccessfullyinsomeBEV cars. This type of hybrid electric car battery does not get power from outside(canberechargedfroman outsidesourceofthecarsystem).The recharging of hybrid electric car batteries depends on engine speed, wheels and regenerative braking.

NiMHbatterieshavealongerlifecyclethanlithium-ionbatteriesorSLA batteries.NiMHbatteriesaresafeandtolerantofincorrectusage.The biggest disadvantages of NiMH batteries include:

- Thepriceisrelativelymoreexpensive
- Highself-dischargerate
- Generatesignificantheatathightemperatures.

ThesedeficienciesmakeNiMH lesseffectiveasabatteryforelectriccars whosebatteriesmustbeabletoberechargedfromoutsidethesystem, such as from the PLN network. That is why the car battery is the most widely applied by hybrid cars.

NiMHbattery
parameters

NiMH Battery Paramaters

| | | | |
|---|---|---|---|
| Mass energy density | 40-120 Wh/kg | Self-discharge rate | ~30% / month |
| Volume energy density | 140-400 Wh/L | Cycle durability | 500-1000 cycles |
| Power density | 300-1000 W/kg | Typical cost | $0.30-$0.60/Wh |
| Efficiency | 65-80% | | |

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Lead-Acid(SLA)Batteries

SLA(lead-acid)batteriesaretheoldestrechargeablebatteries.Comparedto lithiumandNiMH batteries,lead-acid batteriesdolosecapacity and are muchheavier, butthe price isrelatively cheapand safe.There are large capacitySLAelectriccarbatteriesunderdevelopment,butSLAbatteries are now only used by commercial vehicles as a secondary storage system.

Lead-acidbattery
parameters

Lead-acid Battery Paramaters

| | | | |
|---|---|---|---|
| Mass energy density | 30-40 Wh/kg | Self-discharge rate | 3-20% / month |
| Volume energy density | 60-75 Wh/L | Cycle durability | 500-800 cycles |
| Power density | 180 W/kg | Typical cost | $0.15-$0.30/Wh |
| Efficiency | 70-92% | | |

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Ultra-capacitorBatteries


The ultra-capacitor battery is not like the general definition of a battery. In contrast to other electro-chemical batteries, this type of electric vehicle battery actually stores polarized liquid between the electrode and the electrolyte. As the surface area of the liquid increases, the energy storage capacity also increases. Like SLA batteries,ultra-capacitorbatteriesarevery suitableassecondary storage devices in electric vehicles. This is because the ultra-capacitor helps electro-chemical batteries increase their load levels. In addition, ultra-capacitorcanprovideextrapowertoelectricvehiclesduringacceleration and regenerative braking.

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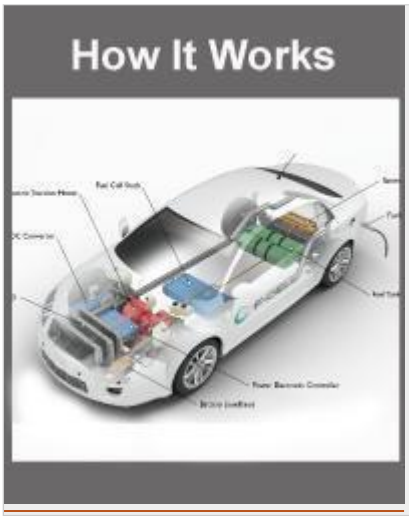
ZEBRABatteries

ThebatteryforZEBRAelectriccarsisalow-temperature variant of sodium-sulfur (NaS) batteries and is a developmentofZEBRA(originally“ZeoliteBatteryResearchAfrica” thenbecamea“ZeroEmissionsBatteriesResearchActivity”battery) in1985.FromthebeginningZEBRAbatterieswereindeeddevelopedfor electricvehicleapplications.ThebatteryusesNaAlCl4withNa+ -beta-alumina ceramic electrolyte.

CharacteristicsofZEBRAbatteries

- Highpowercellsothatitfitsasanelectriccarbattery
- Hightemperaturebatteriesoperateatmorethan270°C
- ThechemicalSodiumNickelChloride(NaNiCl)providesanominal operating cell voltage of 2.58 Volts

## FuelCellElectricVehicles




Fuelcellelectricvehicles(FCEVs)are poweredbyhydrogen.Theyare moreefficientthanconventionalinternalcombustionenginevehiclesand

producenotailpipeemissions—theyonlyemitwatervaporandwarmair. FCEVs and the hydrogen infrastructureto fuel them are in the early stages of implementation. The U.S. Department of Energy leads researchefforтsto make hydrogen-powered vehicles an affordable, environmentally friendly, and safe transportation option. Hydrogen is consideredanalternativefuelunderthe EnergyPolicyActof1992and qualifies for alternative fuel vehicle tax credits.

### Fuelcellelectricvehicle

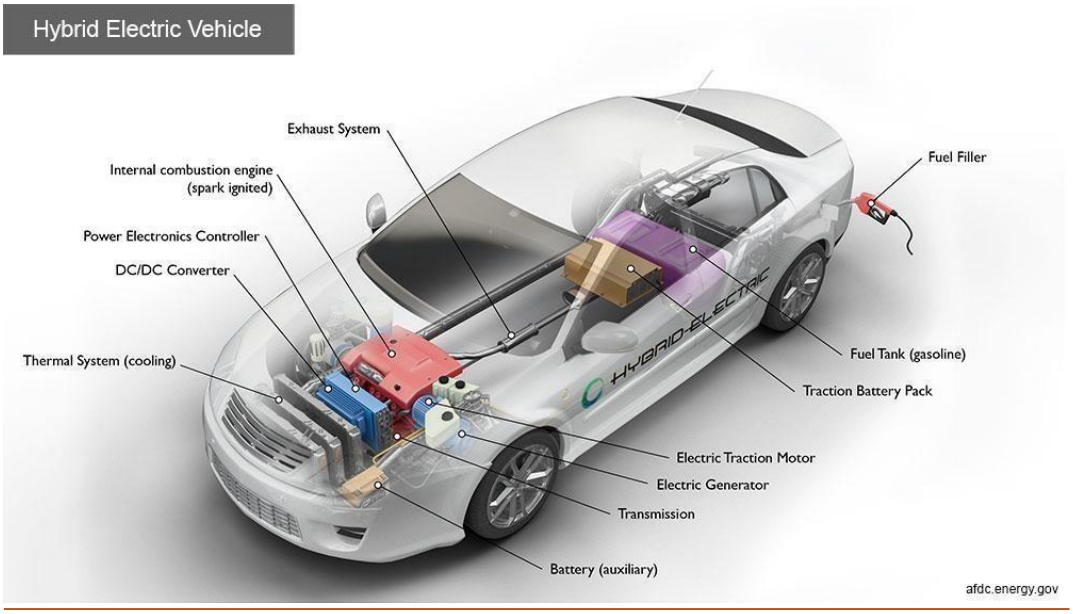
FCEVsuse apropulsionsystemsimilartothatofelectricvehicles, where energy stored as hydrogen is converted to electricity by the fuel cell. Unlikeconventionalinternalcombustionenginevehicles,thesevehicles producenoharmfultailpipeemissions.Otherbenefitsincludeincreasing U.S.energyresiliencythroughdiversityandstrengtheningtheeconomy.

FCEVsarefueledwithpurehydrogengasstoredinatankonthevehicle. Similartoconventionalinternalcombustionenginevehicles,theycanfuel inless than4 minutesandhave adrivingrange over 300miles.FCEVsare equipped with other advanced technologies to increase efficiency, such as regenerative braking systems that capture the energy lost during braking and store it in a battery

## 6.4 Hybrid vehicles, Types of Hybrid and Electric Vehicles: Parallel, Series, Parallel and Series configurations

Hybridelectricvehiclesarepoweredbyaninternalcombustionengine and an electric motor, which uses energy stored in batteries. A hybrid electric vehicle cannotbe pluggedin tocharge the battery.Instead, the battery is charged through regenerative braking and by the internal combustionengine.Theextrapowerprovidedbytheelectricmotorcan

potentially allow for a smaller engine. The battery can also power auxiliaryloadsandreduceengineidlingwhenstopped.Together,these features result in better fuel economy without sacrificing performance.Learnmoreabouthybridelectricvehicles.




## KeyComponentsofaHybridElectricCar

Battery(auxiliary):Inanelectricdrivevehicle,thelow-voltageauxiliary batteryprovideselectricitytostartthecarbeforethetractionbatteryis engaged; it also powers vehicle accessories.

DC/DCconverter:Thisdeviceconvertshigher-voltageDCpowerfromthe traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.

Electricgenerator:Generateselectricityfromtherotatingwheelswhile braking,transferringthatenergybacktothetraction batterypack.Some vehicles use motor generators that perform both the drive and regeneration functions.

Electrictractionmotor:Usingpowerfromthetractionbatterypack,this motor drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.

Exhaustsystem:Theexhaustsystemchannelstheexhaustgasesfrom theengine outthroughthetailpipe.Athree-waycatalystisdesignedto reduce engine-out emissions within the exhaust system.

Fuelfiller:Anozzlefromafueldispenserattachestothereceptacleon the vehicle to fill the tank.

Fueltank(gasoline):Thistankstoresgasolineonboardthevehicle until it's needed by the engine.

Internalcombustionengine(spark-ignited):Inthisconfiguration,fuelis injectedinto either the intake manifoldor the combustionchamber, whereitiscombinedwithair,andtheair/fuelmixtureisignitedbythe spark from a spark plug.

Powerelectronicscontroller:Thisunitmanagesthe flow ofelectrical energydeliveredbythetractionbattery,controllingthespeedofthe electric traction motor and the torque it produces.

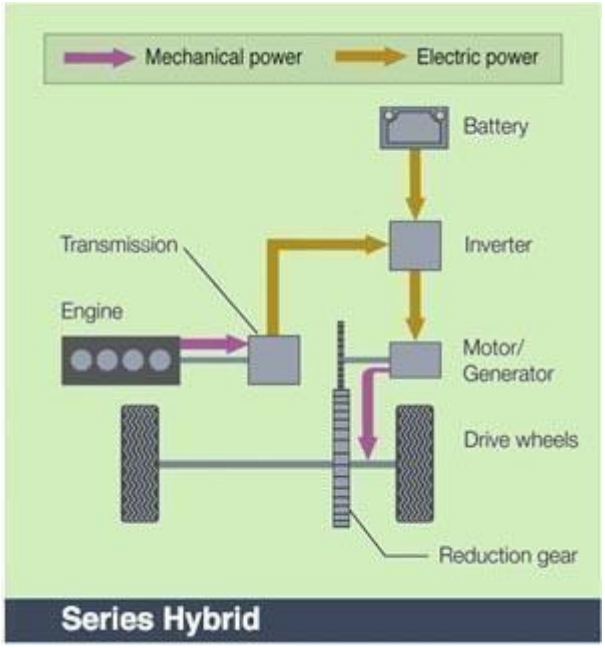
Thermalsystem(cooling):This systemmaintainsaproper operating temperaturerangeoftheengine,electricmotor,powerelectronics,and other components.

Tractionbatterypack:Storeselectricityforusebytheelectrictraction motor.

Transmission:Thetransmissiontransfersmechanicalpowerfromthe engine and/or electric traction motor to drive the wheels.

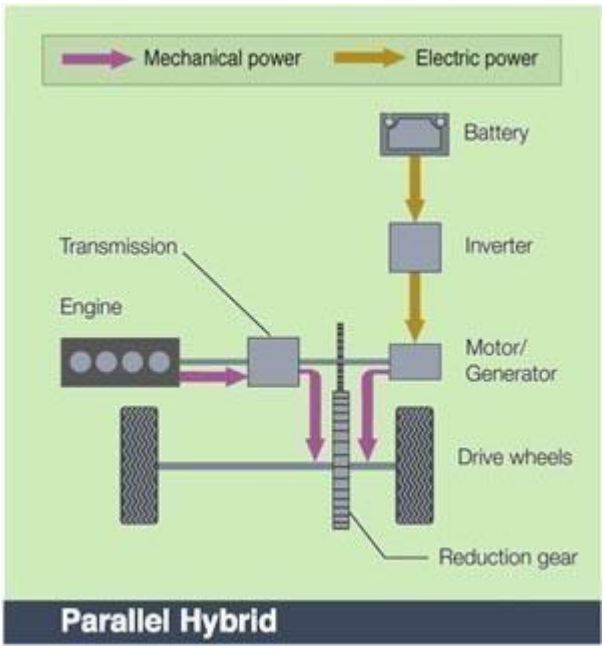
hetypeofHEVisdeterminedbyhowthepowertrainpropelsthevehicle down theroadandmaybeconsideredeitherseries,parallel,orseries- parallel.

# EnergyFlowDiagramsandDescriptions



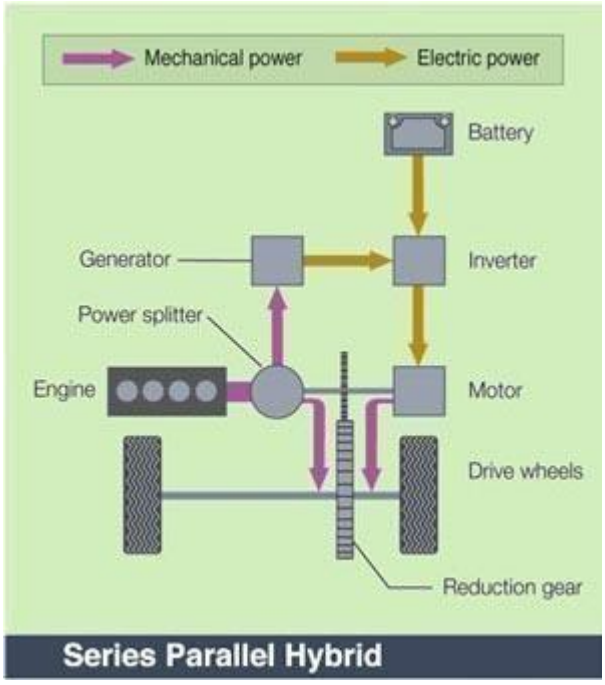

Series(Extended-Range)Hybrid

A series hybrid is like a battery electric vehicle (BEV) in design. Here, the combustionengine drivesan electric generator insteadofdirectly driving thewheels.Thegenerator both chargesabatteryandpowersanelectric motor that moves the vehicle. When large amounts of power are required, the motor draws electricity from both the battery and the generator. Series hybrids may also be referred to as extended-range electricvehicles(EREVs)orrange-extendedelectricvehicles(REEVs)since the gas engine only generates electricity to be used by the electricmotorandneverdirectlydrivesthewheels.Modernexamplesinclude the Cadillac ELR, Chevrolet Volt, and Fisker Karma.




ParallelHybrid

A parallel hybridis propelledby bothaninternal combustionengine (ICE) and an electric motor connected to a mechanical transmission. Power distribution between the engine and the motor is varied so both run in theiroptimumoperatingregionasmuchaspossible.Thereisnoseparate generator in a parallel hybrid. Whenever the generator's operation is needed, the motor functions as generator. In a parallel mild hybrid, the vehiclecanneverdriveinpureelectricmode.Theelectricmotorturnsononly when a boost is needed.




Series-Parallel

The vehicle can be powered by the gasoline engine working alone, the electricmotorbyitself,orbybothenergyconvertersworkingtogether. Powerdistributionbetweentheengineandmotorisdesignedsothatthe engine can run in its optimum operating range as much as possible.

Note:Allconfigurationsabovemayusemorethanonemotortodrivethe vehicle.

## 6.5 Drive train

A drivetrain is the collection of components that deliver power from a vehicle'sengineormotortothevehicle'swheels.Inhybrid-electriccars,the drivetrain's design determines how the electric motor works in conjunction with the conventional engine. The drivetrain affects the vehicle'smechanical efficiency, fuelconsumption, andpurchasingprice.

Hybrids that use a series drivetrain only receive mechanical power from theelectricmotor,whichisrunbyeitherabatteryoragasoline-powered generator. In hybrids with parallel drivetrains, the electric motor and internal combustion engine can provide mechanical power simultaneously.Series/parralleldrivetrainsenabletheengineandelectric motor to provide power independently or in conjunction with one another.

Bothconventionalhybridsandplug-inhybridshavemodelswithseries, parallel, and series/parallel drivetrains. Since battery-electricandhydrogenfuelcellvehiclesdon'thaveinternalcombustion engines, they utilize different drivetrain assemblies.

# 6.6 Solar powered vehicles

Battery recharging and range issues have been the Achilles heel of electricvehicles.Someautomotiveengineersbelievesolarpowermaybethe solution.

ThegoalofvehicleintegratedphotovoltaicsistoenableEVstorecharge without stopping. Unlike traditional EVs that must periodically pull overtorechargebatteriesduringalongroadtrip,solar carscankeepongoing.

Electriccarsandtrucksembeddedwithphotovoltaiccellscanconvert energy from sunlight into electricity. Storing solar energy in batteries enablesthemtorunsmoothlyatnightorintheabsenceofdirect sunlight.

Severalstart-ups,such asApteraMotors,AtlisMotor Vehicles,FiskerInc., LightyearOneandSonoMotors,aswellasestablishedOEMslikeHyundai, Tesla and Toyota, are developing solar cars or hybrid versions of them. Theyareintegratingsolarcellsintoroofs.However,otherbodyparts,such asdoors, hoods, tailgatesandtrunks, are alsoprime real estate.

"Automotive solar panels are a very interesting topic, because the technology can enable electric vehicles to recharge up to 40 percent faster," says Peter Harrop, Ph.D., chairman of IDTechEx, a market researchfirmthatrecentlypublishedareportonthesubject."Somecars have up to 7 square meters of space available for solar panels.

"The technology has already been successfully used on everything from boatstosatellites,"notesHarrop."Anycarortruckmanufacturerthatis not considering solar panel bodywork is crazy."

Solarpanelscanbeattachedtovehiclebodiesusingmechanicalfasteners or structural adhesives. However, to be aerodynamic and aesthetically pleasing, automotive engineers prefer to integrate solar modules into body panels.

“Whileitmay be possibletouseflexiblefilminthe future,solar panels arenotsimplystuckontovehiclestoday,”explainsHarrop.“Toachievethe complex shapes needed for car bodies, thin solar cells must be moldedintocarbon fiber, glass orpolycarbonate sheets.They become less like traditional solar panels, because they are actually structural elements.”

Asanexample,HarroppointstoLightyearOne,aDutchcompanythat planstolauncha“long-rangesolarelectricvehicledesignedtobegrid independent”laterthisyear.Itwillfeature5squaremetersofintegrated solar cells protected by double-curved and super-strong safety glass.

Thesolarroofwillcapturesunlightcontinuallywhetherthecarismoving or stationary.LightyearOneclaimsthatfeaturewilldeliverenoughenergy to cover an average of more than 70 percent of annual mileage.

AconductivebacksheetproducedbyRoyalDSMisanintegralelementof LightyearOne’ssolarroof.Itenablesalltheconnectionsofthesolarcellstobe put on the back of the solar panel, which makes every available centimeter on the front of the module available for capturing sunlight.

“Thereductioninelectrical(cell-to-module)lossesnotonlydeliversa3 percent increase in power output; it has the added advantage of contributingtoamorestylishsunroofwithaestheticappeal,”claims Pascal de Sain, vice president of DSM Advanced Solar.

AnothersolarroofconceptwasrecentlydevelopedbyengineersatTeijinLtd.It uses the company’s Panlite polycarbonate resin glazing for its surface.

“[Wemolded]theroof’scurvedsurfaceintoanidealshape,anextremely challenging process in the case of using glass,” says Toshiaki Hotaka, generalmanagerofTeijin’smobility division.“Not only istheroofideally shaped,itachievesthestrengthandrigidityrequiredforthe[application.”

The Teijin solar roof was installed on a prototype from Applied Electric Vehicles.DuringtestsconductedinAustralia,itachievedoutputofabout 330 watts, which is equivalent to a conventional solar panel housed under glass.

## NumerousBenefits

“Thebenefitofsolar-poweredvehiclesisthattheydon’trequirefuelandhave a low cost of maintenance,” says Lex Hoefsloot, CEO of Lightyear One. “Solar cars run longer on the same battery. This requires less charging stops and will get you faster from point A to point B. Solar energy will never run out and it is free.

“Becausethepressureonthegridfromsolarcarsisfarless,theyoffer thepotentialtotrulyscalecleanmobility,”explainsHoefsloot.“Froma userperspective,allyouneedisaregularpoweroutletcombinedwiththe sun; no need to wait for charging infrastructure, again creating a scalable solution.”

HoefslootclaimsthatLightyearOnewill“consumetwotothreetimesless energythanany otherelectricvehicleonthemarkettoday,whichresults in an exceptional range of 725 kilometers.” However, the overall achievable yield strongly depends on the driving patterns of individuals.

“[Ourvehicle]has around 1,000individual solar cells acrossthe car that ultimately add 50 to 70 kilometers of range per day during summer,” Hoefslootpointsout.“[Oursolarmodules]canchargethecar’sbattery with up to 12 kilometers of range an hour. These solar cells are 20 percentmoreefficientthanthesolarpanelsyoucanbuyforyourhome.And, they’re encased in safety glass to protect them from damage.

“Wewilloutsourcetheproductionofourvehicles,”saysHoefsloot.“We are currentlytalkingto[several]potentialproductionpartners...in Europe.”

“Thepowerthatcanpotentially be generatedon acar roofhasincreased substantially, due to the continuous improvement of solar cell and solar module technology, leading to higher efficiency,” adds Martin Heinrich, Ph.D.,headofthedepartmentofmoduletechnologyatthephotovoltaics divisionoftheFraunhoferInstituteforSolarEnergySystems.“Therefore, not only a cooling of the passenger cabin could be provided by the solar roof, but even a significant extension of the driving distance could be feasible.”

AccordingtoHeinrich,boththransparentandopaquephotovoltaicscanbe used for automotive applications. “But, since the available area on vehicles is quite small, we would rather use as much irradiation as possibleforpowergenerationinsteadofreceivinglightinthevehicle,”he explains.

“OpaquePVworksbetterandoffershigherpoweroutput,andtherefore generatesalargersolarrange,”saysHeinrich.“Iftransparencyisrequired(such asasunrooforrear window),transparentsolar celltechnologycan be used, but it currently has a significantly lower power output.”

Heinrich and his colleagues are working on several projects involving solarpanelintegrationintoroofsandhoodsforpassengercars,including efficient connection to the vehicle power management system. They're alsodevelopingmoduletechnologyforboxbodiesontrucksthatcanbe integrated into bodywork seamlessly, without any parts sticking out.

EngineeringChallenges

Despitetremendouspotential,equippingavehiclewithsolarpanels presentsnumerouschallengestoautomotiveengineers.Accordingto Heinrich, there are three big challenges:

- Makingthemostofthegeneratedenergy.Batterycharging lossesduetoself-consumptionorchargingstatuswherethe batteryisfullbutsolarpowercanstillbegeneratedmustbe addressed.
- 
- Manufacturingsafe,reliableandcost-effectivemodulesfor vehicle integration.
- 
- The reduction of power generation by bad weather and shadowingbyothervehicles,inadditiontobuildings,bridges, trees and tunnels. "This cannot be avoided, but prediction modelswouldprovidebetterestimatesforyieldcalculations and charging optimization," explains Heinrich.
- 

"Therearesolutionsavailabletothosechallenges,butinmostcases,they are still being studied," says Heinrich. "The main technological challenge is the utilization of the generated power. For a high utilization, the high-voltage drivetrain battery is preferred. However, this could lead to significanttransformationlossesandpotentiallysafetyconcerns."

Furtherchallengesariseduetothecurvatureofcarroofs.Forinstance,a strong curvature may lead to a significant irradiance mismatch and resulting cellpower,whichcouldreducetheyieldofthe solarmodule.In addition, moduleandcelltechnologyneedstoprovidethehighestyield,but alsoa premium aesthetic appearance and durability.

“Thechallengewithintegratingsolarcellsintoanelectricvehicleisto maximizethesurfacearea,makingsureyouachieveautomotive-grade standards for reliability and safety, while still optimizing the total performance,”saysArjovanderHam,chieftechnologyofficerat LightyearOne.“Integratingthecellsonadoublecurvedsurfaceensuresa great aerodynamic performance of the vehicle, but also creates a challenge in optimizing the yield.

“Normallysolarcellsareputinseries,”explainsvanderHam.“Inthatcase,the part in the shadow will reduce the yield of the total panel.

“Wehavedevelopedproprietaryandhighlyefficientsolarelectronicsto compensate for this loss,” adds van der Ham. “[It enables us] to put groupsofcellsinparallel.Wehavealsoperformedmanytypesofimpact,heat and vibration tests.”

Anotherstartupfirmthathasbeenstudyingtheprosandconsofsolarpoweris Atlis Motor Vehicles Inc. The company is getting ready to produce an electric pickup truck at a new factory in Mesa, AZ. Its innovative XT model,whichisaimedatcommercialusers,willbeequippedwitha solar panel tonneau cover system called TerraVis.

“Webelievetherecanbearoleforsolartoplayonafull-sizetrucklikeours,” says Mark Hanchett, CEO of Atlis Motor Vehicles. “There are ancillary functions where we feel solar could offer some advantages.

“Oneexampleisclimatecontrol,especially inhotclimateswherethesun is high,” notes Hanchett. “Even getting a couple hundred watts from a small solar array may be enough to run fans to provide circulation of air into the cab to avoid the 140 to 160 F peaks that are possible during the summer.Anotherpossibleuseforon-boardsolarisforlong-termstorage, to compensate for parasitic or ‘vampire’ drains on the battery.

“Eveninamuchshorterterm,likeduringthedayonajobsite,solarmaybeable to keep the battery at a consistent level while using power tools or chargerspoweredfromthetruck’son-boardpowerinverter,” Hanchettpointsout.“Forthesetasksandmore,asmallersetofpanelsableto make 250 to 500 watts of power would be sufficient.

“The problem comes down tothe energy density of solar,” warns Hanchett.“Simplyput,onlysomuchenergyfromthesunisavailableper

squaremeter,andsolarpanelscanonlycaptureaportionofthatenergy. Further complications arise from the orientation of the panels.

“[Unlike solar panels on homes], vehicles really only have horizontal surfaces to work with, and they are at a very flat angle, which is not the most optimal for making power,” says Hanchett. “And, parking in partial shadenearatreemayalsomeanthatacertainpanelcan’tmakeenoughpower, which can affect the output of the whole array.”

LettheSunShine

Several solar-powered cars are currently available, with others on the horizon. Last year, Hyundai Motor Co. unveiled a hybrid version of its popularSonatasedanthatisequippedwitharoof-mountedsystem.Itconsists of a solar panel and controller that enable the vehicle to generate and store electricity in a battery.

AccordingtoHyundai, the system can charge 30percentto 60 percentof thebatteryperday,whichcanincreasethe vehicle’straveldistancebyan extra 1,300 kilometers annually.

Severalstartupcompaniesarealsojumpingonthesolarcarbandwagon.

Laterthisyear,ApteraMotorsCorp.planstobegin mass-producinga three-wheeledsolar vehicleatitsfactoryin San Diego.Itscarbon-fiber compositebodywillbe coveredin3 square metersofsolar cells.The companyclaimsthatatleast90percentofthepowerproducedbythe solar panels will go toward propelling the vehicle.

“Integratedsolarcanbeconfiguredtoprovideupto45miles of range perday,”claimsChrisAnthony,CEOofApteraMotors.“[Thiswillbethe] first vehiclecapableof meetingmost daily drivingneedsusing solarpower alone.

“Ourbuilt-insolararraykeepsthebatterypacktoppedoff,”explains Anthony. “Never Charge technology is built into every vehicle and is designedtoharvestenoughsunlighttotravelover11,000milesperyear in mostregions.”

Sono Motors is a German start-up company that plans to ramp up productionofitsSionvehiclein2023ataformerSaabplantinTrollhättan, Sweden.Sono'sproprietarytechnology replacestraditionalpaintwith integrated solar panels.

“Solarmodulesareworkedseamlesslyintothesurfaceofthebodypartsto supply vehicles with electricity,” says Mathieu Baudrit, director of photovoltaic integrationatSono Motors.“Drawing onthe power of the sun,[our]systemwillbeabletoprovideenergyforanadditionalrangeofupto 245 kilometers a week.

“We have found away todeliver sustainable,free power acrossvarious transportation applications by replacing the traditional paint shop process with integrated solar technology,” claims Baudrit. “[Our] solar technologyischeaper,lighterandmuchmoreefficientthanconventional glass-basedsolarcells.Withaboundlessrangeofpotentialapplications, [it] is a seamless, flexible solution for efficient electric charging.

"We wanted to developavehicle thatcan harvestthe maximumamount ofenergy fromthesun,"explainsBaudrit."Currenttechnologiesavailable on the market are based on glass photovoltaics, only allowing solar cells to integrate on flat surfaces such as the roof. Having solar cells only on theroofwillnotharvestthemaximumsolarenergythroughouttheentire year, because the sun is lower in the sky during winter.

"Wehadtocreateawholenewmanufacturingprocesstointegratethe solar cellsonthevehiclebody,basedoninjectionmolding,"saysBaudrit. "Injection molding is a manufacturing process which allows us to make complex shaped parts out of polymers. It is a very fast manufacturing process, allowing low scrap rate and many different applications.

"[This enables us to] achieve a seamless integration of the photovoltaic functionintothecarbodypanels,"addsBaudrit."Itisflexibleinthesense that wecanshapethePVfunctiontotheformofthehostvehicleasrobustas conventional polymer car body panels and cheaper. Thanks to the injection molding process, we remove the need for curved glass.

"Weare planningtointegrate morethan248solarcellsintotheSion, withatargetofhaving1.2kWpofsolarcellsinstalledonthevehicle,"Baudrit points out. "The solar panels are the body panels. The solar

panelswillbeintegratedintothehood,fenders,sides,roofandrearof the vehicle, visually blending into the surface."

*THANKYOU*