AUTOMOBILE

ENGINEERING - 5th Sem

(Mechanical Engg)

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AUTOMOBILE

The automobile is defined as a self-propelling vehicle. In the past, the automobile was only required to serve as the legs for the people, but today many more things are demanded such as comfort and convenience, high mobility and maneuverability, running safety, economy and personnel safety.

The automobile has five basic components or parts:

1. The power plant or engine, which is the source of power.
2. The chassis, which supports the engine and body and includes the brake, steering and suspension systems.
3. The power train or drive train, which is the power-transmission system that carries power from the engine to the drive wheels. This unit includes clutch, gearbox, drive axle assembly, final drive, differential and the wheel axles.
4. The car body.
5. The car-body accessories, which include the heater and air conditioner, lights, radio and music player, windshield wiper and washer, power windows and seat adjusters.

VEHICLE LAYOUT

The following Fig.1.1 shows a basic structure and simplified layout of various transmission components used on a vehicle.

Transmission system

The transmission system covers the complete driveline between the engine and the road wheels. However, in many countries the term "transmission" refers to the gearbox unit.

Power unit

The normal source of power is provided by an internal combustion engine. The gasoline (petrol) engine is the most popular for its superior performance, but if the vehicle is used extensively, the excellent fuel economy given by a diesel engine makes this type attractive. The economy feature of the diesel engine offsets the higher initial cost and slightly reduced output.

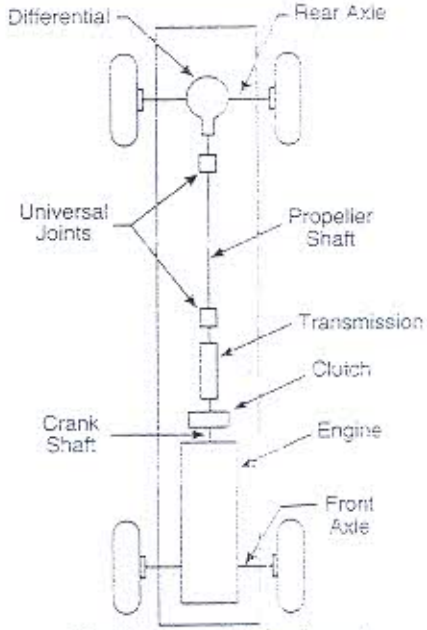


Fig. 1.1: Transmission layout

Clutch

The gears in a manual gearbox have to be changed. This action should only be performed when the gears are not under load, so a clutch is fitted to meet this need. This enables the driver to disconnect the engine from the gearbox.

Gearbox

Gearbox consists of sets of gears that amplify the engine torque to enable the driving force at the road wheels to be increased sufficiently to overcome the resistance to movement of the vehicle. Also the gearbox enables the engine speed to be kept within its working limits irrespective of the speed of the vehicle. In addition it provides neutral, where the engine can run without moving the vehicle and a reverse to drive the vehicle backwards.

Propeller shaft

This is the long tubular shaft which links the gearbox to the final drive. Normally an open type arrangement is used in which the shaft is exposed.

Universal joints

Universal joints are fitted to each end of the propeller shaft to enable the drive to be transmitted through a varying angle. This is to allow for the flexing of the chassis components that occurs when the vehicle is traveling over a bumpy surface.

Front axle

This arrangement supports the front of the vehicle and is also used for steering.

Rear axle

This carries the wheels and supports the weight of the rear of the vehicle. The axle is tubular in section and contains two axle shafts (half shafts) to drive the road wheels in rear wheel drives.

Final drive

On the vehicle centre line the axle is enlarged to house the final drive. This pair of gears turns the drive through 90° and reduces the driving speed which is suitable for the size of the road wheels.

Differential

When the vehicle is turning a corner, the inner and outer road wheels travel at different speeds. When the two road wheels are both rigidly connected to single axle shaft, the greater distance covered by the outer wheel causes one or both wheels to slip on the road. In addition to causing excessive tyre wear, this action makes the vehicle difficult to steer. Also axle shaft may break due to twisting of the shaft because of speed difference between the outer and inner wheels. These problems are overcome by using a differential. This unit ensures each wheel can rotate at different speed that suits the cornering conditions.

Wheels

Most light vehicles run on four wheels fitted with hollow rubber tyres filled with air under sufficient pressure to support the load they have to carry. These provide grip to the road and absorb shocks caused by small road irregularities.

TYPES OF AUTOMOBILES

Light vehicles

Vehicles classified in this category have a laden mass of less than th
different body shapes and sizes come into this light vehicle category. Th
cars to personnel carriers (mini-buses) and small trucks.

Commercial vehicles

Commercial vehicles are used to transport goods and people safely a
vehicles can be divided up not only according to the position of their en
their use, their body or their trailer type.

Light commercial vehicles

These small commercial vehicles are used for the conveyance of
ally over short distances, e.g. the type of vehicles used by tradesmen to c
shopkeepers to make local deliveries to their customers. Common types
trucks and mini-buses.

a. Vans

Vans are light commercial vehicles with a maximum weight of 7.5 t. They are generally used for short-range distribution of goods and passengers. Most vans have a load-carrying capacity of about 0.5 tonnes.

Fi

b. Pick-up

When a vehicle is required for the transportation of bulky equipment, e.g. materials carried by builders and decorators, an open body is often preferred. A light vehicle having this partly enclosed body is called a pick-up.

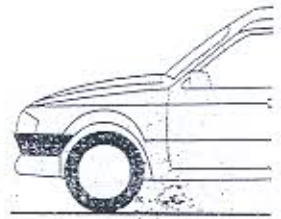


Fig. 1.3

Light trucks and mini-buses

Larger vehicles such as light trucks and minibuses need to carry heavier loads, so they require a stronger construction and have to be specially designed to suit the application. Since low-cost operation is an essential factor, most of these vehicles are fitted with a diesel engine.

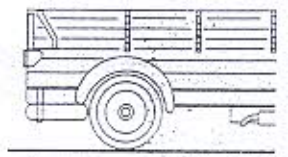


Fig. 1.4 L

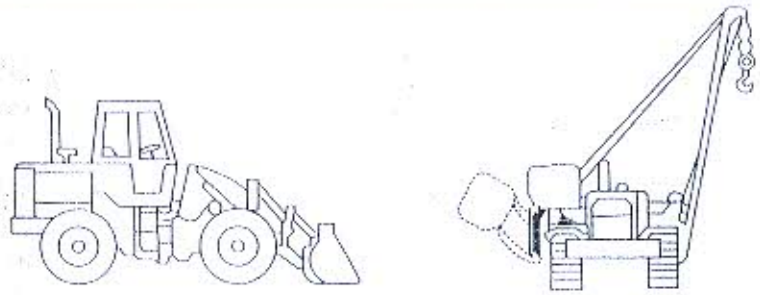
Heavy commercial vehicles

Although this book concentrates mainly on light vehicles, a review c
included for comparison purposes. Common types are:

- Trucks
- Road trains (truck and trailer outfits)

e. Special-purpose vehicles

These are large vehicles for the transportation of very heavy loads. They also include fire engines and trucks with crane or concrete-pump bodies. Because of their high permissible gross weight and their unusual dimensions, special-purpose vehicles often require a special operating license.



Loader Mobile crane

Fig. 1.9 Special-purpose vehicles

VEHICLE WEIGHTS & DIMENSIONS

Major weights and dimensions of a vehicle are explained below:

Weights

Payload

The total weight of passengers and cargo that a vehicle carries or can carry.

Gross Vehicle Weight (GVW)

GVW is the weight of the vehicle, plus the weight of all passengers the vehicle is designed to carry, plus the maximum allowable payload (passengers and cargo) or luggage load. It is also known as laden weight.

Curb Weight (CW) or Kerb Weight (KW)

CW is the weight of a vehicle wet, meaning with a full tank of fuel and all fluids filled, but without passengers or cargo (luggage).

Dimensions

(*a*) **Overall length:** The distance between the front and rear of the vehicle measured along the longitudinal centre line, including bumper guards, if the vehicle has them.

(*b*) **Overall width:** The maximum lateral distance measured between the sides of the vehicle. It includes bumpers, moldings, sheet metal protrusions, etc., measured to the outside of the metal.

(*c*) **Overall height:** The maximum vertical distance from the top of the roof to the road surface, measured with the vehicle in a curb weight condition.

(*d*) **Wheelbase:** The distance between the center lines of the front and rear axles.

(*e*) **Wheel tread (or) wheel track:** The distance between the longitudinal axes of the impressions (on the road surface) of the right and left wheels of a single axle of a vehicle.

(*f*) **Minimum running ground clearance:** The minimum clearance measured from ground with the vehicle in a gross vehicle weight condition.

(*g*) **Room length:** The horizontal distance along the vehicle's longitudinal (lengthwise) center line from the top of the instrument safety pad to the point directly above the top of the rear seatback.

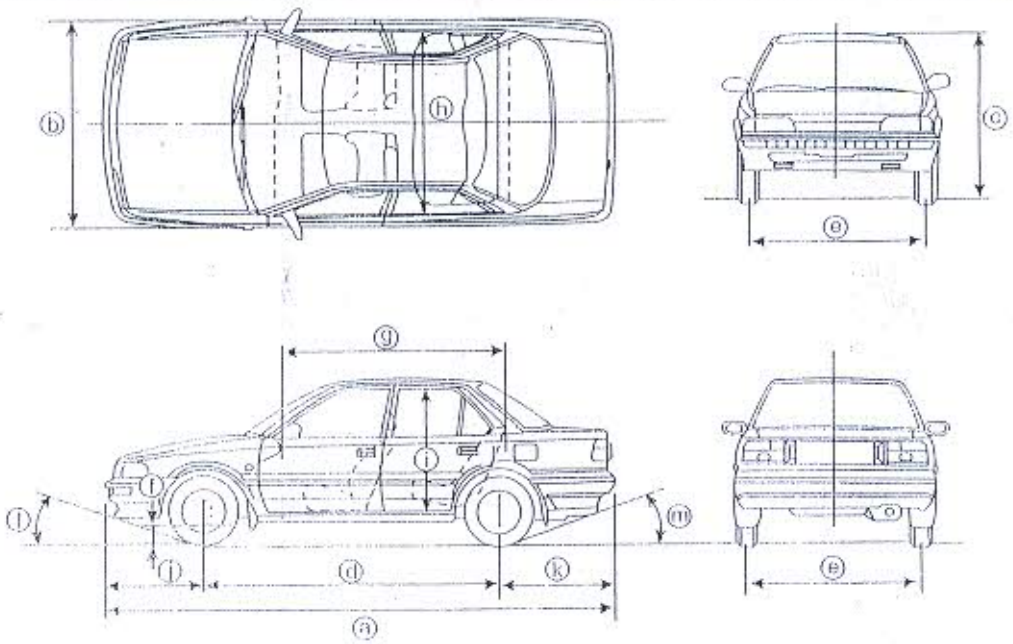


Fig. 1.10 Vehicle dimensions

(*h*) **Room width:** The maximum lateral distance between the trimmed interior body surfaces.

(*i*) **Room height:** The maximum vertical distance from the top of the floor covering to the headlining.

(*j*) **Overhang-front:** The distance from the center line of the front wheels to the front of the vehicle, including bumper guards if they are standard equipment.

(*k*) **Overhang-rear:** The distance from the center line of the rear wheels to the rear of the vehicle, including bumper guards if they are standard equipment.

(*l*) **Angle of approach:** The angle formed by the ground and the line tangent to the front tyre static loaded radius arc and the first point of interference (i.e. bumper, guard, gravel deflector, fender or other components excluding license plate).

(*m*) **Angle of departure:** The angle formed by the ground and the line tangent to the rear tyre static loaded radius arc and the first point of interference (i.e. bumper, guard, gravel deflector, tail pipe, fender or other components excluding license plate).

HISTORICAL DEVELOPMENT OF AUTOMOBILES

Development of the motor vehicle, that is to say a land based vehicle not limited to travelling on rails and driven by an engine or motor, received a decisive stimulus when the internal combustion engine was invented.

The pioneer years

1860 The Frenchman Lenoir constructs the first internal combustion engine capable of driving itself, with coal gas as a fuel. Efficiency was ~3%.

1867 Otto and Langen exhibit an improved internal combustion engine at the world exhibition in Paris. Efficiency was ~9%.

1878 Otto constructs the first gas engine using mixture compression and the four-stroke operating principle. Efficiency approx.15%. Almost simultaneously, the Englishman Clerk builds the first two-stroke gas engine.

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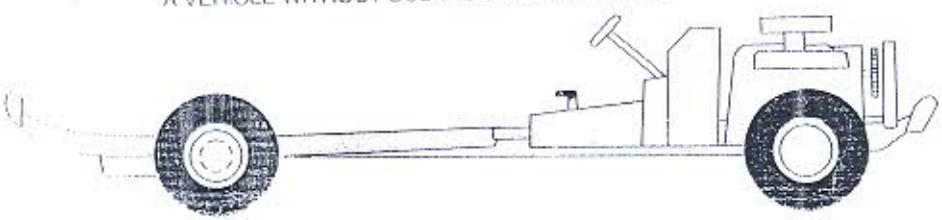
CHAPTER 2

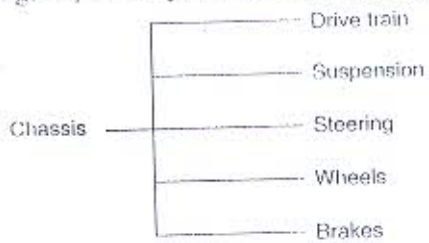
VEHICLE STRUCTURE

CHASSIS (OR) RUNNING GEAR

A VEHICLE WITHOUT BODY IS CALLED CHASSIS



The vehicle chassis includes the frame, engine, suspension system, steering system, and other mechanical parts with the body removed. These systems have direct impacts on riding comfort, the vehicle stability, steering feeling, etc, and vary widely in mechanisms and devices.



CHASSIS LAYOUT

Chassis layout refers to location of an engine and driveline components and also how power is transmitted from the engine to the drive wheels.

Chassis layout with reference to drive

Rear wheel drive

This layout has the engine in the front, mounted longitudinally, and the drive axle in the rear. The transmission is usually right behind the engine, and a drive shaft transfers power back to the rear axle. In this arrangement the rear wheels act as the driving wheels and the front wheels swivel to allow the vehicle to be steered. Spacing out the main components in this layout makes each unit accessible but a drawback is the intrusion of the transmission components into the passenger compartment. These create a large bulge in the region of the gearbox and a raised long bulge, called a tunnel, down the centre of the car floor for the accommodation of the propeller shaft. Using the rear wheels to propel the car utilizes the load transfer that takes place from the front to rear of the vehicle when the car is climbing a hill or accelerating and therefore good traction is obtained.

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1997 Present Toyota Prius was launched in the Japanese market, in September 2010 reached worldwide cumulative sales of 2.0 million units, becoming the most iconic hybrid electric vehicle in the world.

1998 Present Ford Focus is one of the most popular hatchbacks across the globe, that is also one of Ford's best selling world cars.

2008 Present Tata Nano is an inexpensive, rear-engined, four-passenger city car built by the Indian company Tata Motors and is aimed primarily at the Indian domestic market.

2010 Present, Nissan Leaf and Chevrolet Volt, an all-electric car and a plug-in hybrid correspondingly, were launched in the U.S. and Japanese markets in December 2010, becoming the first mass production vehicles of their kind.

THE MOTOR VEHICLES ACT, 1988

This volume examines laws regarding motor vehicles and their operation, including traffic violations and infractions, with significant focus on two major areas of public interest: speeding, and drinking and driving. It covers laws related to victims of accidents, young drivers, licensing requirements, vehicle safety issues, helmet use laws, seat belts, child restraints, and air bags, and the Transportation Equity Act.

The first enactment relating to motor vehicles in India was the Indian Motor Vehicles Act, 1914, which was subsequently replaced by the Motor Vehicles Act, 1939. The Act of 1939 had been amended several times. Inspite of several amendments it was felt necessary to bring out a comprehensive legislation keeping in view the changes in the transport technology, pattern of passenger and freight movements, development of the road network in the country and particularly the improved techniques in the motor vehicles management. Various committees as well as the Law Commission had gone into different aspects of road transport. Several members of parliament have also urged for comprehensive review of the Motor Vehicles act, 1939. A working group was, therefore, constituted in January, 1984 to review all the provisions of the act of 1939. This working group took into account the suggestions and recommendations earlier made by various bodies and institutions and made certain recommendations. On the recommendations of the working group state governments were asked to submit their comments. The recommendations made by the working group and comments received from the state governments were discussed at a special meeting of transport ministers of all states and union territories. Based on the conclusions reached in the meeting of transport ministers and suggestions made by the Supreme Court in a case the motor vehicles bill was introduced in the parliament.

Review Questions

1. What is meant by Automobile?
2. List the components of an automobile.
3. Who invented automobile?
4. Who first commercially manufactured motor vehicles?
5. What are the different types of motor vehicles on the basis of their construction?
6. What are the main units of a motorcar?
7. Which car set the pattern for many of those in use today?
8. Define body of a car.
9. What are the nominal requirements of a body?
10. What is meant by a saloon body?
11. What is meant by a coupe in an automobile?

the body is a part of the vehicle that carries the driver & passengers or cargo. It is made of steel sheets 0.6mm to 3mm thick welded into a box shape. It is a beam supported at each end by the wheels. So it has to be strong enough not to sag in the middle. So the middle not to sag when

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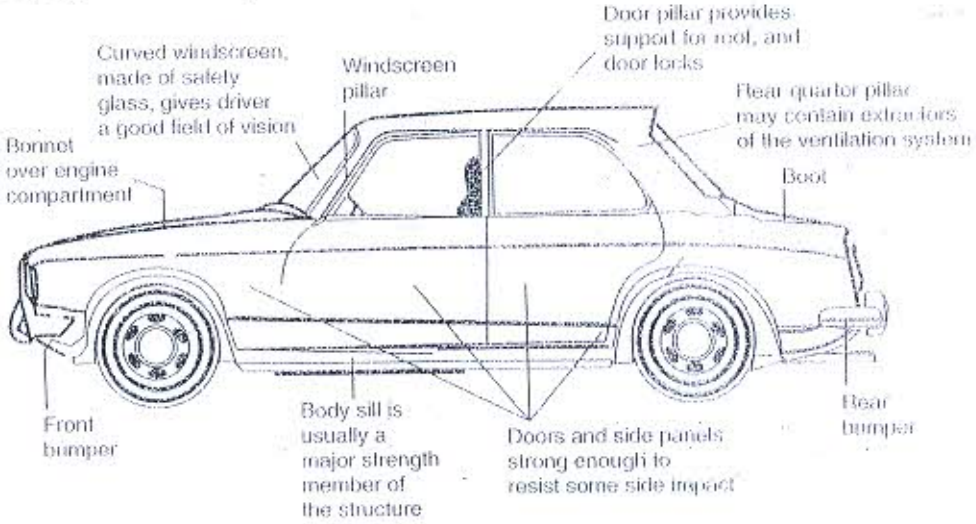


Fig. 2.14 Parts of a car body

The main parts of the car body are:

- **Bonnet** (or hood) over the engine compartment.
- Curved **windscreen**, made of safety glass, gives driver a good field of vision.
- **Windscreen pillar** provides support for windscreen glass.
- **Body sill** is usually a major strength member of the structure.
- **Door pillar** provides support for roof, and carries hinges and door locks.
- **Rear quarter pillar** may contain extractors of the ventilation system.
- **Boot** over the luggage compartment.
- **Doors and side panels** strong enough to resist some side impact.
- **Bumpers**, a horizontal bar fixed across the front or back of a motor vehicle to reduce serious damage in a collision or as a trim
- **Floor panels** ribbed for stiffness.

Bodywork materials

Steel (mild steel) is still the cheapest and the most efficient material for mass-produced separate bodies. It is strong and easily formed. The parts are stamped out by machine presses from varying thicknesses of sheet steel. Apart from steel, cast iron, aluminum, magnesium, copper, zinc, glass, and polymers are also the most commonly used materials.

Styling forms and role of stylist

Designing a form based on artistic vision is known as 'styling'. Styling enables high-volume production articles to be both attractive and functional. In fact in an age where mechanical reliability is almost automatic it is aesthetic value that provides the truly commercial success of a specific product.

Thus the stylists responsibilities in modern industry cover a very wide range. That is today's automotive stylist is required to be a combination of artist, inventor, craftsman, engineer and to some

extent psychologist. He must have the ability to conceive new ideas with inventive flair and imagination and bring them to an economical reality using modern techniques and facilities, correctly selecting for the specific project in hand. To do this, he must thoroughly understand the product, its function and its appeal, have a thorough knowledge of the materials available, costs, capacities of the machinery from which the product is to be made, in an economical manner, as well as sources of supply and so on and be constantly aware of worldwide changes in customs and tastes. His responsibilities include the conception, detail design and development of all new products and the form, both visual and ergonomic, which the product must take. In the case of automobile, this constitutes the exterior form and all applied finishers, the complete interior, control instrumentation, seating, etc and colours and textures of everything visible outside and inside the vehicle.

Body styling has to accommodate passengers and luggage space, the functional power train, steering, suspension and wheels, etc. Thus vehicle design will conflict with minimizing the body surface drag so that the body shape finally accepted is nearly always a compromise. The following are some of the body styles used for cars.

Saloon (or) Sedan

The basic car body shape is the saloon, with two or four doors and a luggage compartment at the front or rear. The shape of body shell is based on three 'boxes'. The front box forms the engine compartment, the centre section the container for the occupants and the rear box a storage space, called a boot (trunk) for the luggage. This type has the features such as well designed seats, ease of entry and exit, good heating and ventilation system and better styling.

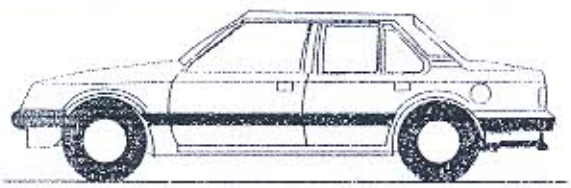
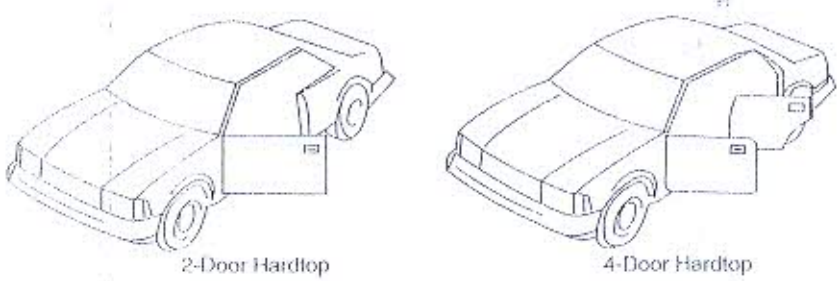


Fig. 2.15 Saloon

Hardtop

Hardtop passenger vehicles also have front and back seats and are generally characterized by their lack of door pillars or 'B' pillars. They can also be classified as either a 2 or 4-door hardtop.



2-Door Hardtop 4-Door Hardtop

Fig. 2.16 Hardtop

Hatchback (or) Lift back

This type is half-way between a saloon and an estate car. The distinguishing feature of this type of vehicles is their rear luggage compartment, which is an extension of the passenger compartment. Access to the luggage compartment is gained through an upward opening hatch door from which this type of vehicle derives its name. This type of vehicles comes in 3 and 5-door versions.

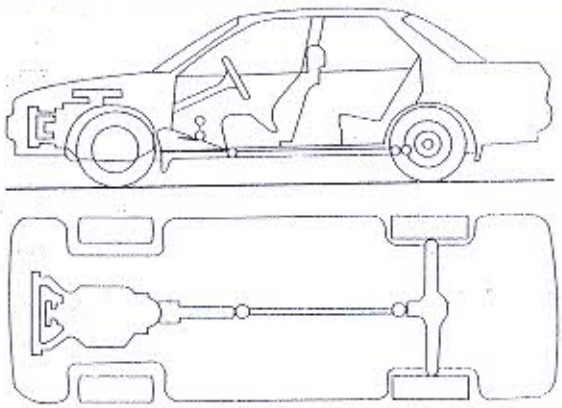


Fig. 2.1 Front engine rear-wheel drive

Front wheel drive

The compactness of the layout has made it very popular for use on cars. The vehicle has both the engine and transaxle in the front. Accommodating all the main components under the bonnet (hood) in one compartment give maximum space within the car for the occupants, also the absence of floor bulges and tunnel provides more room for the rear passengers. Transverse mounting of the engine simplifies the transmission, because the output shafts from the engine and gearbox move in a similar direction to the wheels. This avoids the need for a bevel-type final drive. Instead a simple reduction gear, incorporating a differential, transmits the power by short drive shafts to the road wheels. The heavy drive train adds weight to the front drive wheels for good traction on slippery pavement. Mounting the main units in one assembly sometimes makes it difficult to gain access to some parts.

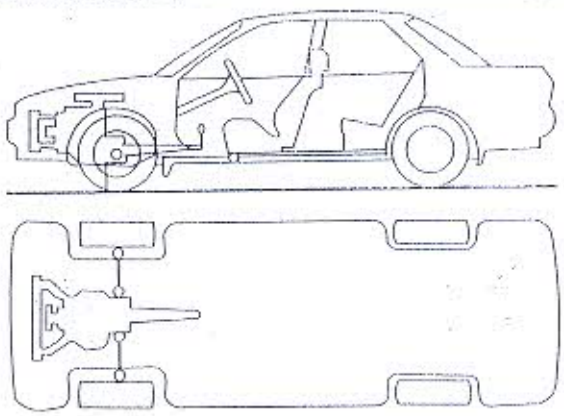


Fig. 2.2 Front engine front-wheel drive

The major criticism of front-wheel drive is that the driving wheels have less grip on the road when the vehicle is accelerating and hill-climbing. Although this characteristic can be partly corrected by placing the engine well forward to increase the load on the driving wheels, the car is then liable to become "nose-heavy". The effect of this is to make the steering of the car more difficult. For this case the car is to be fitted with power steering. Using the front wheels for steering allows the driving force to act in the same direction as the wheel is pointing. This feature improves vehicle handling especially in slippery conditions.

Four wheel drive

This arrangement is safer because it distributes the drive to all four wheels. The sharing of the load between the four wheels during acceleration reduces the risks of wheel spin. Also the positive

drive to each wheel during braking minimizes the possibility of wheel lock-up. A further advantage of this layout is when the vehicle is driven on slippery surfaces such as snow and mud. When on an icy road or driven cross-country (off-highway), a two-wheel drive vehicle soon becomes undrivable because the loss of grip of one of the driving wheels causes the wheel to spin.

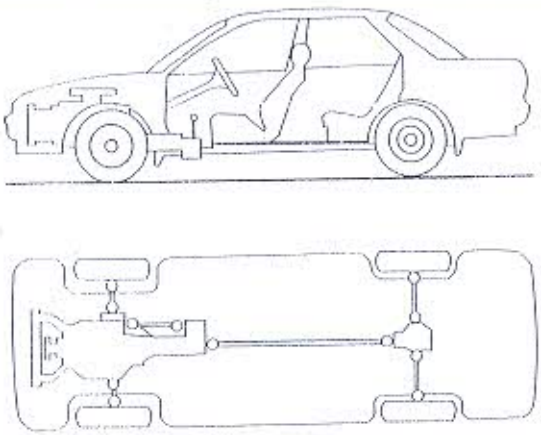


Fig. 2.3: Four-wheel drive

Chassis layout with reference to power plant location

Front engine

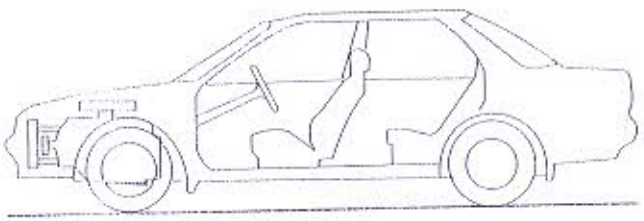


Fig. 2.4 Front-engine vehicle

Apart from tradition there are number of reasons for sitting the engine at the front of a car. The large mass of an engine at the front of the car gives the driver protection in the event of a head-on collision. Also engine cooling is simpler to arrange. In addition, the cornering ability of a vehicle is normally better if the weight is concentrated at the front. One of the main advantage is that engine can be controlled easily by the driver.

Rear engine

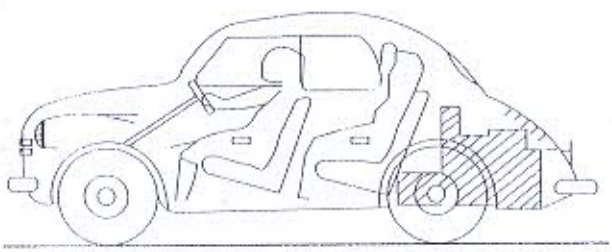


Fig. 2.5 Rear-engine vehicle

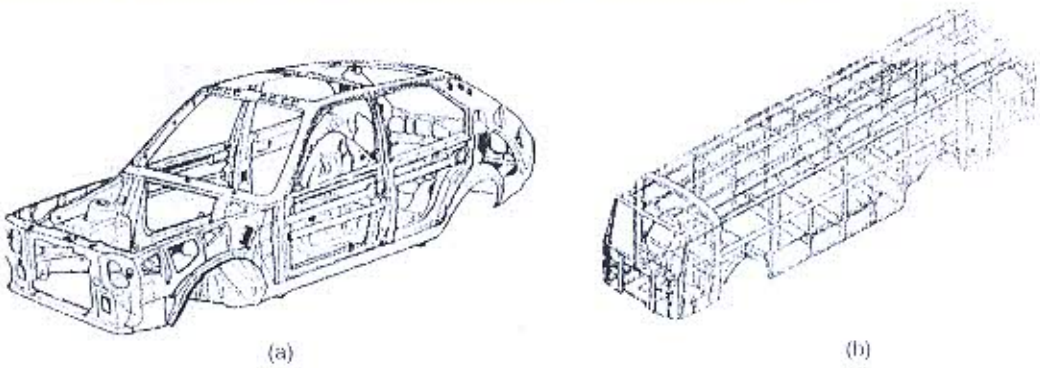
Most rear-engine layouts have been confined to comparatively small cars, because the heavy engine at the rear has an adverse effect on the 'handling' of the car by making it 'tail heavy'. Also it takes up a good deal of space that would be used on a front-engined car for carrying luggage. Most

in the chassis frame than a SUV/passenger car engine and therefore there is more space available for the front road wheels to turn on the larger vehicle and the ground clearance is greater.

Unitized body design (Frameless construction)

Today, almost all passenger cars, most vanes and even some buses are of integral construction, also known as integral or monocoque construction.

In this type of construction heavy side members used in conventional construction are eliminated and the floor is strengthened by cross members and the body, all welded.



(a) (b)

Fig. 2.9 Unitized body designs: (a) passenger car and (b) bus

Most of the modern cars have this integral construction. In this body design, the frame and body are combined as one unit. All the members of a unitized body are load carrying members. Panels or members that share the load are called stressed panels. Very often their creases and bends are there to increase strength rather than change the vehicle's appearance. Unstressed panels are those that do not contribute significantly to the strength of the structure. The floor pan, roof, inner aprons, quarter panels, pillars and rocker panels are integrally joined to form an unitized body. The unitized body has a complex design that spreads collision forces throughout the body to help protect the vehicle occupants.

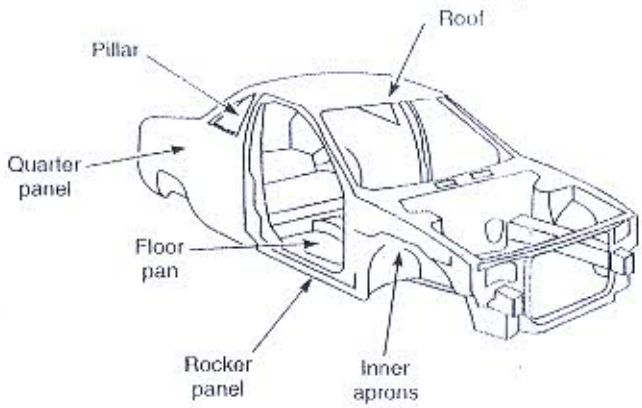


Fig. 2.10 Parts of an unitized body of a car

The strength and rigidity of the unitized body is achieved by body design rather than by having a heavy steel frame to support the body. In this body design, body sheet metal is fabricated into a box design which provides good resistance to bending and torsion.

The advantages of this construction are low weight and the ability to style the outer body panels as desired.

Design and production costs are very high, which means that integral construction is used only for mass-produced vehicles. A further disadvantage of this type of construction is that the resulting box-like shape tends to amplify road and engine noise for the occupants. Special sound-deadening materials are used to minimize the transmission of noise.

FRAME SECTIONS

In order to provide a good resistance to bending and torsional effect, the frame sections are made of proper forms.

Table 2.1 Frame sections and behaviours

Frame Section	Behaviour
Flat	Offers little resistance to bending and twisting.
Channel	Excellent resistance to bending. Resistance increases as depth of section is increased.
Tubular	Excellent resistance to torsion. Resistance increases as diameter is increased.
Box	Good resistance to both bending and torsion.
Top-hat	Not commonly used due to weakness and a propensity to rust.
I	Good resistance to both bending and torsion.

Channel section is usually employed for the side members as it provides good resistance to vertical bending loads, but with minimum weight. A further advantage of channel section is that it allows easy attachment of the cross members and mounting of other components. However, channel section provides only a limited resistance to torsion forces (i.e. poor in torsion) and is therefore unsuitable for the construction of cross members. As the cross members must be capable of resisting torsional effects, they may be formed from tubular or circular section, although for convenience a box section is sometimes employed.

Various other material sections may be used for the construction of cross members. These include the top-hat section and the I-section which is manufactured from two channel sections placed back-to-back. Provided the correct material section is used, the chassis frame can be made rigid enough to withstand the loads placed upon it.

FRAME MATERIALS

Frames are usually made of steel or aluminium and sometimes composite materials. Most frames used on light vehicles are made of low-carbon steel having a carbon content of 0.15-0.25

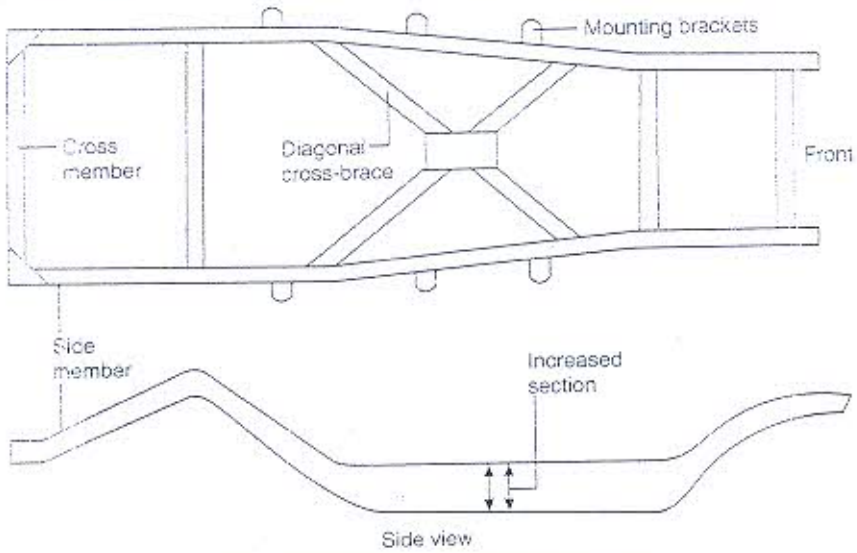
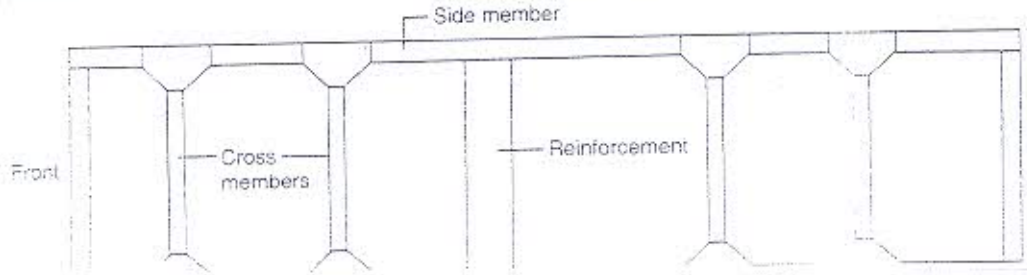


Fig. 2.7 SUV/Passenger car chassis frame

The front and rear ends of the side members are swept upwards (curved upwards) to accommodate the movement of the axle due to springing and also kept the chassis height low (lower ground clearance). This also avoids impact due to the rear axle bouncing. It is also common practice to provide the side members with an increased depth of section towards the centre, where there is a tendency for the greatest bending loads to occur. A number of brackets are attached to the main chassis members to provide a means of mounting and securing the vehicle body and components.

Although the use of a separate chassis frame is now restricted to low volume production cars it is still the main method of construction of commercial vehicle chassis.

Conventional construction for commercial vehicles

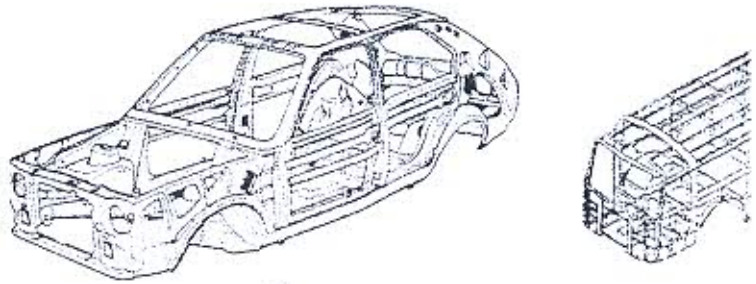


in the chassis frame than a SUV/passenger car engine and therefore there the front road wheels to turn on the larger vehicle and the ground clearar

Unitized body design (Frameless construction)

Today, almost all passenger cars, most vanes and even some buses a also known as integral or monocoque construction.

In this type of construction heavy side members used in conventio nated and the floor is strengthened by cross members and the body, all w



(a)

Fig. 2.9 Unitized body designs: (a) passenger car and (

Most of the modern cars have this integral construction. In this body are combined as one unit. All the members of a unitized body are load ca members that share the load are called stressed panels. Very often their c to increase strength rather than change the vehicle's appearance. Unstress not contribute significantly to the strength of the structure. The floor pan, panels, pillars and rocker panels are integrally joined to form an unitize has a complex design that spreads collision forces throughout the body occupants.

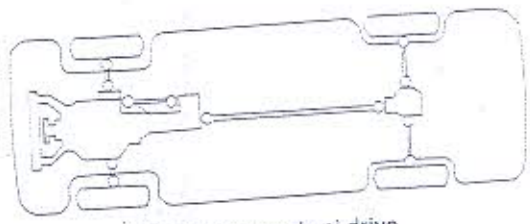


Fig. 2.3: Four-wheel drive

th reference to power plant location

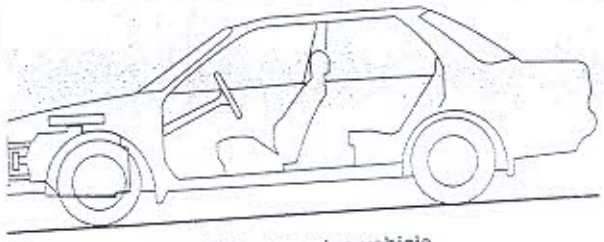


Fig. 2.4 Front-engine vehicle

on there are number of reasons for sitting the engine at the front of a car. The
ıe at the front of the car gives the driver protection in the event of a head-on
cooling is simpler to arrange. In addition, the cornering ability of a vehicle is
weight is concentrated at the front. One of the main advantage is that engine
ly by the driver.

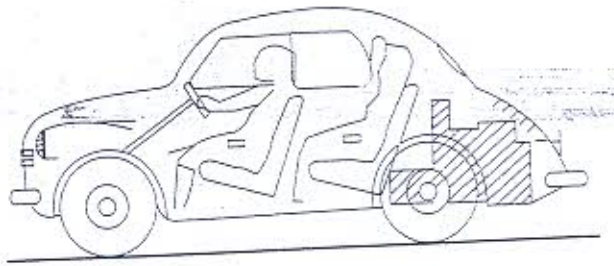


Fig. 2.5 Rear-engine vehicle

ıe layouts have been confined to comparatively small cars, because the heavy
s an adverse effect on the 'handling' of the car by making it 'tail heavy'. Also it
l of space that would be used on a front-engined car for carrying luggage. Most

Fig. 2.6 Mid-engine vehicle

The term mid-engine is used because the engine is mounted in front of the rear axle line. This situations generally apply to sports cars because the engine sitting gives a load distribution that achieves both good handling and maximum traction from the driving wheels.

CHASSIS FRAME

The vehicle frame is a high-strength structure used to support all other parts of the vehicle. Besides bolt-on body panels, the frame holds the engine, transmission, suspension, and other parts in position. The frame can be separate from the body or integrated into the body shell as in the case of unitized body design.

Purpose of a frame

The vehicle frame is used:

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

Constructional details

The chassis frame is usually constructed from steel pressings which may be welded, riveted or bolted together and reinforced where necessary. There are two major types: conventional construction and unitized body construction.

Conventional construction

In this type of chassis construction the frame is the basic unit to which various components are attached and body is bolted on the frame later on. It is also known as framed construction.

Conventional construction for passenger cars

The actual chassis frame consists of two longitudinal members which are referred to as side members. These members are braced by cross members (horizontal members) at the front and rear of the frame. To improve the torsional stiffness of the frame a diagonal cross-brace arrangement is added to the centre of the frame. The side members must taper in (narrow) at the front to provide shorter turning radius of front wheel and give improved support to the engine assembly. It is widening out at the rear end to provide a bigger space for body.

springs are fitted at the rear to support the extra load. Station wagons come in 2 and 4-door versions. More luggage space and longer wheel base are a specialty. Used for touring, picnics, etc.

Limousine

Limousine is the luxury car. The term now refers to a luxury sedan or saloon car, especially one with a lengthened wheelbase or driven by a chauffeur. It is usually with high quality equipments and best finish. Cushioned seats, air conditioning system, cooling glasses, etc., are other features.

Fig. 2.21 Limousine

Racing car

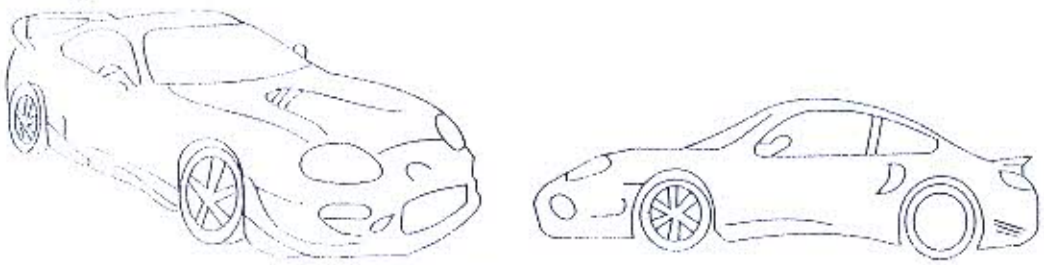


Fig. 2.22 Racing cars

Two prime criterias for racing cars are (1) lightness coupled with rigidity regardless of comfort and (2) body design must comply with the rules of the race or event such as length, width and height of car, engine capacity, fuel capacity, etc. Better aerodynamic shape reduces is the unique feature of this design.

VEHICLE BODY AERODYNAMICS

Aerodynamics is a branch of physics and is concerned with all the processes which can be observed when air flows around a body. This study deals with a solid body moving through the atmosphere and the interaction which takes place between the body surfaces and the surrounding air with varying relative speeds and wind direction.

Economy is of decisive importance in the transport sector. The most important factors in reducing fuel consumption in long distance traffic with its high average speeds are the economy of the drive train and aerodynamics.

As regards aerodynamics, the following are some of the features incorporated into the vehicle design.

- Large corner radii on the front section
- Low-level front skirts
- Fairings above and behind the driver's cab
- Aerodynamically shaped mirrors
- Enclosed steps

In addition to optimizing the shape of the driver's cab in terms of air flow to improve fuel consumption, there are a number of other aims to be considered in aerodynamic design, namely:

- Intensive air flow around cooling units
- Optimized air flow through the interior of cab

- Minimizing dirt deposition on visible areas
- Reducing impairment of the vision of other drivers in the wet

Importance of aerodynamic study

With proper aerodynamic design, the following advantages could be achieved

1. Drag force is reduced. So maximum speed and acceleration are obtained for the same power output.
2. Fuel consumption of the vehicle can be reduced to the maximum (about 35% of fuel cost).
3. Gives better appearance and styling.
4. By reducing the various forces and moments, good stability and safety can be achieved.
5. Helps to provide proper ventilation system.
6. Helps to understand the dirt flow and exhaust gas flow patterns.
7. Aerodynamic noise could be reduced which results in quite running of the vehicle.

AERODYNAMIC DRAG

This study concerns about the airflow around the vehicle body. Drag is caused by the movement of a vehicle in the atmosphere. This term is used to describe the resistance presented by the air to the moving object as it progresses. Aerodynamic drag is usually insignificant at low vehicle speed but the magnitude of air resistance becomes considerable with rising speed. This can be seen in Fig. 2.23 which compares the aerodynamic drag forces of a poorly streamlined and a very highly streamlined medium sized car against its constant rolling resistance over a typical speed range. A vehicle with a high drag resistance tends only marginally to hinder its acceleration but it does inhibit its maximum speed and increases the fuel consumption with increasing speed.

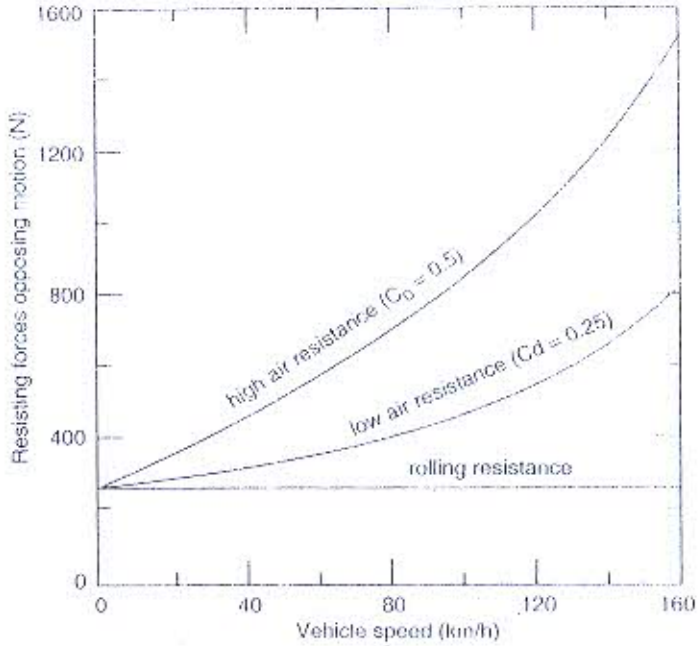


Fig. 2.23 Comparison of low and high aerodynamic drag forces with rolling resistance

Drag force depends on the following factors:

- The size and shape of the vehicle (area of nose end, vehicle super structures, shape of the loads being carried).

- Travel speed.
- Air density (air density decreases at higher temperatures and increases at higher atmospheric pressure).
- Wind direction and strength.

The aerodynamic resistance of a vehicle in air is referred to as drag force F_L. It is calculated according to the following formula:

$$F_L = \frac{1}{2} Cd\, A \rho v^2$$

Cd : Vehicle's drag co-efficient
A : Area of vehicle's nose end
ρ : Density of air
v : Velocity of the vehicle

To overcome drag, a vehicle must develop a specific amount of power. The drag power P_L is the result of drag force multiplied by travel speed v:

$$P_L = F_L\, v = \frac{1}{2} Cd\, A \rho\, v^3$$

At increasing travel speed, drag force increases by a power of two and drag power by a power of three. The increase in drag is as the square of the speed, i.e. if the speed doubles, the drag quadruples.

TYPES OF DRAG

The drag force is most easily understood if it is broken down into five constituent elements. This includes:

(*a*) Pressure drag	– 57%
(*b*) Induced drag	– 8%
(*c*) Friction drag	– 10%
(*d*) Interference drag	– 15% and
(*e*) Cooling and ventilation system drag	– 10%

(a) Pressure drag (or) Form drag (or) Profile drag

The most significant of the five in relation to road vehicles is the form drag which is the component that is most closely identified with the external shape of the vehicle. As a vehicle moves forward the motion of the air around it gives rise to pressures that vary over the entire body surface as shown in Fig. 2.24. If a small element of the surface area is considered then the force component acting along the axis of the car, the drag force, depends upon the magnitude of the pressure, the area of the element upon which it acts and the inclination of that surface element (Fig.2.25). Thus it is possible for two different designs, each having a similar frontal area, to have very different values of form drag.

Form drag depends upon the longitudinal section of the vehicle body. For low drag coefficient a careful choice of body profile is essential, i.e.

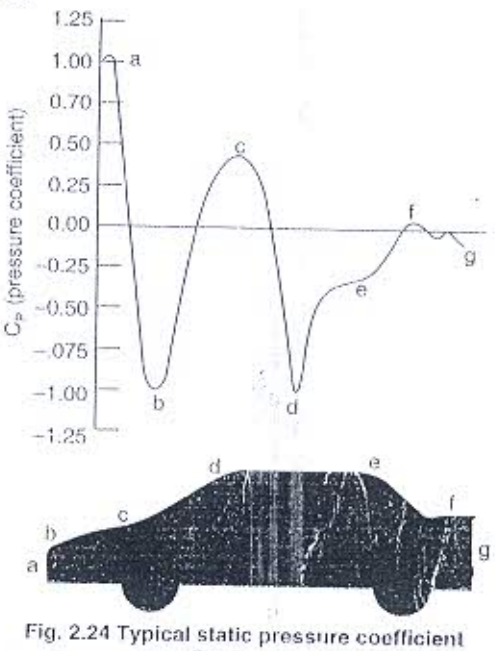


Fig. 2.24 Typical static pressure coefficient distribution

streamlines should be continuous and separation of boundary layer with its vortices should be avoided.

Body shapes that minimize positive aerodynamic forces on the front of the vehicle and minimize negative aerodynamic forces or suction on the rear of the vehicle will exhibit low form drag. The trend to lower vehicles has reduced the frontal area significantly which has reduced form drag appreciably. Constantly retarding fast back bodies may lead to passenger car shape of relatively low form drag.

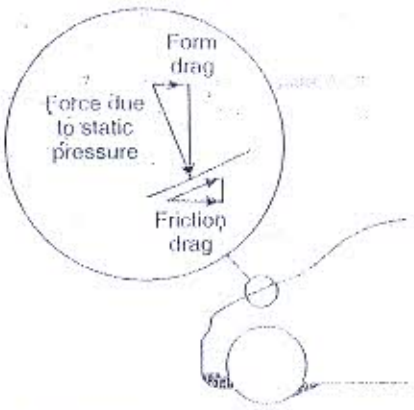


Fig. 2.25 The force acting on a surface element

(b) Friction drag (or) Surface drag

As air flows across the surface of the car frictional forces are generated giving rise to the second drag component which is usually referred to as surface drag or skin friction drag. If the viscosity of air is considered to be almost constant, the frictional forces at any point on the body surface depend upon the shear stresses generated in the boundary layer. The boundary layer is that layer of fluid close to the surface in which the air velocity changes from zero at the surface (relative to the vehicle) to its local maximum some distance from the surface.

This is caused by friction force between the boundary layer and the body surface. If this surface is kept smooth, a laminar boundary layer will be maintained. Thus a well-polished surface is not only attractive but also makes the vehicle more economical.

Body paint surface roughness has considerable effect on friction drag. Body smoothness is of the order of 0.5 to 1.0 microns.

(c) Induced drag (or) Lift drag

A consequence of the constraints imposed by realistic passenger space and mechanical design requirements is the creation of a profile which in most situations is found to generate a force with a vertical component. That lift, whether positive (upwards) or negative, induces changes in the character of the flow which the selves create an induced drag force. This is caused by vortices formed at the side of the vehicle. These vortices are in turn caused by the aerodynamic lift of the vehicle.

A car body produces accelerated air flow and the corresponding low pressure on its upper surface, especially in such areas of the lending edge of the hood, wind shield corners and the leading edge of the roof. Because of the low pressure developed on the upper surface than on the under body, aerodynamic lift results. This lift force depends on the contour of the body, underbody and ground clearance.

Lift is not a serious problem at normal speeds but it possesses a serious problem at very high speeds such as in racing cars. It also affects stability and braking performance of the vehicle. In general modification to the body so as to reduce accelerated flow and corresponding low pressure on the upper side and to reduce deceleration flow and corresponding high pressure on the underside of the body will reduce the aerodynamic lift.

(d) Interference drag

The flow over many exterior components interact with the flow over basic body shape and this lead to interference drag. Exterior components include projecting door handles, mirrors, aerials and badges which project out of the normal surface of the body. Also projectors below the vehicle such as axles, etc contribute towards the interference drag.

The various mechanical components project from under the vehicle such as an engine parts, suspension arms, exhaust system, frame rail and rear suspension also contribute to the interference

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e F_L. It is calculated

e drag power P_L is the

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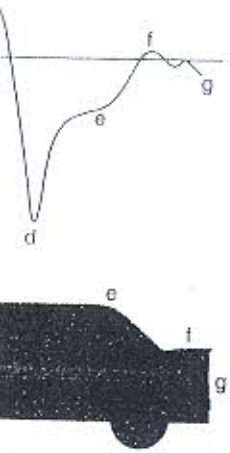
constituent elements,



pressure coefficient
tion

drag on the vehicle under body.Exterior body ornaments must be placed where the velocity is minimum. Door handles must be placed in a close proximity and longitudinally in line with each other.

(c) Internal drag (or) Cooling and ventilation system drag

The last of the major influences upon vehicle drag is that arising from the cooling of the engine, the cooling of other mechanical components such as the brakes and from cabin ventilation flows. Together these internal drag sources may typically contribute in excess of 10% of the overall drag.

DRAG CO-EFFICIENT (Cd)

The aerodynamic drag coefficient is a measure of the effectiveness of a streamline aerodynamic body shape in reducing the air resistance to the forward motion of a vehicle. Low Cd values indicate low drag and allow a higher terminal speed and lower fuel consumption. A low drag coefficient implies that the streamline shape of the vehicle's body is such as to enable it to move easily through the surrounding viscous air with the minimum of resistance. Conversely a high drag coefficient is caused by poor streamlining of the body profile so that there is a high air resistance when the vehicle is in motion. The drag coefficient is calculated in tests carried out in aerodynamic or wind tunnels. It indicates the magnitude of a vehicle's drag as a result of its shape.

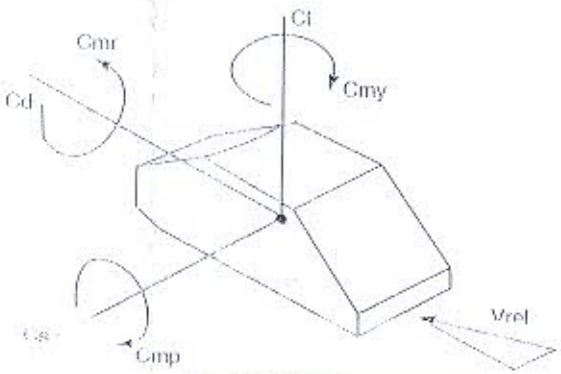
Typical drag coefficients for various classes of vehicles can be seen as follows:

Vehicle type	Drag coefficient (Cd)
Saloon car	0.22 – 0.4
Sports car	0.28 – 0.4
Light van	0.35 – 0.5
Buses and coaches	0.4 – 0.8
Articulated trucks	0.55 – 0.8
Ridged truck and draw bar trailer	0.7 – 0.9

The drag coefficient of a vehicle can be significantly reduced by rounding the front section and using a front apron, a roof spoiler and side skirts. Only a slight improvement in the drag coefficient is possible by altering the external shape of a commercial vehicle body since rounding the corners and edges reduces the load space and hence the payload. In combination with air deflectors, an aerodynamically optimized cab provides significant reductions in the drag of the vehicle as a whole.

Another measure for reducing resistance is to enclose the exposed running gear of the vehicle with fairings. This reduces the air resistance of the vehicle especially in a cross-wind.

AERODYNAMIC FORCES



Force coefficients:

Cl	lift
Cd	drag
Cs	side force

Moment coefficients:

Cmp	pitch
Cmr	roll
Cmy	yaw

Velocity:

Vrel	Relative airspeed

Fig. 2.26 Lift, drag, side force and moment axes

(21)

Aerodynamic research initially focused upon drag reduction, but it soon became apparent that the lift and side forces were also of great significance in terms of vehicle stability.

The aerodynamic forces and moments that act upon a vehicle are shown in coefficient form in Fig. 2.26. The forces may be considered to act along three, mutually perpendicular axes. Those forces are the drag, which is a measure of the aerodynamic force that resists the forward motion of the car, the lift which may act upwards or downwards and the side force which only occurs in the event of a cross-wind or when the vehicle is in close proximity to another. The lift, drag and pitching moments are a measure of the tendency of those three forces to cause the car to rotate about some datum, usually the centre of gravity. The moment effect is most easily observed in cross-wind conditions when the effective aerodynamic side force acts forward of the centre of gravity, resulting in the vehicle tending to steer away from the wind. In extreme, gusting conditions the steering correction made by the driver can lead to a loss of control.

In order to analyze the various aerodynamic forces and moments acting on the vehicle body, consider the vehicle as a mass having six degrees of freedom.

Now the various aerodynamic forces acting on the vehicle body can be summarized as follows:

Px – Force of air drag in the direction of motion with wind angle along the longitudinal axis

Py – Cross wind force

Pz – Aerodynamic lift

Longitudinal air drag (Px)

The longitudinal component of the resultant of pressure distribution is called longitudinal air drag. The magnitude of this component can be represented by,

$$Px = Cx \rho A v^2 / 2$$

Where,

Cx - Longitudinal wind force dimensionless co-efficient

ρ - Air density in kg/m^3

v - Velocity of wind in m/s

A - Cross sectional area of the vehicle viewed from the front in m.

Cross wind force (Py)

It is formed by the asymmetric flow of air around the vehicle body when the wind angle is not equal to zero. The cross wind force can be given as

$$Py = Cy \rho A v^2 / 2$$

Where,

Cy - Cross wind force dimensionless co-efficient

Aerodynamic lift (Pz)

It is the vertical component of the resultant of the pressure distribution over the vehicle body due to flow of air around it. The aerodynamic lift can be represented as

$$Pz = Cz \rho A v^2 / 2$$

Where,

Cz - Lift co-efficient

The lift will tend to reduce the pressure between the wheels and the ground, which causes losses of steering on the front axle and the loss of friction on the rear axle. The magnitude of this lift and its distribution over the front and rear is a function of ground clearance, the contours of the body and the underbody and the angle of attack of the air on the vehicle body.

Since these factors are not acting at the CG of the vehicle body but at the centre of pressure, they create the following three aerodynamic moments:

Mx - Rolling moment

My - Pitching moment

Mz - Yawing moment

Rolling moment (Mx)

This moment is caused by the cross wind force Py about the longitudinal axis. This magnitude of this rolling moment is given by

$$Mx = Py\ a = Cmx\ \rho\ A\ L\ v^2 / 2$$

Where,

a - Height of centre of thrust above CG

Cmx - Rolling moment coefficient

L - Reference length

The rolling moment effects the weight distribution on the wheels. This effect is dangerous for tall vans where the side force acts much above the CG. The only near solution to reduce rolling moment is to increase the wheel track.

Pitching moment (My)

This moment is caused about Y-axis by cross wind force Py or the longitudinal force Px. The pitching moment My is given by

$$My = Px\ b = Cmy\ \rho\ A\ L\ v^2 / 2$$

Where,

b - Distance between CG and CP

Cmy - Pitching moment coefficient

L - Reference length of the wheel base

The pitching moment is usually negative i.e., nose down and this moves. The rear axle lifts off the ground and further reduces the available traction.

Yawing moment (Mz)

This moment is caused about Z-axis by cross wind force Py. The yawing moment Mz is given by

$$Mz = Py\ c = Cmz\ \rho\ A\ L\ v^2 / 2$$

Where,

c - Distance between CG and CP

Cmz- Yawing moment coefficient

L - Reference length

These moments adversely affects the directional stability of the vehicle at high speed. The use of stabilizer fins at the rear of the vehicle gives a very good reduction in yawing moment.

Both aerodynamic lift and pitching moment have undesirable effects. The lift will lend to reduce the pressure between the wheels and the ground, which causes loss of steering on the front axle and loss of traction on the rear axle. Pitching moment is usually negative that is nose down and this makes the rear axle lift off the ground and further reduce the available traction.

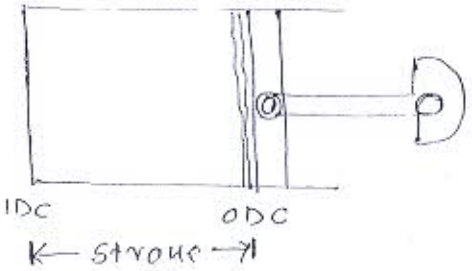
Note:

CG – is the point where the whole mass of a system is assumed to be act.

CP – is the point where the total pressure acts on the system.

Engine performance

when the piston moves from one end of the cylinder to the other, it displace air equal to the volume of cylinder.



piston displacement volume or swept volume

$$V = \frac{\pi}{4} D^2 \times L \times N$$

V = piston displacement volume

D = cylinder bore

L = Stroke length

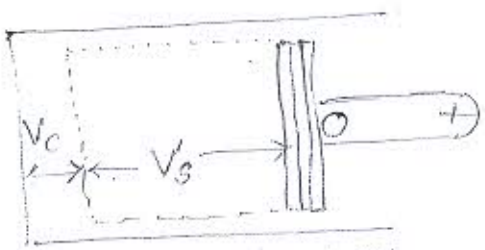
N = no of cylinders.

mean effective press (Pm)

It is defined as the hypothetical pressure which is acting on the piston throughout the power stroke.

$$\text{W.D/cycle} = P_m \times V_s$$

compression ratio (r)



but V_c = clearance volume

V_s = Stroke volume

V_{Total} = Total volume = $V_c + V_s$

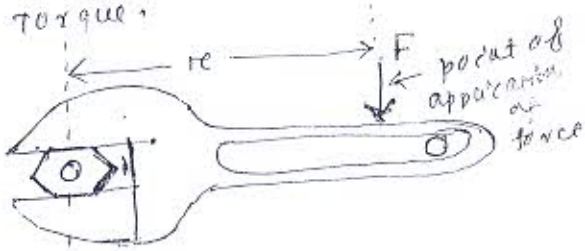
r = comp ratio

It is defined as the ratio between total volume and clearance volume

$$r = \frac{V_c + V_s}{V_c}$$

Engine Torque:- Defn of Torque:

Ex:- For tightening a bolt with the wrench, the force used to turn the bolt is Torque.



$$T = F \times r \quad Nm$$

Torque tending to turn the bolt is the product of the force and the distance from the centre of the bolt to the point where the force is applied. Therefore if greater torque is required a longer wrench should be used or more force applied

I.P (Indicated power): the power developed inside the engine cylinder

Indicated power per cylinder $P_m = N/m^2$

$$I.P = \frac{P_m A L N}{n}$$

A = m^2

L = m

N = Rotational speed of the engine in rev/s

n = no of revolutions required to complete one engine cycle.

n = 1 for 2 stroke engine

= 2 for 4 stroke engine

B.P (Brake power): the power available at the engine crankshaft is called brake power. It is called brake power because some types of brake (dynamometer) ...

$B.P = \frac{2\pi NT}{60}$ watt

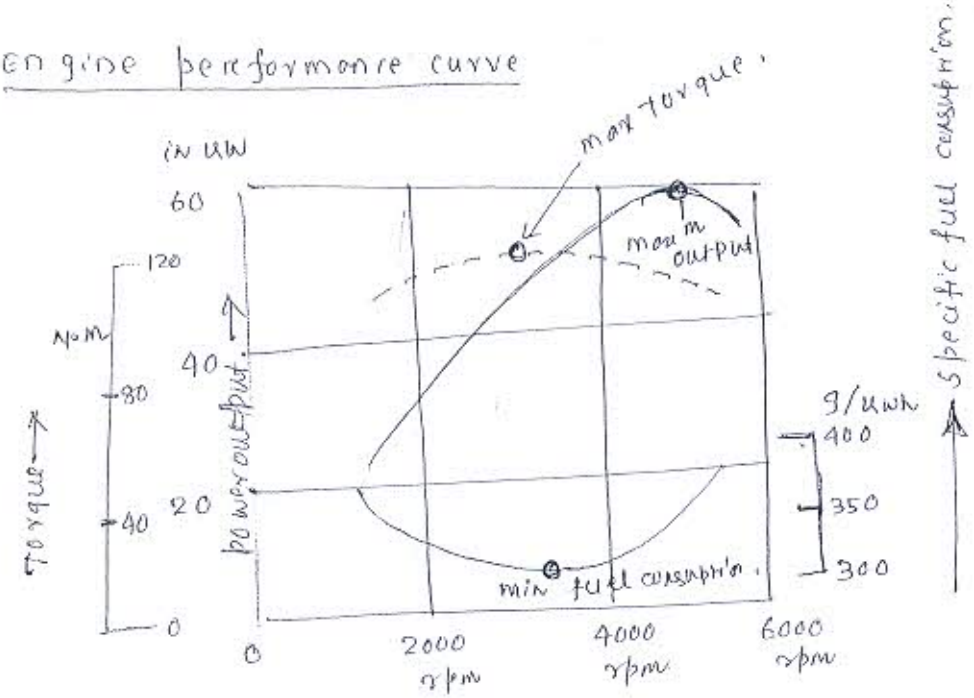
N = R.P.M

T = Braking Torque.

Frictional power (FP) :- Some power is lost in the cylinder, piston, connecting rod, crankshaft, gears, bearings, valve mechanisms, combustion chamber, fuel feed pump, injection pump, Atomiser, cooling system, lubricating system. This lost power is called friction power.

$$F.P = I.P - B.P$$

Engine performance curve



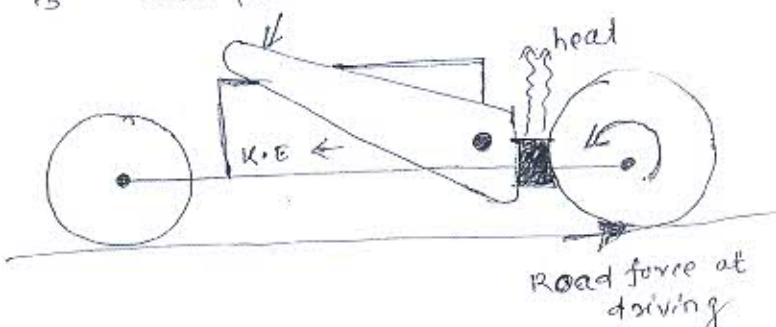
power torque and fuel consumption can be said as being important factors of engine performance. In regard to these three factors curves are plotted to determine how they vary with the engine speed. These curves are known as engine performance curve.

Brake system

Brakes are designed to

1) Decelerate or slowdown the vehicle
2) to stop the vehicle
3) Allow the vehicle to be parked on slope

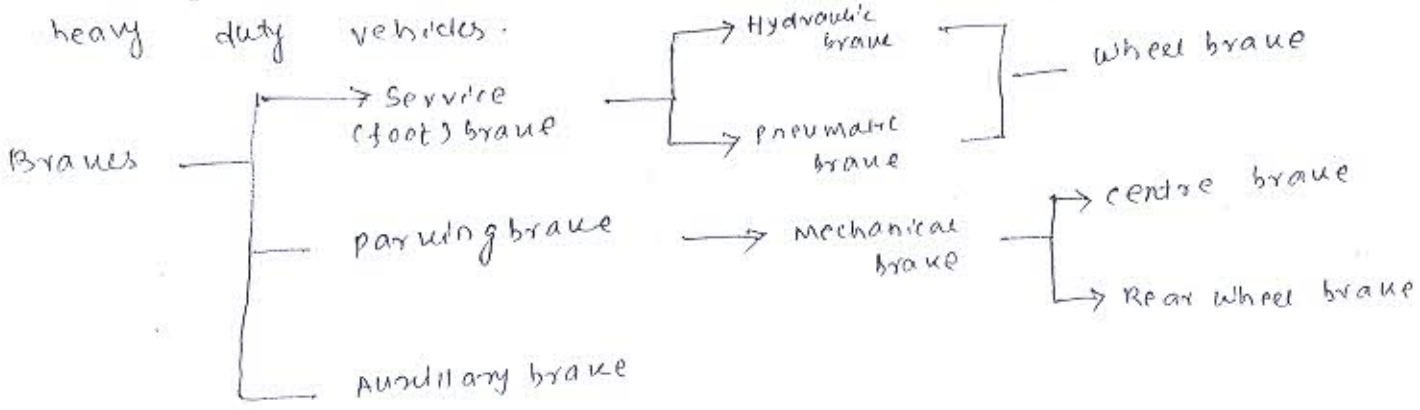
Principle:- A moving vehicle cannot stop immediately when the engine is disconnected from the power train, due to inertia (the tendency of a moving object to continue moving). This inertia must be reduced inorder to bring the vehicle to a halt. This engine converts heat (thermal energy) into kinetic energy (energy of motion) to move the vehicle. On contrast, the brakes change this kinetic energy back into heat energy to stop the vehicle. Generally brakes work by causing a fixed object to be pressed against a rotating object. The braking effect is obtained from the friction that is generated between the two objects. The heat formed at this time is dissipated to the atmosphere.



Types of Brake

Brakes that are used on motor vehicles can be grouped into several types depending on their purpose

1. the service brakes, operated by a foot pedal, which slow or stop the vehicle.
2. the parking brakes, operated by a foot pedal or hand Lever which hold the vehicle stationary when applied.
3. Auxiliary breaks are used in combination with the ordinary service brakes by diesel trucks and other heavy duty vehicles.



Service brakes (Foot brake or Foundation brake)

Different types of service brake systems are used in different vehicles, depending on the application

1) mechanical brake 2) Hydraulic brake 3) air brake.

There are two main types of service brake

1) drum brake 2) disc brake.

Drum brake :- the drum brake consists of following components :

(i) Backing plate
(ii) Wheel cylinder
(iii) Brake shoe and lining
(iv) Brake drum

Backing plate :- the backing plate is a pressed steel plate bolted to the rear axle housing or rear axle carrier. Since the brake shoes are fitted to the backing plate, all of the braking force acts on the backing plate.

Wheel cylinders :- It is used to expand the brake shoes against the brake drum, one or two wheel cylinders are used for each wheel. Some systems have two pistons (operated by hydraulic press) to operate two shoes, one at each side of the wheel cylinder

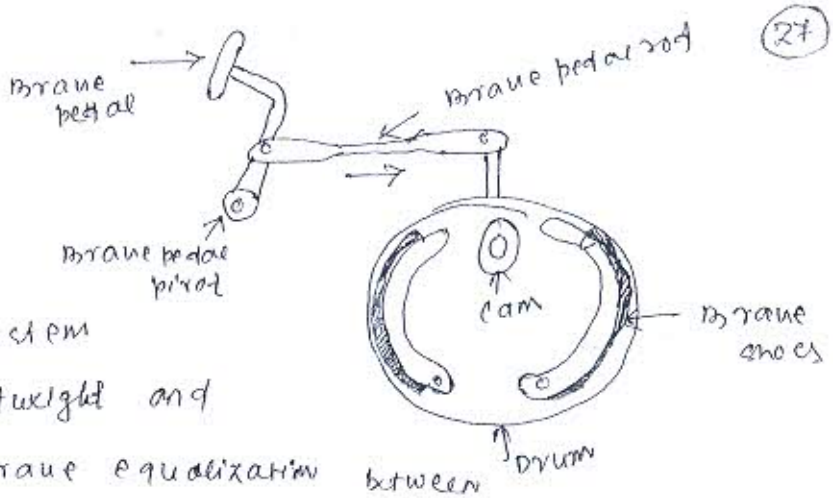
Brake shoe and brake lining :- the brake shoe is semi-circular in shape. Brakes shoes are usually made of steel plates, the brake lining is attached to the shoe by rivets (on Large vehicle) or by adhesives (on small vehicles), the material used for lining must have the following qualities.

- Good frictional properties
- wear resistance
- Heat resistance

Lining were once largely made of asbestos, but the health risks associated with this substance have brought about its replacement with synthetic materials.

Brake drum :- It is made of gray cast iron. It is positioned very close to brake shoe without actually touching it and rotates with the wheel. As the lining is pushed against the inner surface of the drum when the brake is applied, friction heat can reach as high as 200°C to 300°C.

Mechanical braking system



mechanical brakes are usually limited today to the parking brakes on vehicles fitted with a hydraulic brake system or the service brakes of lightweight and medium weight motorcycles. brake equalization between the left and right wheels on an axle can be ensured by incorporating a balance beam in the linkage or by means of a pulley. lengthy brake rods must be guided halfway along to avoid vibration or buckling. the linkage can be arranged to generate additional force by incorporating levers at the appropriate points.

Hydraulic brake system :- fluid is not compressible. any effort applied at one place will be transmitted without loss of press or movement anywhere in the systems. so the hydraulic brakes can respond much faster than other types and are simpler in design hydraulic brakes also have superior design flexibility. due to the advantages, hydraulic brakes are most commonly used with passenger cars and light duty trucks today.

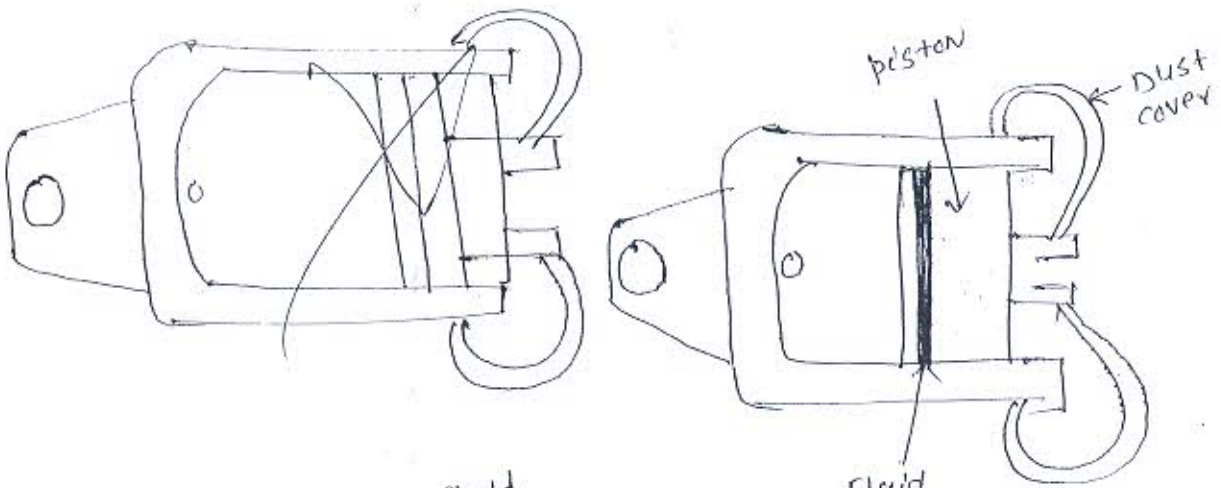
operating mechanism :-

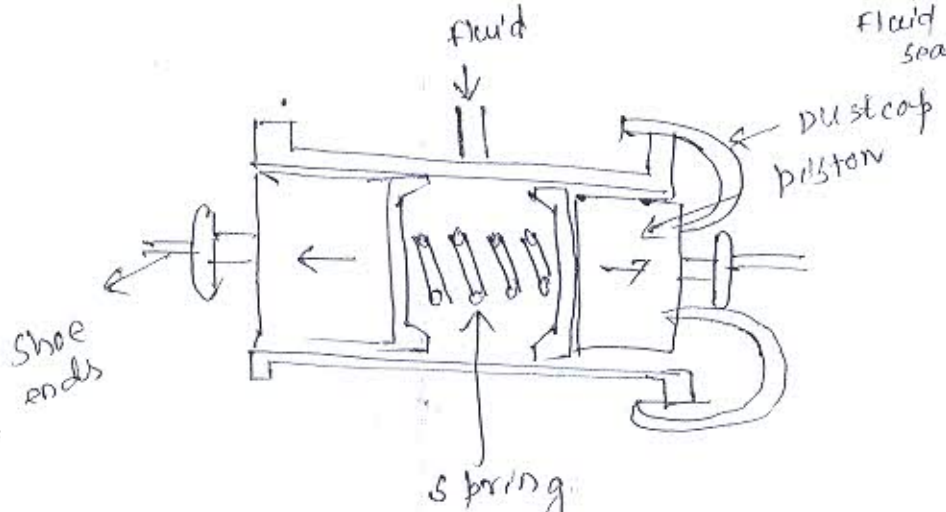
master cylinder:- the master cylinder converts the motion of the brake pedal into hydraulic press. it consists of the reservoir tank which contains the brake fluid as well as the piston and cylinder which generate hydraulic press. there are two types of master cylinder :- the single type and tandem type. the tandem type master cylinder is used more commonly than the single type. the tandem master cylinder has separate hydraulic systems for front and rear wheels so that if one of these systems becomes inoperative, the other system can still function properly. the tandem master cylinder is basically two single master cylinders mounted end

the cylinder contains two pistons, dividing it into two chambers. the first piston is operated by the brake pedal and a pushrod. the second piston is normally operated by the fluid press created by the first.

Wheel cylinders (slave cylinder)

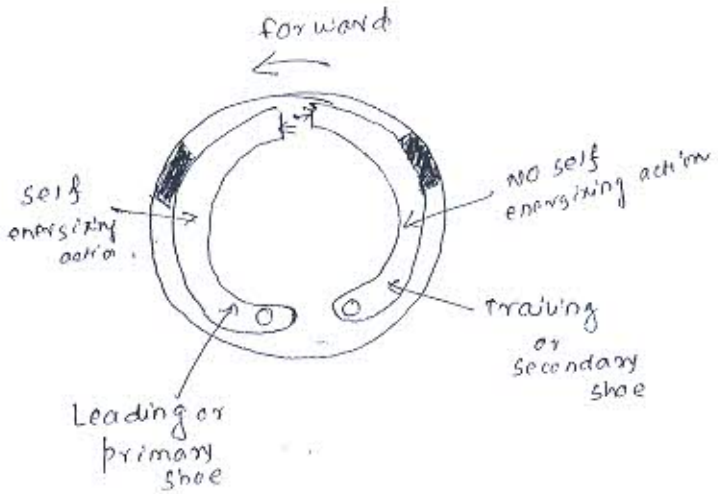
these are sometimes called expanders or actuators. it is the purpose of the wheel cylinder pistons to force the brake shoes into contact with brake drum. the wheel cylinder consists of a cylindrical casting made from castiron or aluminium alloy. it is rigidly attached to the back plate, but is sometimes free to slide slightly to centralize its position. there are two basic types: single acting and double acting. externally both have a machined bore but cut in a single acting cylinder one end is blind and contains only one piston. A double acting system is open at both ends and contains two pistons separated by a spring. the pistons are free to move inside the cylinder.





Self energizing action:-

In the drum type brake, braking power is obtained by causing non-rotating shoes to be pushed against the inner surface of a drum that rotates together with the wheel. There are two types of brake shoe : the leading (primary) shoe and the trailing (secondary) shoe. The shoe facing the front of the vehicle is called the leading shoe and the shoes facing the rear of the vehicle is called the trailing shoe. The action of the drum, in which it tries to force the leading shoe to rotate with it, is called self energizing or self servo action. Self-energizing action creates a greater breaking force results from a relatively small pedal effort. Although leading shoes provide more braking power, there is a disadvantage to this in that they wear faster than trailing shoe.



Disc brake :-

A disc brake basically consists of a cast iron disc (disc rotor) that rotates with the wheel and fixed friction material (disc pads) that are pushed against the disc rotor. Braking force is generated by friction between the disc and the disc pads.

Advantages over drum brake

- Not as effective at slow speed
- Need more press to work effectively
- Size of the disc pad is limited
- Pads wear faster than drum brake shoe lining.

Disadvantages:

- Has the same stopping power in forward or reverse
- Has progressive action - the greater the effort applied to the pedal the more effective the brake will be.
- self adjusting.
- High braking efficiency.
- High stability
- Because the

to the air, good heat radiation is ensured. this minimized fading.

- good water recovery. water that splashes onto the discs can be removed by centrifugal force.
- simpler design facilities easy maintenance and pad replacement

components of disc braue

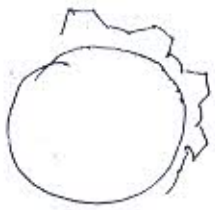
1. cast iron disc rotor
2. Braue pad
3. caliper

GEARBOX

the purpose of gear box

- To multiply engine torque
- to provide a definite break in the transmission system so that the engine may run with the vehicle stationary.
- To provide a means of reversing the drive to the road wheels, thus enabling the vehicle to move backwards.

Gear ratio



A gear ratio is a measure of the relationship between two or more gear wheels that are meshed contact with each other.

$$\text{Gear ratio} = \frac{\text{Number of teeth in driven gear wheel}}{\text{Number of teeth on driver gear wheel.}}$$

Ex:- two gear wheels are meshed in contact with each other. the driver gear has 8 teeth and driven gear wheel has 24 teeth.

$$\text{Gear ratio} = \frac{24}{8} = 3:1$$

To provide a vehicle with a suitable set of gear ratios, manufacturers use gearboxes that contain several set of gears. these are called compound gears. To calculate a compound gear ratio or overall gear ratio, we use the formula

$$\text{overall gear ratio} = \frac{\text{Product of number of teeth on driven gear wheels}}{\text{product of number of teeth on driver gear wheels}}$$

the engine produces very little power at low speeds. If the engine were permanently connected through the clutch directely to the propeller shaft, it would not be possible to move easily from stationary posn. A vehicle requires a large torque to start off or to climb a hill or to pull a heavy load. However a large torque is not necessary during high speed travel when the wheels need to be driven at a high speed. It should also be noted that any increase in engine speed

by the engine and in turn, the torque at the road wheels. the transmission is provided to handle this problem by changing gear combinations (gear ratios) to change the engine output into a torque that suits the travel conditions of the vehicle.

Manual gear box :- there are two types of gear box, manual and automatic, the latter often being called Automatic transmission. manual gear boxes depend totally on the driver to select and change gear. Automatic gear boxes can change gear according to engine load, road speed, driver's demand and the latest computer controlled units, according to the style of driving. there are three types of manual gear box

1. sliding mesh gear box
2. constant mesh gear box
3. synchronous gear box.

today the synchronous is the most common type in use.

Sliding mesh gearbox :- It is the oldest type of manual transmission used in automobiles. Among the manual gear transmission, this sliding mesh type is the simplest in construction. However in this type mechanical efficiency is very low and noise level is quite high. Moreover the driver required considerable skill in changing the gears.

construction :- It has three forward and one reverse speed. There are two gears (1 and 5) attached on the main shaft and four gears (2, 3, 4 and 7) on the countershaft. The two gears on main shaft can slide and on mesh with the gears on countershaft. Therefore it is called sliding mesh gearbox. In this gearbox spur gears are used because of the sliding action. A separate gear is mounted on the idler shaft (8). The gears 1 and 6 are mounted on the splined main shaft. These gears can be slided by a shifting yoke.

Power flow of 3-speed sliding mesh gearbox :

(i) Gears in neutral (ii) First or low speed gear (iii) Second gear (iv) third or top gear (v) Reverse gear.

constant mesh gearbox :- In this type of gearbox, all the gears are in constant mesh having dog clutches for engaging and disengaging the gears. The gears on the splined main shaft are free. The dog clutches are provided which are free to slide on mainshaft. The gears on the countershaft are fixed. Only reverse gears are spur gear type and all other are helical gears. As the gears are always in mesh, helical gears are used which are quieter running.

Power flow of 3-speed constant mesh gearbox

(i) Neutral (ii) first gear (iii) second gear (iv) third or top gear (v) Reverse gear.

synchromesh gearbox :- This is similar to constant mesh gearbox and dog clutch is replaced by synchronizer unit. Here the gears were synchronized by double de-clutching i.e engaging the clutch with the gearbox in neutral and accelerating the engine to speed-up the input component, then disengaging the clutch again and engaging the appropriate gear. Drivers today are relieved from the need for double de-clutching by a synchronizing device built into the sliding collars in the gearbox. This synchromesh device is usually

(35) Synchronizers:- It equalize the speed of the shaft and gear before they are engaged. They use friction to synchronize the speed of the gear and the shaft before the connection is made.

Automatic Transmission :- When a driver is driving a vehicle with a manual transmission, it is necessary for the driver to be constantly aware of the engine load and vehicle speed and to be shifting gears accordingly. With an automatic transmission this type of driver judgement is unnecessary, shifting by the driver is not necessary and shifting up or down to the most appropriate gear is accomplished automatically at the most appropriate time for the engine load and vehicle speed.

Advantages

1) It reduces driver fatigue. Two pedal control i.e the elimination of the clutch pedal together with automatic gear selection reduces driver fatigue because it overcomes the need for tedious clutch and gear change operations.

2) It automatically and smoothly shifts gears at speeds appropriate to the driving condition, thus relieving to the driver of the need to master difficult and troublesome driving techniques such as clutch operation.

3) It prevents the engine and drive line from becomming overloaded, because it connects them hydraulically (via the torque converter) rather than mechanically.

Automatic transmission can be basically divided into two types, those used in FF (Front engine, front wheel drive) vehicles (automatic transaxle) and those used in FR (Front engine, Rear wheel drive) vehicles.

Gearboxes can change gear according to engine load, road speed, driver's demand and in the latest computer controlled units, according to the style of driving. There are three types of manual gearbox:

1. Sliding mesh gearbox
2. Constant mesh gearbox
3. Synchromesh gearbox

Today the synchromesh is the most common type in use.

Sliding mesh gearbox

Sliding mesh type gearbox is the oldest type of manual transmission used in automobiles. Among the manual gear transmission, this sliding mesh type is the simplest in construction.

However, in this type the mechanical efficiency is very low and the noise level is quite high. Moreover the driver required considerable skill in changing the gears.

Construction

The Fig. 9.5 below shows the construction of a sliding mesh type transmission having three forward and one reverse speeds. There are two gears (6 and 5) attached on the main shaft and four gears (2, 3, 4 and 7) on the counter shaft. The two gears on the main shaft can slide and can mesh with the gears on counter shaft. Therefore, it is called sliding mesh gearbox. In this gearbox, spur gears are used because of the sliding action. A separate gear is mounted on the idler shaft (8). The gears 1 and 6 are mounted on the splined main shaft. These gears can be slided by a shifting yoke.

Power flow of 3-speed sliding mesh gearbox

(i) Gears in neutral

When the engine is running and the clutch is engaged, the counter shaft is driven by the clutch gear. The low speed and high speed gears are fitted on the transmission main shaft which does not rotate.

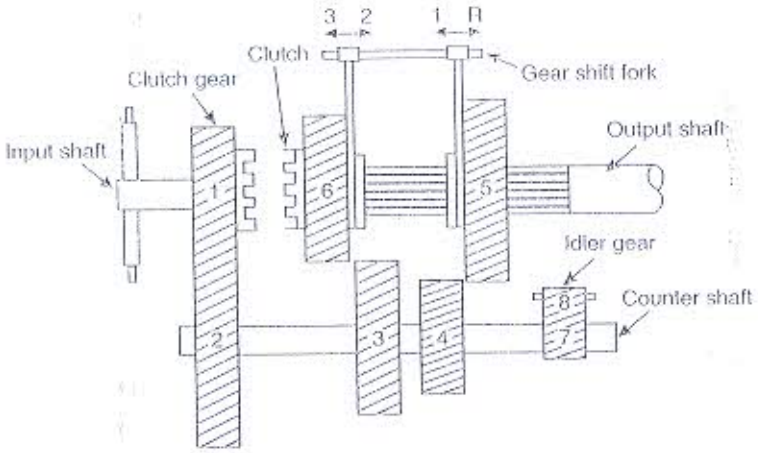


Fig. 9.5 Gears in neutral

At the same time, they are not engaged with any driving gears. Therefore, there is no motion transmitted from engine to the wheels. Hence, the vehicle is stationary.

(ii) First (or) Low speed gear

When the gear shift fork moves towards direction (1) by operating the gear shift lever, the sliding gear (5) on the output shaft will be shifted forward to mesh with low speed gear (4) on the countershaft. It results the rotations of input shaft being transmitted in the order (1) ⇒ (2) ⇒ (4) ⇒

(5) to turn the output shaft. This gear combination is the one that produces the lowest speed from the input shaft and low transmission. In this case the torque output from the gearbox will be as geart as that applied at the input.

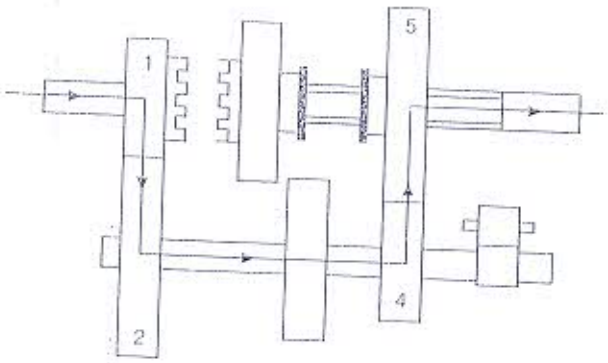


Fig. 9.6 First gear

(iii) Second gear

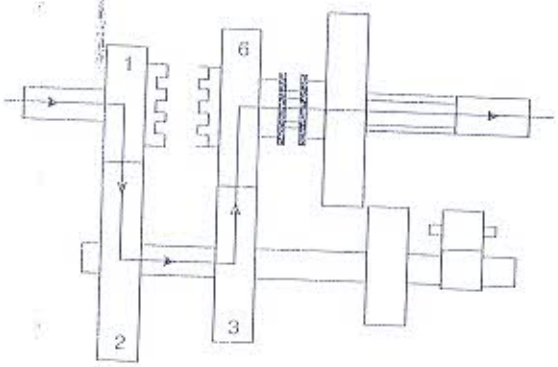


Fig. 9.7 Second gear

When the gear shift fork is moved toward direction 2, the second sliding gear (6) will be shifted backward to mesh with the second speed gear (3) but (5) and (4) are unmeshed. The rotation of input shaft is transmitted in the order (1) ⇒ (2) ⇒ (3) ⇒ (6) to turn the output shaft. This is the transmission in the second speed.

(iv) Third (or) Top gear

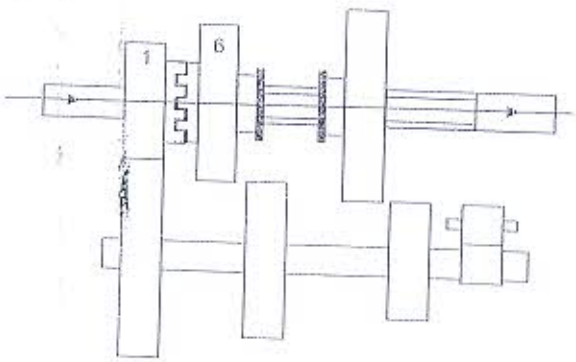


Fig. 9.8 Third gear

When the gear shift fork is moved toward direction 3, the clutch will be meshed but gears (6) and (3) are unmeshed. Due to this, both the input and output shafts are coupled and rotated together with the same speed. This is the transmission in the third or top speed that gives a ratio of 1:1.

(v) Reverse gear

When the gear sh
d to mesh with th
der (1) ⇒ (2) ⇒ (7)
in reverse speed.

This is the same
be seen that the ratio
irection, but does no

Constant mesh

In this type of ge
engaging the gear
which are free to slid
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used which are quite

Power flow of 3

(i) Neutral

When the gear le
ny of the gears and

(ii) First gear

The dog clutch
through the gear (1)
first gear speed is ob

v) **Reverse gear**

When the gear shift fork is moved toward direction R, the sliding gear (5) will be shifted backward to mesh with the reverse idler gear (8). Then the rotation of input shaft is transmitted in the order (1) ⇒ (2) ⇒ (7) ⇒ (8) ⇒ (5) to turn the output shaft in reverse direction. This is the transmission in reverse speed.

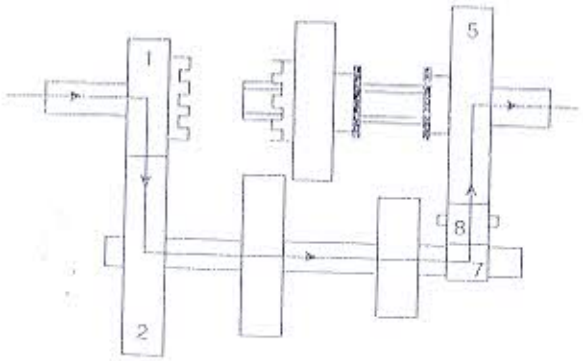


Fig. 9.9 Reverse gear

This is the same ratio as for the first gear and irrespective of the size of the idler gear it will be seen that the ratio always remains the same. For this reason it is called an idler – it changes the direction, but does not alter the ratio.

Constant mesh gearbox

In this type of gearbox, all the gears are in constant mesh having dog clutches for engaging and disengaging the gears. The gears on the splined main shaft are free. The dog clutches are provided which are free to slide on the main shaft. The gears on the counter shaft are fixed. Only reverse gears are spur gear type and all other are helical gears. As the gears are always in mesh, helical gears are used which are quiter running.

Power flow of 3-speed constant mesh gearbox

(i) Neutral

When the gear lever is in neutral position, the two dog clutches D_1 and D_2 are not in contact with any of the gears and cannot transmit torque to the main shaft.

(ii) First gear

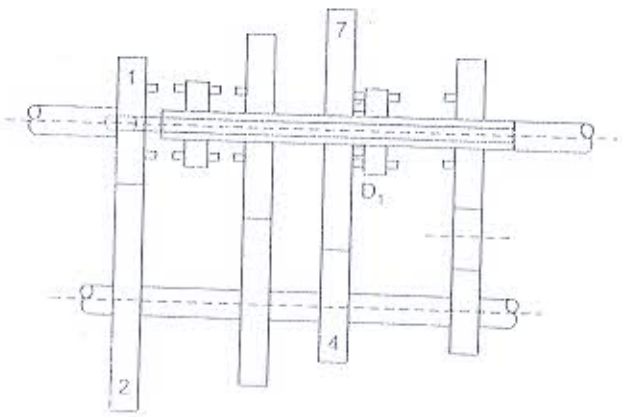


Fig. 9.10 First gear

The dog clutch (D_1) is shifted to left to make engage on (7). Now the power is transmitted through the gear (1) ⇒ (2) ⇒ (4) ⇒ (7) and dog clutch D_1, transmits to the main shaft. Hence, the first gear speed is obtained.

(iii) Second gear

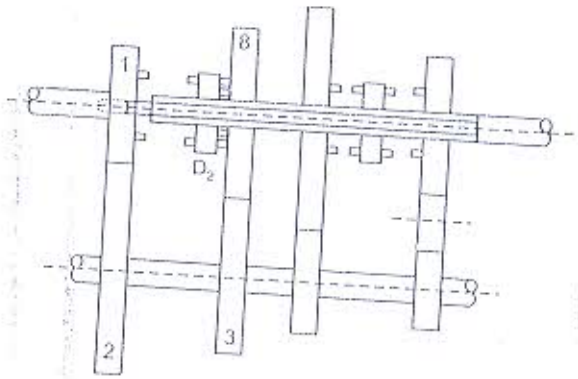


Fig. 9.11 Second gear

Now, the dog clutch (D_1) is disengaged. The dog clutch (D_2) is shifted to right to lock with the gear (8). Therefore, the power is transmitted from clutch shaft through (1) ⇒ (2) ⇒ (3) ⇒ (8) and dog clutch (D_2) to the main shaft. So, the main shaft rotates with the second gear speed.

(iv)Third (or) top gear

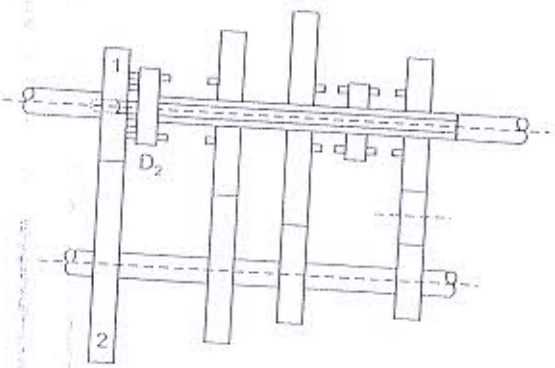


Fig. 9.12 Third gear

In this layout, third gear is a direct drive; namely a gear that gives a ratio of 1:1. The dog clutch (D_2) is moved left to engage with the gear (1) on clutch shaft. Now the engine speed is directly supplied to the main shaft. This is called as top gear speed. In this gear the power flow is not transmitted through any gear teeth so the energy loss is small, i.e., the efficiency is high.

(v) Reverse gear

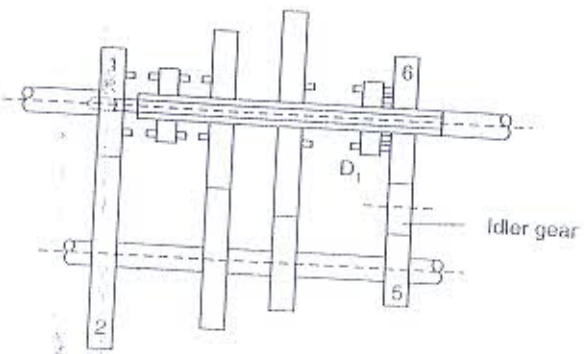


Fig. 9.13 Reverse gear

First the dog clutch D_2 is disengaged. Then the dog clutch D_1 is shifted to right to engage with the gear (6). The idler gear causes the main shaft to rotate in the opposite direction.

Synchromesh gearbox

This is similar to constant mesh gearbox and dog clutch is replaced by synchronizer unit. In the simplest type of constant mesh gear box, which is now absolute, gears could be engaged by snatching the gear lever from one position to the next as fast as possible. This was noisy and jerky. There will still be noise if the dog teeth are not rotating at the same speed when the engagement is made. To do the job more quietly and smoothly without clashing, the gears were synchronized by ***double de-clutching*** i.e., engaging the clutch with the gearbox in neutral and accelerating the engine to speed up the input component, then disengaging the clutch again and engaging the appropriate gear. Drivers today are relieved from the need for double de-clutching by a synchronizing device built into the sliding collars in the gearbox. This synchromesh device is usually fitted to all forward gears.

Synchronizers

Synchronizers equalize the speed of the shaft and gear before they are engaged. They use friction to synchronize the speed of the gear and the shaft before the connection is made.

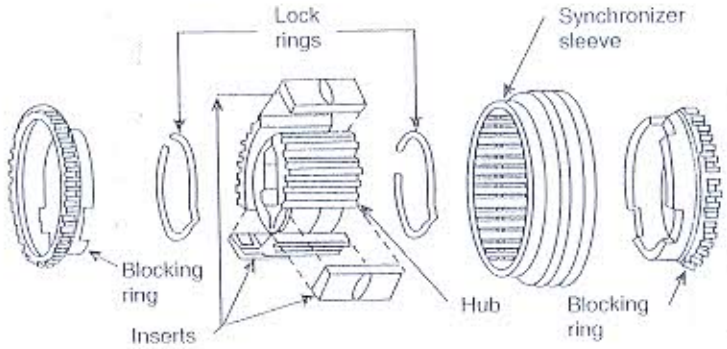


Fig. 9.14 Components of synchronizer

Neutral position

When the gearbox is in neutral, the synchronizers are in their neutral position and are not rotating with the main shaft.

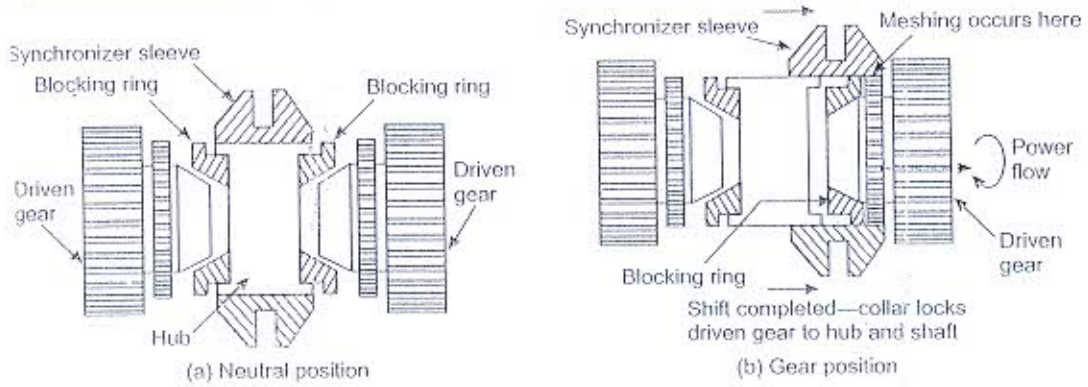


Fig. 9.15 Synchronizer operation

Gear position

When a gear is selected, the shifting fork forces the sleeve toward the selected gear. As the sleeve moves, inserts also moves because they are locked in the sleeve. The movement of the inserts pushes the blocking ring into contact with the shoulder of the gear. When this contact is made, there is a metal to metal contact and begins to rotate.

As the components reach the same speed, the synchronizer sleeve can now slide over the external dog teeth on the blocking ring and then over the dog teeth on the gear's shoulder. This completes the engagement of the synchronizer and the gear is locked to the main shaft. Power now flows as follows:

Input gear ⇒ Counter gear ⇒ Gear selected ⇒ Synchronizer ⇒ Main shaft

Power flow of 3-speed synchromesh mesh gearbox

(i) First gear

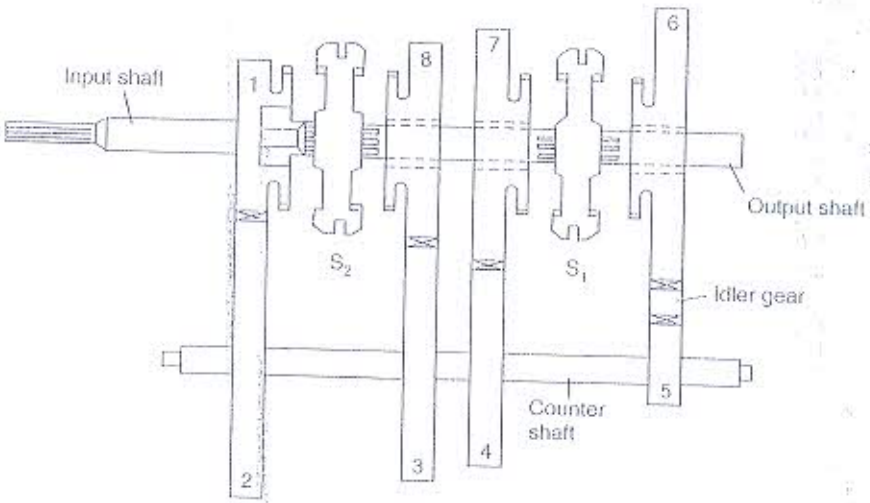


Fig. 9.16 Synchromesh gearbox

The synchronizer (S_1) is shifted to left to make engage on (7). Now the power is transmitted through the gear (1) ⇒ (2) ⇒ (4) ⇒ (7) and synchronizer S_1, transmits to the main shaft. Hence, the first gear speed is obtained.

(ii) Second gear

Now, the synchronizer (S_1) is disengaged. The synchronizer (S_2) is shifted to right to lock with the gear (8). Therefore, the power is transmitted from clutch shaft through (1) ⇒ (2) ⇒ (3) ⇒ (8) and synchronizer (S_2) to the main shaft. So, the main shaft rotates with the second gear speed.

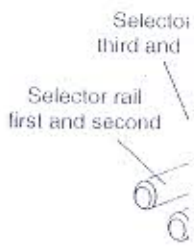
(iii) Third (or) Top gear

The synchronizer (S_2) is moved left to engage with the gear (1) on clutch shaft. Now the engine speed is directly supplied to the main shaft. This is called as top gear speed. The top gear provides a 1:1 ratio between the input shaft and the main shaft by locking the two shafts together.

(iv) Reverse gear

First the synchronizer S_2 is disengaged. Then the synchronizer S_1 is shifted to right to engage with the gear (6). The idler gear causes the main shaft to rotate in the opposite direction.

GEAR SELECTOR M



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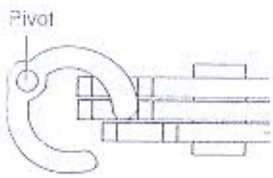

Swinging caliper-type interlocking device

To ensure that only o
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GEAR SELECTOR MECHANISM

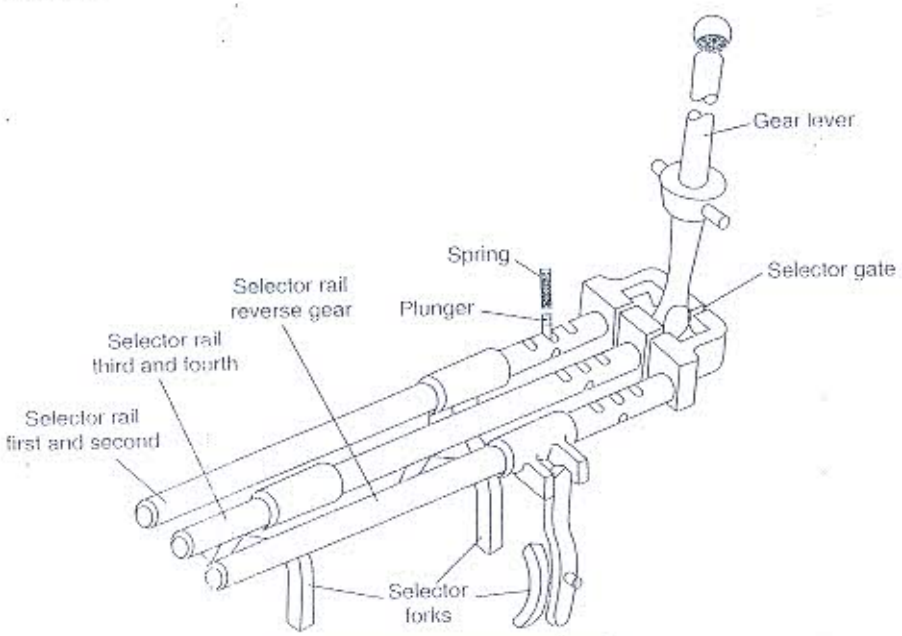

Fig. 9.17 Gear selector mechanism

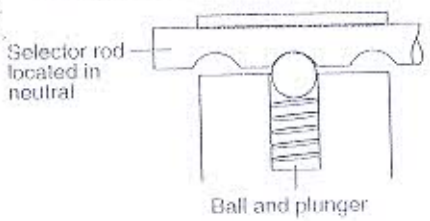

Fig. 9.18: Gear Locating Device

To allow the driver to select the most suitable gear ratio, manual gearboxes are fitted with a gear lever and selector mechanism. The main components of such a selector mechanism are shown in Fig. 3.4. When the driver uses the gear lever to select a particular gear, the movement is transmitted along the appropriate selector rail to the gearwheel. Selector-locking or gear-locating device hold a gear engaged when it has been selected as shown in Fig. 9.21.

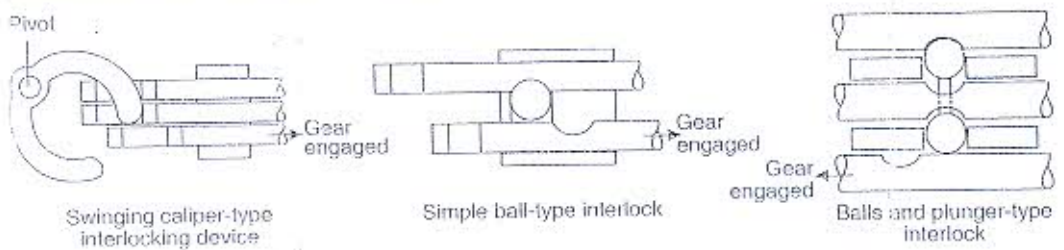

Fig. 9.19 Interlocking mechanism

To ensure that only one gear can be selected at a time, an interlocking mechanism is incorporated into the gearbox selectors. A selection of interlocking mechanisms is shown in Fig. 9.22.