UNIT 6

Braking System

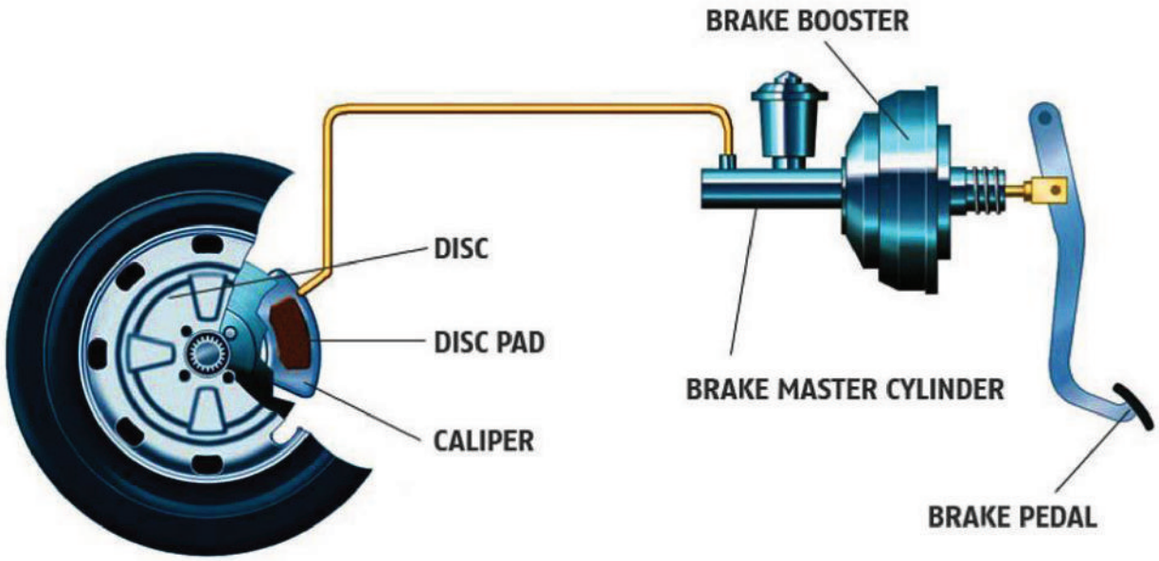
JG01A

Contents

6.0 Introduction
6.1 Functions of Braking System
6.2 Requirements of Braking System
6.3 Types of Brake
  6.3.1 Mechanical Brake
6.4 Types of Power Brake
  6.4.1 Hydraulic Brake
  6.4.2 Air Brake
  6.4.3 Servo Brake
  6.4.4 Engine Exhaust Brake
6.5 Disc Type Brake
6.6 Antilock Braking System
6.7 Hand Brake
6.8 Common Components of Braking System
  6.8.1 Brake Drum
  6.8.2 Brake Shoes
  6.8.3 Brake Linings
6.9 Brake Adjustments
  6.9.1 Minor Adjustment
  6.9.2 Major Adjustment
6.10 Brake Pedal Free Play
6.11 Brake Efficiency
6.12 Stopping Distance
6.13 Brake Testing
  6.13.1 Stopwatch Test
6.14 Trouble Shooting

Learning objectives

1. To understand the need and types of braking system.
2. To understand the parts of all types of braking system and their working principle.



6.0 Introduction

For the safe and accident free travel the vehicle must be driven under control. we have to drive the vehicle with control. All the mechanical devices invented by human beings must be controlled by the human. As compared to the earlier automobile vehicles, the modern automobile vehicles are faster in speed. Such vehicles are controlled by the controlled system provided in the vehicles. Braking System is one among the important systems in controlling these fastest vehicles. The driver (for him and for the passengers) can stop the vehicle whenever he needs to stop it without causing any disturbances to the person inside the vehicle and for the vehicle coming in the opposite direction by using the system called as braking system.

6.1 Functions of braking system

The important functions of the braking system are

1. To reduce the speed of the vehicle in a controlled level by using the braking system.
2. To stop the vehicle within the specified distance or suddenly as per the condition of the road.
3. To control the speed of the vehicle while climbing down from the hill station roads and bends.
4. To park the vehicle permanently in particular place.

6.2 Requirements of braking system

1. It should be easy to operate, powerful, and reliable.

2. Vehicle must stop immediately after applying the brake.
3. Brake shoes and brake linings should have better anti-wear property.
4. It should not be over sensitive.
5. It must be durable and have less maintenance.
6. The operation of the braking system should not interfere the operation of the other systems of the vehicle.
7. Braking system should not be noisy during its operating condition.

6.3 Types of brake

The brakes are classified into a number of types. They are,

i. According to the application

1. Normal brake or foot brake
2. Hand brake or parking brake

ii. According to application of brake shoe

a. Drum type brake
   1. Internally expanding type brake
   2. Externally contracting type brake

b. Disc type or caliper type brake

iii. According to the power

1. Mechanical brake
2. Hydraulic brake
3. Air brake
4. Vacuum brake and
5. Electric brake

6.3.1 Mechanical brake

Mechanical brakes are classified into two different types, they are shown as follow

1. Internal Expanding Brake
2. External Contracting Brake

Internally Expanding Brake

In this braking system the brake shoes are mounted inside of brake drum and the lower ends of brake shoes are connected with help of anchor pins and brake carrier plate. Based on this the movement of brake shoe is positioned. In between the upper ends of brake shoes one brake cam is mounted. Brake pedal is located at the right side corner of the driver's leg. When the brake pedal is pressed, a long rod which is connected with the brake cams in the four brake carrier plate simultaneously are expanded inside the brake drum which causes friction that stops the rotating wheel. When the brake pedal is released, the brake cam is brought to its original position. The brake shoes are also brought to their original positions at the same time without touching the brake drum due to the spring's compressive force. Hence the wheels on the brake drum rotate immediately without any friction.

Externally contracting type brake

This type of braking system is mostly used in cars as hand brake. In this system the outer layer of the brake drum has a brake lining which is contact with the brake band. The brake band is operated by brake lever and the linkages to stop the rotating brake drum. By pulling the hand brake lever, the brake band is forced to press the brake drum tightly. Hence the rotation of brake drum is stopped and the vehicle is stopped. When the hand lever is released, the brake band

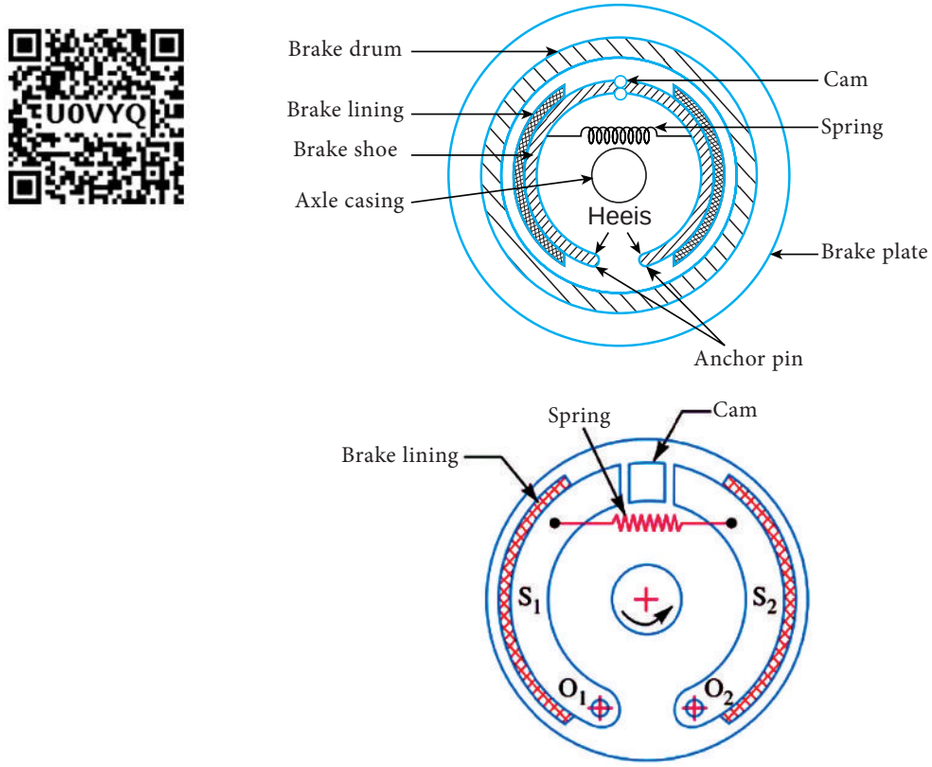


Figure 6.3.1.1 View of the Internal expanding shoe brake and the forces acting on it

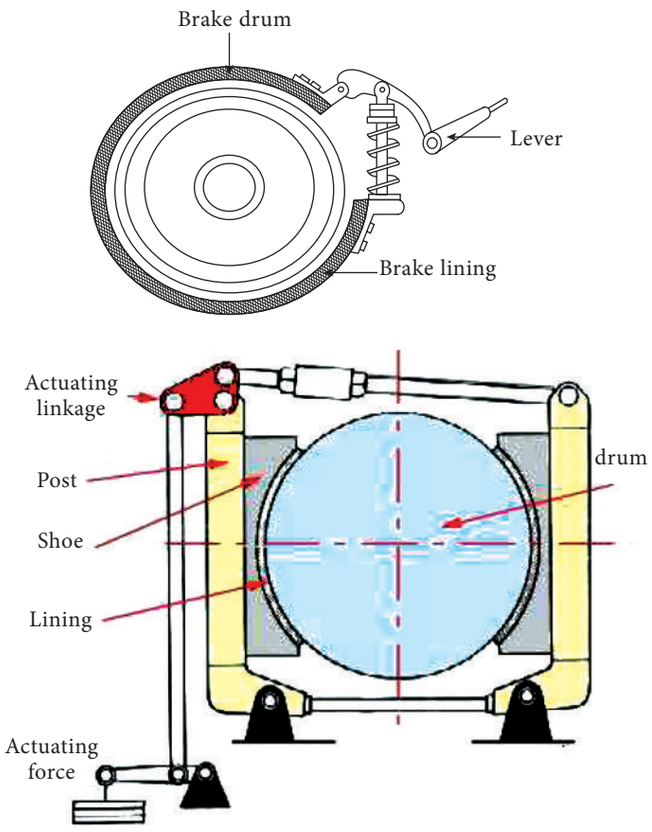


Figure 6.3.1.2 View of the externally contracting type brake

is loosened and the force acting on the brake drum is released. Due to this action the wheels connected with the brake drums are started to rotate without any difficulties. Figure 6.2 shows the view of an externally contracting type brake used in cars.

6.4 Power brake

In mechanical braking system, when the braking force is applied by the driver by pressing the brake pedal due to the mechanical advantage combined with braking force the vehicle is stopped. However, when the vehicle's weight and speed are increased, the mechanical braking system will be no longer capable of providing sufficient braking force to stop the vehicle immediately. Hence for providing sufficient power to the mechanical braking system and to increase the braking force we use any one of the following support as a supplemental force. This type of brake is called as power brake. This power brake is classified according to the following categories as

1. Hydraulic brake
2. Air brake
3. Vacuum brake
4. Electric brake
5. Servo brake

6.4.1 Hydraulic brake system

The schematic view of the hydraulic braking system can be seen in Figure 6.4.1.

The hydraulic braking system works based on the principle of Pascal's law. It is simple in construction and can provide more braking force. The hydraulic brake is capable of delivering the braking

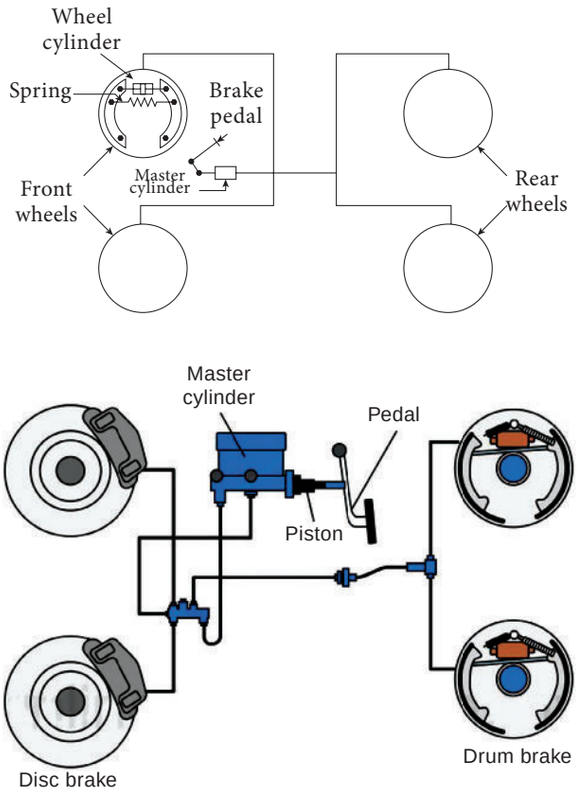


Figure 6.4.1 The schematic view of the hydraulic braking system

force evenly to all the wheels at a time, smoothly and consistently for all the wheels. Therefore most of the cars and some of the two wheelers are employed with hydraulic braking system.

Construction and working principle of hydraulic brake system

The construction of the hydraulic brake system could refered from the Figure 6.3. The hydraulic brake system consists of a master cylinder and wheel cylinders which are the two important components of the system. The master cylinder is used to store the brake fluid. One side of the master cylinder is connected with brake pedal and on the other side there is a pipe line which connects the wheel

cylinders that are kept separately on the back plates.

When the brake pedal is pressed, the brake fluid inside the master cylinder is pressurized and sent to the wheel cylinders through four pipe lines and pushes the pistons inside the cylinder in outward direction. At that time the brake shoes which are connected to the pistons get expanded and force the rotating brake drum to stop which stops the rotation of the wheel.

When the brake pedal is released the pressure of the brake fluid in the master cylinder is reduced. This causes the piston in the master cylinder to come back to its original position due to the spring's action. Thus, pressure in the brake lines is reduced completely. Due to the drop in pressure of the brake fluid, the piston inside the wheel cylinder is move inward. Due to this action, the brake shoes get contracted by the return spring and moved away from the brake drum. Thus, the wheels are allowed to rotate freely. By this way, returning action of piston in the wheel cylinder makes the brake fluid to return back to the master cylinder.

Merits and demerits of hydraulic brake system

The following are the merits and demerits of the hydraulic braking system used in automobiles.

Merits

1. Unlike the mechanical brakes it is simple in construction with no mechanical lever and linkage.
2. The braking force in this system is uniformly distributed to all the wheels.
3. Parts of this system are self-lubricated.
4. It occupies less space.
5. More braking efficiency could be achieved.
6. The braking force is equally shared for all the four wheels.
7. Even for small force of the driver on the brake pedal, the master cylinder multiplies the pressure and gives increased mechanical advantage.
8. Due to the possibility in varying the diameter of the brake pipe lines from the wheel cylinders, variable braking efficiency could be achieved.

Demerits

1. Even a small leakage in the brake lines makes the entire system failure.
2. The air entering into the system reduces the braking efficiency.
3. There is a chance of oil leakage from wheel cylinder. Due to this the frictional force and braking force get reduced in between brake drum and brake shoe.

Quality of the brake fluid

The brake fluid is an important part which acts as a brake force transmitter in the hydraulic braking system. The compression of the brake fluid increases the pressure in the system. However the volumetric capacity of the fluid does not change. The pressure applied at one point on the fluid is equally distributed in all directions, based on the scientific law Pascal by that way the hydraulic braking system works. The brake fluid is generally made up of glycol with different alcoholic additives. In addition, the brake fluid can also be prepared by good quality silicon based fluids.

Figure 6.4.1.1 Quality of the brake fluid

In general the quality brake fluids such as DOT3, DOT4, DOT5, DOT5.1 are commonly used in modern vehicles. These brake fluids are certified by the Society of Automotive Engineers (S.A.E). The DOT3 type brake fluid is widely used in both cars and heavy vehicles.

Requirements of a brake fluid

The following are the important requirements of a brake fluid to be used in automobiles.

1. It should withstand high temperature. The boiling point of the brake fluid should be approximately 300°C.
2. Even at high temperatures the brake fluid should not lose it's viscosity and lubricity.
3. It should lubricate the various parts of the braking system.
4. It should not react and corrode with the rubber and metal parts of the braking system.
5. It should not lose its properties when it is stored for very long time (upto the maximum of 3 years).

Parts of the hydraulic braking system

The hydraulic braking system of an automobile consists of the following parts

1. Brake pedal
2. Master cylinder
3. Brake Fluid pipelines
4. Hose pipes
5. Wheel cylinder
6. Brake shoes
7. Brake linings
8. Return springs

The parts listed above are discussed in the following paragraphs.

Master cylinder and its type

Master cylinder acts as the heart of the hydraulic braking system. By pressing brake pedal, master cylinder supplies the required amount of the pressurized brake fluid to the wheel cylinders for expanding the brake shoes of the wheel cylinder. There are three different types of master cylinders used in automobiles. They are

1. Simple master cylinder
2. Tandem master cylinder
3. Center valve type master cylinder

Among the above types, the first two are mostly used in automobiles. The details of construction and working principle of the above two cylinders are discussed below.

Simple type master cylinder

Construction

The master cylinder is generally made up of cast iron material. The master cylinder consists of a reservoir tank for storing brake fluid and a compressor unit for operating the braking system. In these two parts are completely filled with brake fluid. In the top of the reservoir unit there

is a filler cap fitted for pouring the brake oil and it is closed tightly. In the filler cap a small air vent hole is provided for maintaining the atmospheric air pressure in the reservoir. The sectional view of the master cylinder can be seen in Figure 6.4.1.3. The piston travels front and back inside the reservoir chamber. The push rod and brake pedal are connected with each other.

As the return or helical spring is placed in front of the piston, the piston always stays in the direction where the push rod stays. With this arrangement a check valve is also connected with four wheel adapter for transferring brake fluid to four wheels. In addition to this operating system a brake light switch is also connected. There are two ports called as inlet port and bypass port located on the wall which separates reservoir tank and compressor unit. The inlet port is made as slightly larger, whereas the bypass port is smaller in their construction. In the front face of the piston small feed holes are provided. In front of the feed holes a primary rubber cup is also present.

These feed holes allow the brake fluid to move from backside of the piston to the front. A check valve and a return spring are provided in front of the primary rubber cup. A secondary rubber cup is also located at the back side of the piston for avoiding brake fluid leakages. In this arrangement, the check valve and primary rubber cup arrangement act as one way valve.

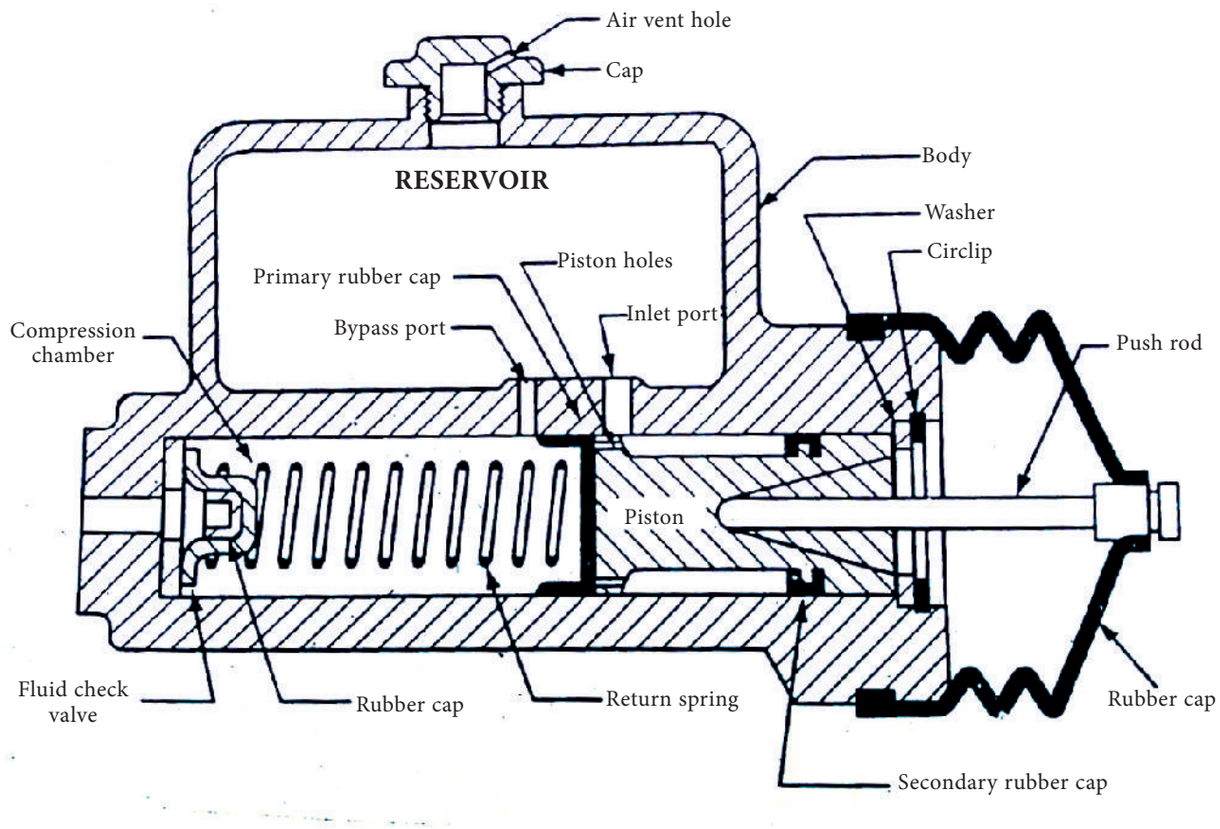


Figure 6.4.1.2 (a) Sectional view of a master cylinder

Working of master cylinder

When the brake pedal is pressed

Normally, the piston inside the master cylinder is positioned in the backward position due to the action of the tensile force of the return spring. Hence due to the opening of inlet and bypass ports the brake oil is filled at the front and back side of the piston. When the brake pedal is pressed by the driver, the piston rod connected to the brake pedal pushes the piston in the forward direction. Because of this action, the two holes are sealed and fluid is pressed well. The compressed fluid is then passed through the one way valve to the wheel cylinder through the pipe lines connected with it. Now the two pistons inside the wheel cylinder are pushed outward. Because of this action the brake shoes are expanded with help of the piston's push rod which forces the brake drum to stop from rotation and stops the wheel from the rotation.

When the brake pedal is released

The pressure inside the master cylinder is reduced. At the same time due to the tensile force of return spring brake shoes are relieved from the brake drum and pulled towards in. Hence the pistons inside the wheel cylinders are moved inward. Hence the brake fluid which is staying in the pipes is forced backwards and sent to the master cylinder through the test valve.

In the master cylinder when the piston moving in backward direction, the brake fluid is initially sent to the reservoir through bypass port. At the same time through the feed holes in the piston the brake fluid is moved to the front side of the piston. Hence the required fluid for the next piston operation is made available at the front side of piston.

Tandem master cylinder

In normal master cylinders only one outlet is generally provided. Moreover, from the location point of view, the master cylinder is located very near to the front wheels and the rear wheels are far away from the master cylinders. Hence, while braking the time taken by the brake fluid to travel from the master cylinder to reach the rear wheel cylinder becomes long. Hence the applied braking force is varied for both the front and rear wheels. Hence, Tandem master cylinder was designed to overcome the above said problem. The photographic view of the tandem master cylinder can be seen in Figure.

In this cylinder there are separate outlets available for front and rear wheels. The brake fluid is passed to the wheel cylinders through separate pipelines and the braking action is performed. In this type of master cylinders, initially the brake fluid is sent to the rear wheels and then to the front wheels. By that way equal amount of braking force is applied at a time for both the wheels. Hence the chance for the faulty operation or faulty situation during braking is eliminated. In the modern vehicles mostly tandem type master cylinder is used. The construction and working principle of the Tandem master cylinder can be seen in Figure.

While pressing brake pedal

Similar to the normal master cylinder, tandem master cylinder also has pistons, primary rubber cap, return

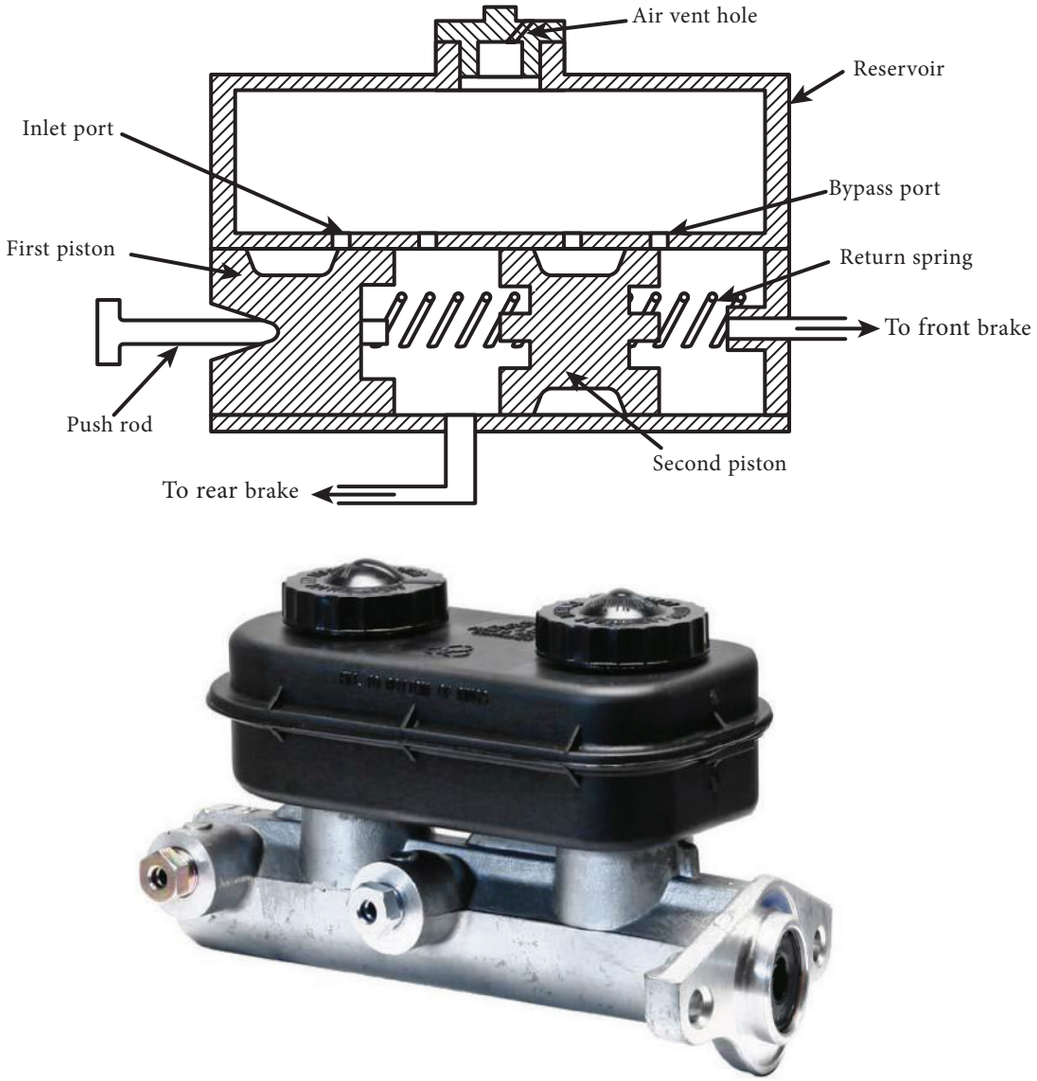


Figure 6.4.1.4 (a) Photographic view of the tandem master cylinder

spring with test valves - all are in two sets, therefore when the driver press the brake pedal, the piston inside the cylinder is moved by means of the push rod and hence the brake fluid is discharged initially to the rear wheels. In addition, while pressing the brake pedal the second piston is also finely moved and through another way the brake fluid is passed to the wheel cylinder of the front wheels and the brakes are activated. When the legs are removed from the brake pedal, the brake fluid pressure is reduced. Hence the brake fluid in the wheel cylinders is pushed backward by means of pistons and comes back to the master cylinders.

Through the pipelines the brake fluid reaches the inlet port and pushes the pistons out there. Hence the both brake shoes are expanded against tensile force caused by the return spring and mate with brake drum which create friction and tend to stop the wheels. Also by releasing brake pedal the fluid pressure is got reduced. Furthermore, by means of return spring the brake shoes are pulled and the pistons get back to its original positions.

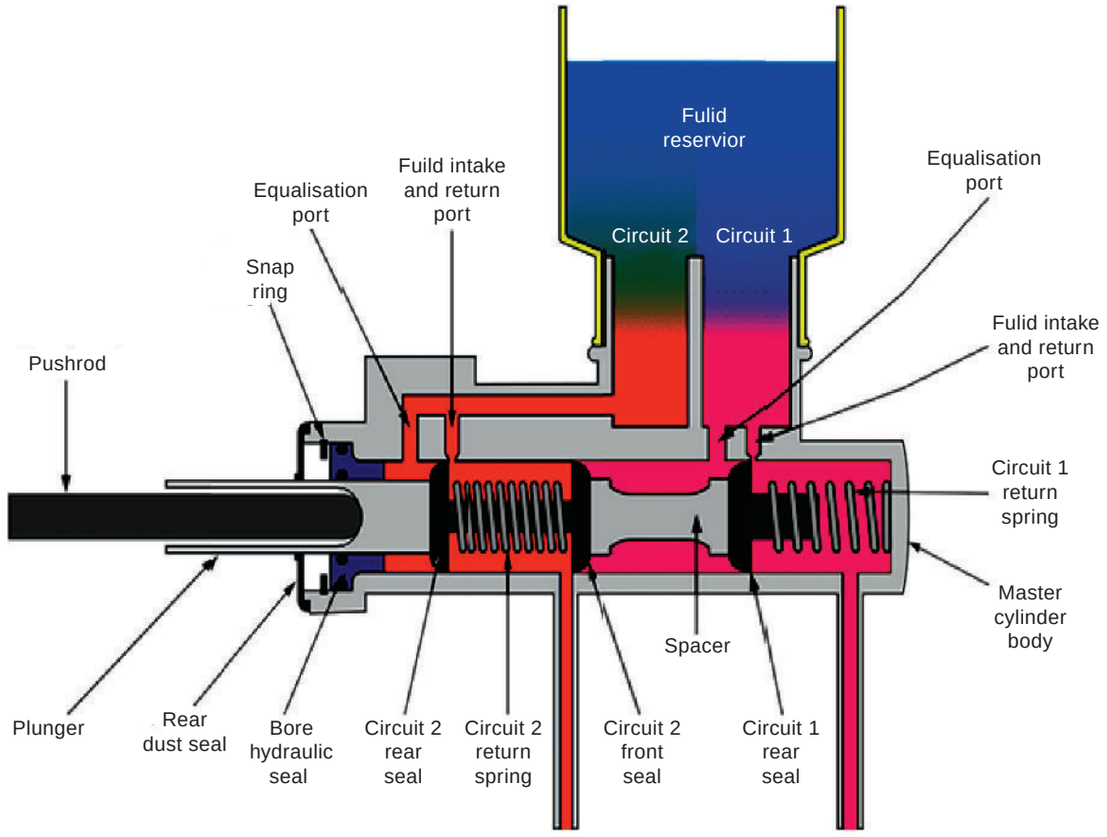


Figure 6.4.1.4 (b) Sectional view of the Tandem master cylinder

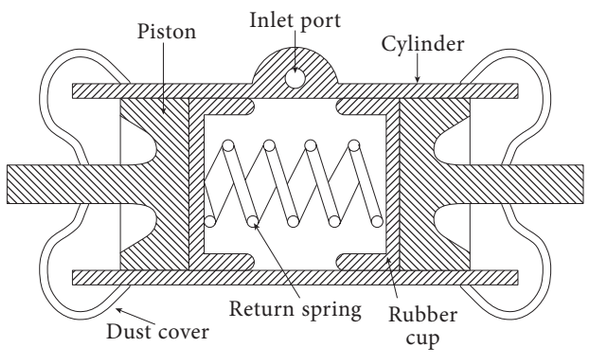
Wheel cylinder and its types

There are two types of wheel cylinders are used. They are

1. One piston type
2. Two piston type

Wheel cylinder

It is located on the brake carrier plate in between the two brake shoes. This



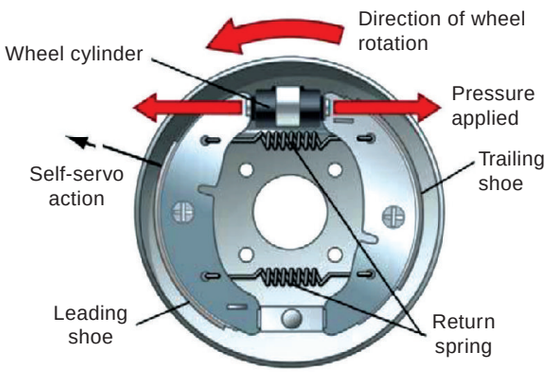


Figure 6.4.1.5 (a) Arrangement of the wheel cylinder

end part of the hydraulic brake system is called as slave cylinder. It is made up of cast iron. In wheel cylinder only the hydraulic pressure is converted in to mechanical work of brake shoes.

Construction

There are two movable pistons located inside the wheel cylinder. At the center position of these pistons inlet port is located. Nearer to this an bleeder screw is located. For avoiding oil leakages on the surroundings of the pistons, a rubber seal is fitted on it. For avoiding sticking of the pistons a return spring is fitted in between them. Moreover, to avoid entering of dust particles inside the cylinder a dust cover is fitted on both the sides.

Working principle

When the brake pedal is pressed by the driver, the brake fluid in the master cylinder is pressurized and enters in to the center of the wheel cylinders through the pipelines. This pressurized fluid pushes the pistons inside the cylinder in the opposite direction and hence the push rod which is connected to the pistons pushes brake shoes in the outward direction and allows the shoes to press the brake drum. By this way the brake is actuated and reduces the speed of wheels.

When the brake pedal is released, pressure in the wheel cylinder is reduced. Due to the action of the spring force both the pistons are moved towards the inward direction. Hence the brake fluid is returned back to the compression chamber of the master cylinder from the wheel cylinder through the same pipelines. The working principle of the hydraulic brake can be seen in Figure.

Bleeding system in hydraulic brake

In the hydraulic brake system if there is any air enters into any part of the braking system then the braking system will not functioning properly or totally. Thus the air must be removed. The process of removing the air present in the braking system is called as the bleeding system in hydraulic brakes. To release the air, the filler cap is opened

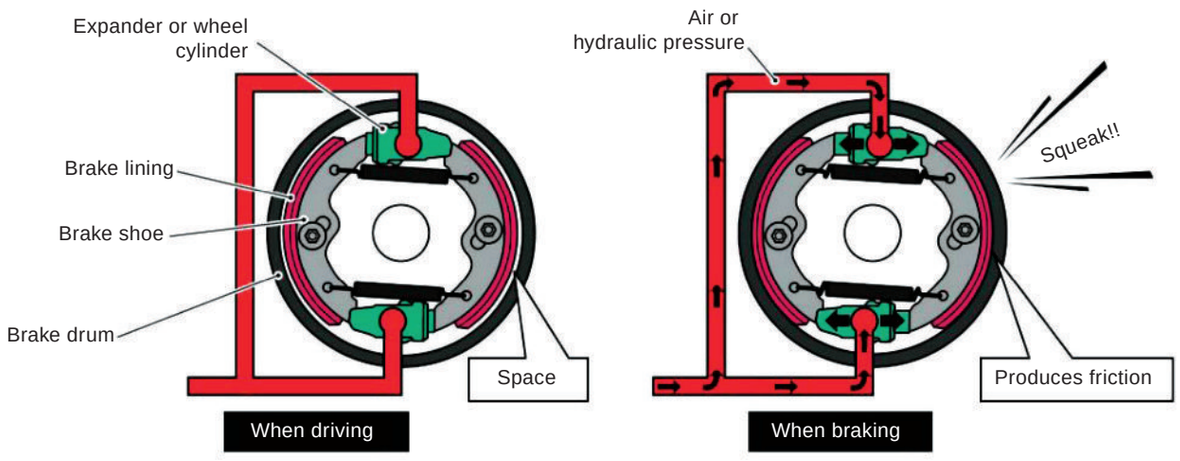


Figure 6.4.1.5 (b) Arrangement of the wheel cylinder

on the top of the master cylinder and a bottle (which contains the brake fluid) is kept at certain height as shown in Figure and connected it through the pipe lines with master cylinder.

The Bleeder valve in wheel cylinder must be connected with one end of the bleeder pipe and other end dipped in the brake fluid in the bottle which is filled by one third of brake fluid inside the container. Now by pressing the brake pedal randomly, the air bubbles presents inside the master cylinders and pipe lines are purged out by the brake fluid to the container placed in the floor through the bleeder valve and bleeder pipe.

After purging the air bubbles by repeatedly pressing the brake pedal, the pipe line which is connected to the bleeder valve has to be removed and the tube connected to the filler cap must be closed. The same procedure should be followed for all the four wheels. Initially the air bubbles must be purged from the wheels which are far away from the master cylinder. by the following air bleeding procedure for the wheels which are far away from the wheel cylinders. After removing the air bubbles from all the wheels the brake fluid must be poured into the reservoir and the tank must be filled.

6.4.2 Air Brake

Introduction

Generally the performance of hydraulic brake is based on the amount force applied on the brake pedal by the driver. Hence for obtaining high braking force the driver has to press the brake pedal at high force. This causes the driver more tiresome. To eliminate this difficulty and obtaining maximum braking force by less pressing, other brake systems such as air type, vacuum type and electric type brakes are used. The air brake is discussed in the following section. Absorbing the ambient air, compressing it to a very high pressure and operating the braking system is called as air brake which is used mostly in all vehicles. The construction of the normal air brake is shown in Figure. The brake cam 'S' placed on the brake carrier plate is actuated by the pressurized air obtained from the air compressor operated by the engine. Hence the brake shoes are

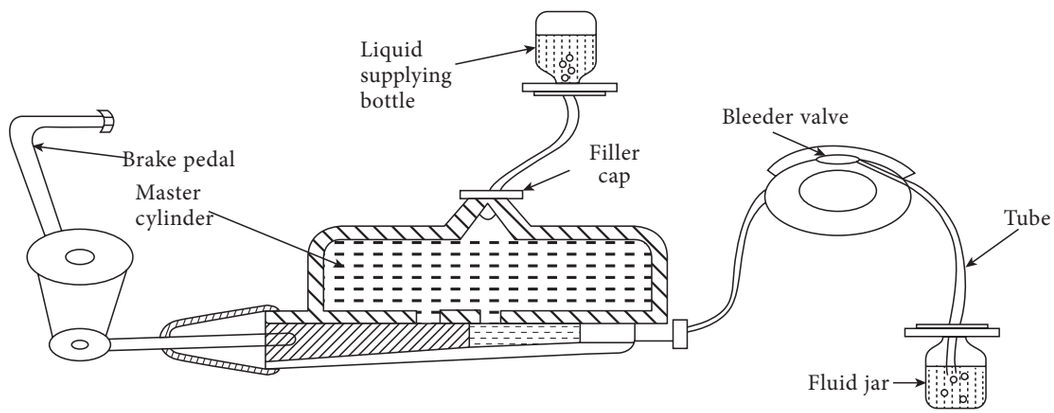
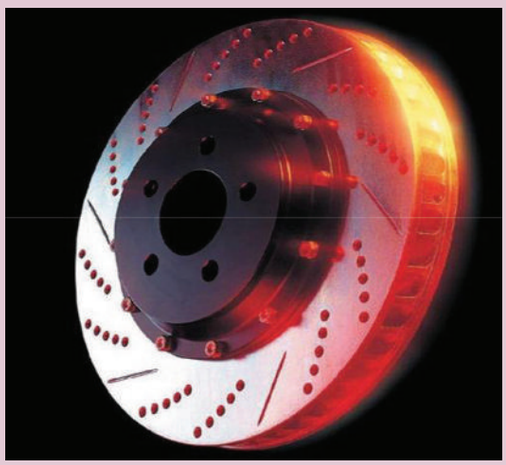


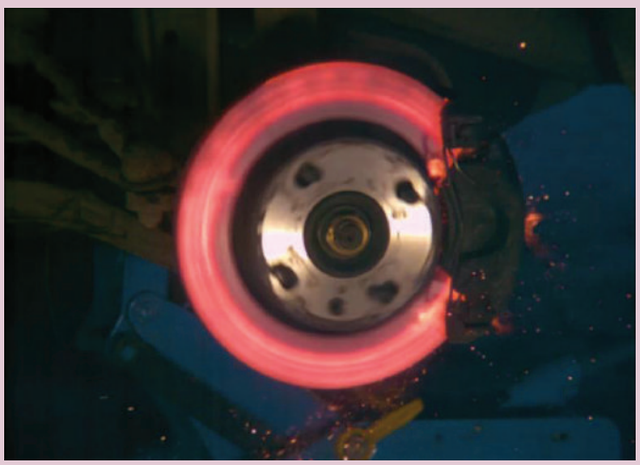
Figure 6.4.1.6 Bleeding system in hydraulic brake

DO YOU KNOW?

1. Brake System:

Modern braking components need exceptional wear resistance, heat resistance and of course exceptional stopping capabilities because, under extreme conditions, their operating temperatures can average over 350 Celsius and peak at up to 700° Celsius.In race use, 400 to 600° C is common on smaller cars. In touring cars and larger race cars temperatures shoot up to 800 - 900° C where the discs will glow red or orange.





expanded and the wheels are stopped from rotation. Brake chambers are located nearer to each wheel of the vehicle.

Each chamber is connected to the reservoir tank through pipelines. When the brake pedal is pressed the brake valve is started to operate. Through the brake valve the pressurized air from the reservoir tank is sent to the brake chamber. In the brake chamber a slack adjuster is operated with help of diaphragm lever which is connected to it. By pressing the top end of the slack adjuster the bottom end turns the "S" cam and rotates the lever. Hence the brake shoes which are connected with the S cam get expanded and the brake drum is stopped from rotation.

While releasing brake pedal

While releasing the brake pedal, exhaust valve in the brake valve is opened. Hence the pressurized air in the brake chamber is forced through exhaust valve from the same way as the air enters to the chamber. At that time, the diaphragm inside the brake chamber is pushed in backward direction with the help of the spring force. At the same time slack adjuster and "S" cam are moved back to their original position. Thus brake shoes are pulled inward and released from the brake drum.

Parts of air brake

1. Air cleaner
2. Air compressor

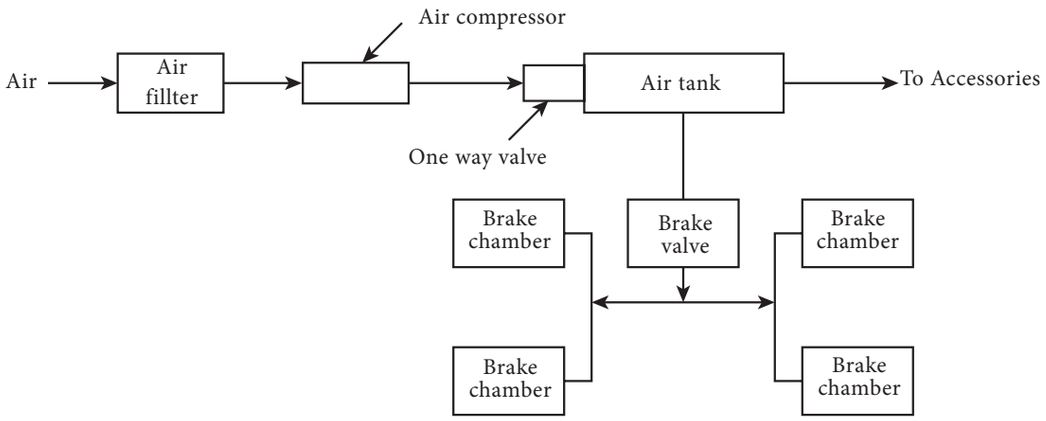


Figure 6.4.2 (a) Air Brake

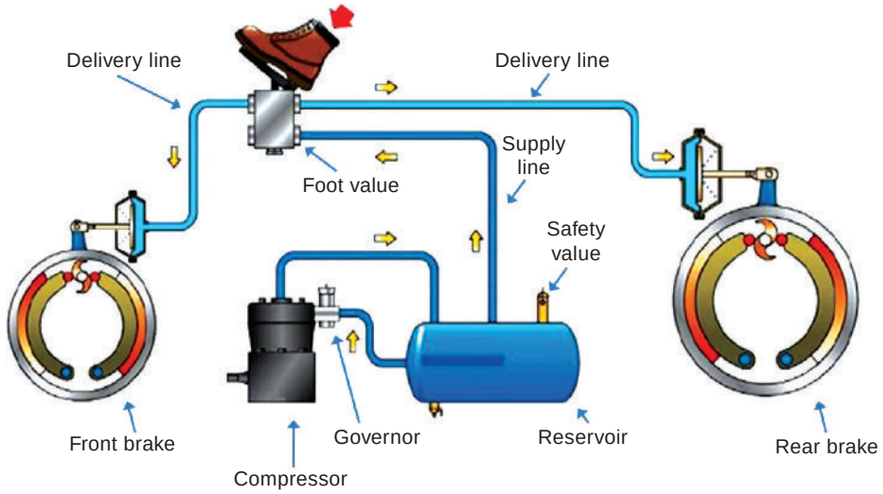


Figure 6.4.2 (b) Working Principle of an Air brake system

3. Unloader valve
4. Air tank
5. Pressure gauge
6. Relief valve
7. Brake valve and brake pedal
8. Brake light switch
9. Brake chamber and
10. Slack adjuster

Air compressor

The device used to produce compressed air which is required for operating the air brake is the air compressor. It is a reciprocating type air compressor. It works on the principle that when the piston moves downwards inside the cylinder, the suction port is opened and through this way the atmospheric air enteres in to the cylinder. When the piston moves upward, exhaust valve is opened and through the exhaust port the compressed air is sent to the reservoir tank.

Governor or unloader valve

This valve controls the compressed air being stored in excess pressure in the air storage tank. Normally the air pressure should be maintained at 7.5 kg/cm^2 in the reservoir tank. When the pressure exceeds above this limit, the unloader valve opens automatically and releases the

compressed air to the atmosphere. When the pressure of the air in the reservoir reaches to 6.5 kg/cm^2, the governor valve automatically closes.

Reservoir tank

Reservoir tank is used for storing amount of air required for operating the brake system. It is made up of steel plate. There are provision given for air inlet and draining the impurities from the tank. In addition to these arrangement a safety valve is also located at the top of the tank for maintaining the air pressure.

Brake valve

This valve is fitted below the brake pedal. When the driver presses the brake pedal, the piston in the brake valve is moved downward. It connects the compressed air with the brake chambers. Therefore the compressed air is sent to the brake chamber located at the four wheels.

Brake chamber

Near to the each wheels, one brake chamber is located and connected with the wheels. The brake chamber is made up of steel plate. The brake chambers are separated by the diaphragm made up of rubber. One chamber is connected to the pressurized air coming from the brake valve and the another chamber is attached to the brake cam that operates the brake through the diaphragm. The diaphragm element is compressed by a spring and the spring is located in the brake chamber. While pressing the brake pedal, the compressed air against the spring force moves the diaphragm and tends to expand the brake shoes.

Slack adjuster

The slack adjuster is attached at the end of the diaphragm lever coming out from the brake chamber. The bottom edge of the slake adjuster is attached to the S cam which is used to operate the brake system. Therefore due to the compressed air diaphragm is moved forward and allowed to rotate the S cam that expands the brake shoes which actuate the brake.

Advantages of air brake system

1. As compared to mechanical and hydraulic brakes it has more power and efficiency. Hence it is mostly used in heavy vehicles.
2. The parts of the brake system can be fitted to anywhere in the vehicle. So the chassis structure becomes simpler.
3. Compressed air in the reservoir tank can be also used to operate air horn, screen wiper and to fill air for tyres.
4. The driver does not feel tiresome by operating the air brake because of its simpler actuation.
5. It has low maintenance cost.
6. The air brake system is widely used in heavy vehicle because it response is faster than any other systems and it works accurately.

6.4.3 Servo brake

For stopping the heavy vehicles, higher amount of braking force is required. Hence for increasing the braking force the driver has to apply more force on the brake pedal. During long distance travels the driver becomes tired due to the above problem. To avoid this difficulty and help the drivers any one type of brake is chosen and the brake system

is coupled with the other brake system that enhances and converts the small power of the driver in to multiple times of the power for braking the vehicle. This type of brake system is called as the servo brake. Generally, by using less amount of force getting more amount of power is called as servo action. In this way, using additional power from the high pressure air or from vacuum the hydraulic brakes are operated. This type of brake is called as servo brake or energized brake.

Air servo brake or air assisted hydraulic brake

In this type of brakes for increasing the force on a piston of the master cylinder, compressed air is used. In this type of braking system half of the pressure applied to the pedal from the simple hydraulic braking is sufficient to operate the system. Moreover, even in case of any leakage in the compressed air path, the brakes can be applied by the servo braking system. The schematic of this brake is shown in Figure 6.4.3.1.

For operating the brake system there are two air compressors and control valves used in this system. Apart from these, connecting pipes are present to connect the servo unit with the master cylinder to combine the air pressure with hydro power. When driver presses the brake pedal, the piston lever inside the servo unit is moved forward. At that time the inlet valve in the master cylinder is opened and the compressed air is allowed to enter into the cylinder for increasing the pressure. Hence the brake fluid is sent out with high pressure to the wheel cylinder and operates the brakes. When the driver releases the brake pedal, the outlet valve is opened and the compressed air is sent out through this valve. Hence the brake shoes are released from the brake drum and the drum is allowed to rotate which rotates the wheels.

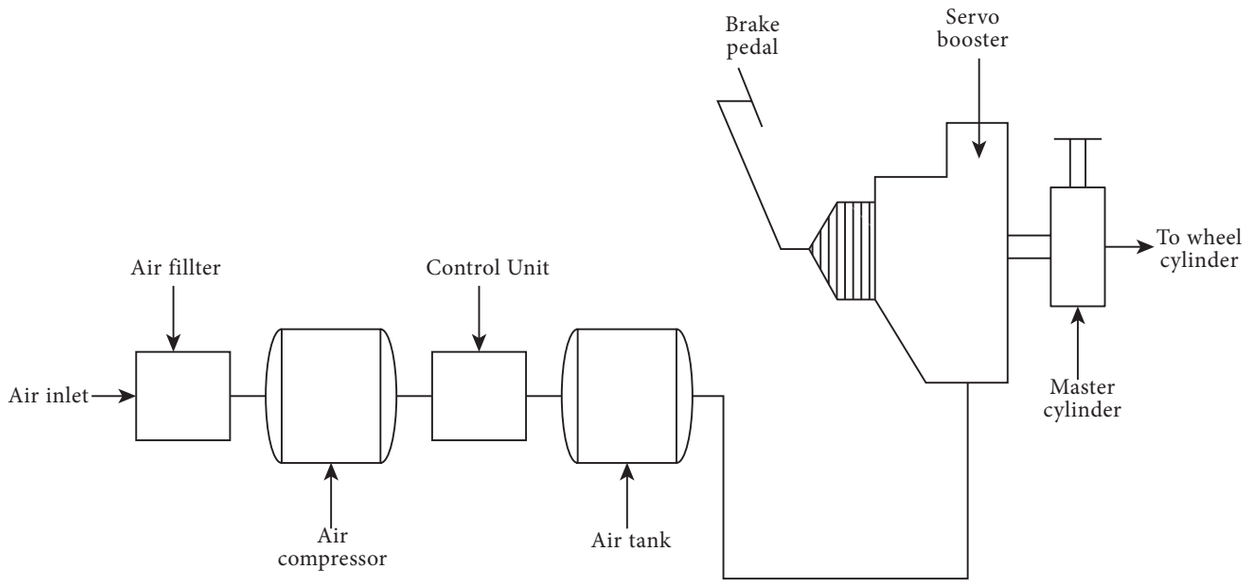


Figure 6.4.3.1 Air servo brake or air assisted hydraulic brake

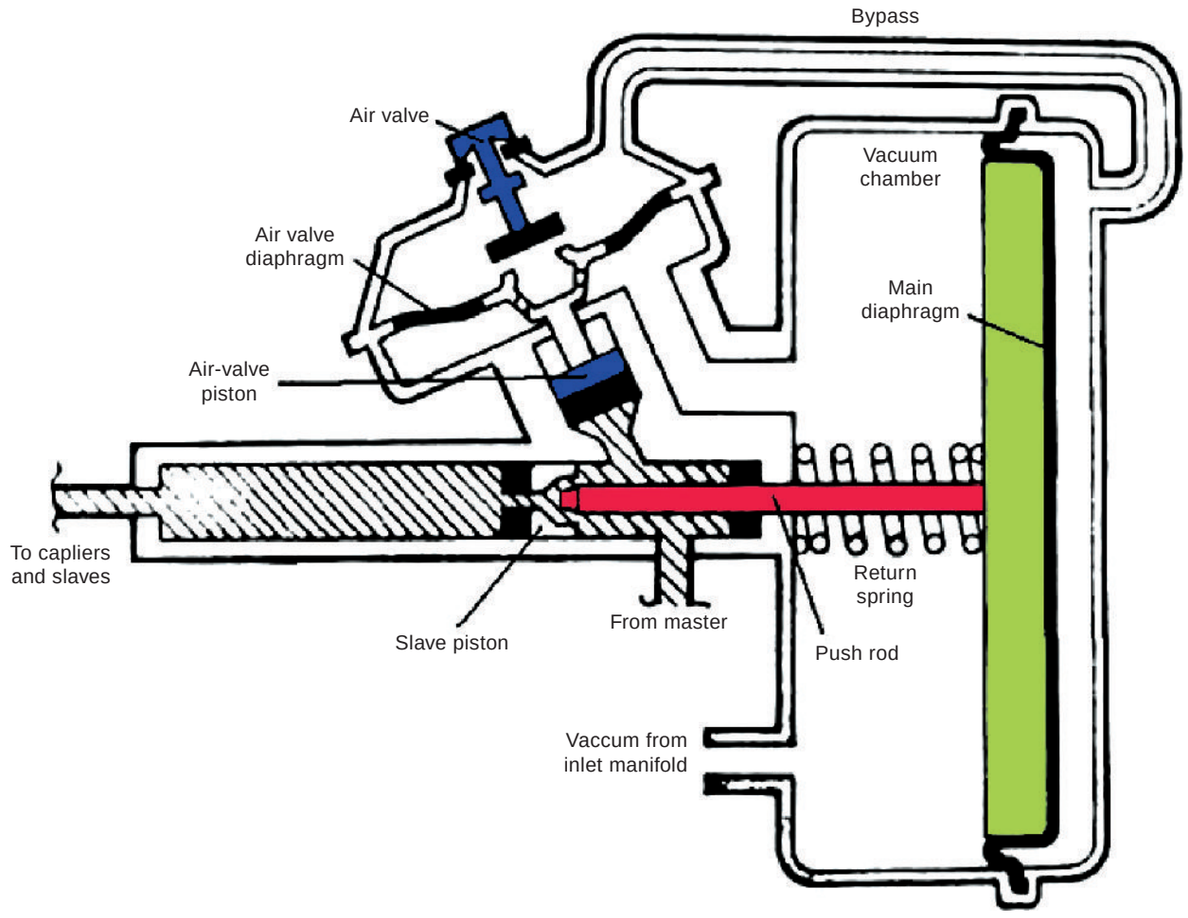


Figure 6.4.3.1 (a) Schematic of the Air assisted servo Brake system

Vacuum servo brake

The schematic view of the vacuum servo brake is shown in the figure. This type of brake system utilizes the vacuum created at the inlet manifold of engine and increases the braking force. The vacuum reservoir is connected to the inlet manifold of the engine with a non-return valve. Moreover, vacuum reservoir is connected on both sides of pistons inside the servo cylinder. In this way the vacuum reservoir is attached to the right side of the piston in the Servo cylinder and the left side is attached with the control unit and the schematic of vacuum assisted servo brake can be seen in Figure 6.4.3.2.

There is a piston in the control unit that has two valves attached to it. These valves are arranged in a compressed state with the help of two springs. The valve at the top of the control unit controls the atmospheric pressure controls the connections in the left side of the piston in the servo cylinder. Similarly, valve at bottom of the control unit controls the connections between the vacuum reservoir which is located in the right side of the control unit and servo cylinder. The piston inside the control unit is actuated by master cylinder. In the control unit valve at the top is in closed position and bottom will be in opened position when there is no any force applied to the brake pedal. Thus, the two sides of the piston inside servo cylinder are equally contacted with the vacuum in the inlet manifold.

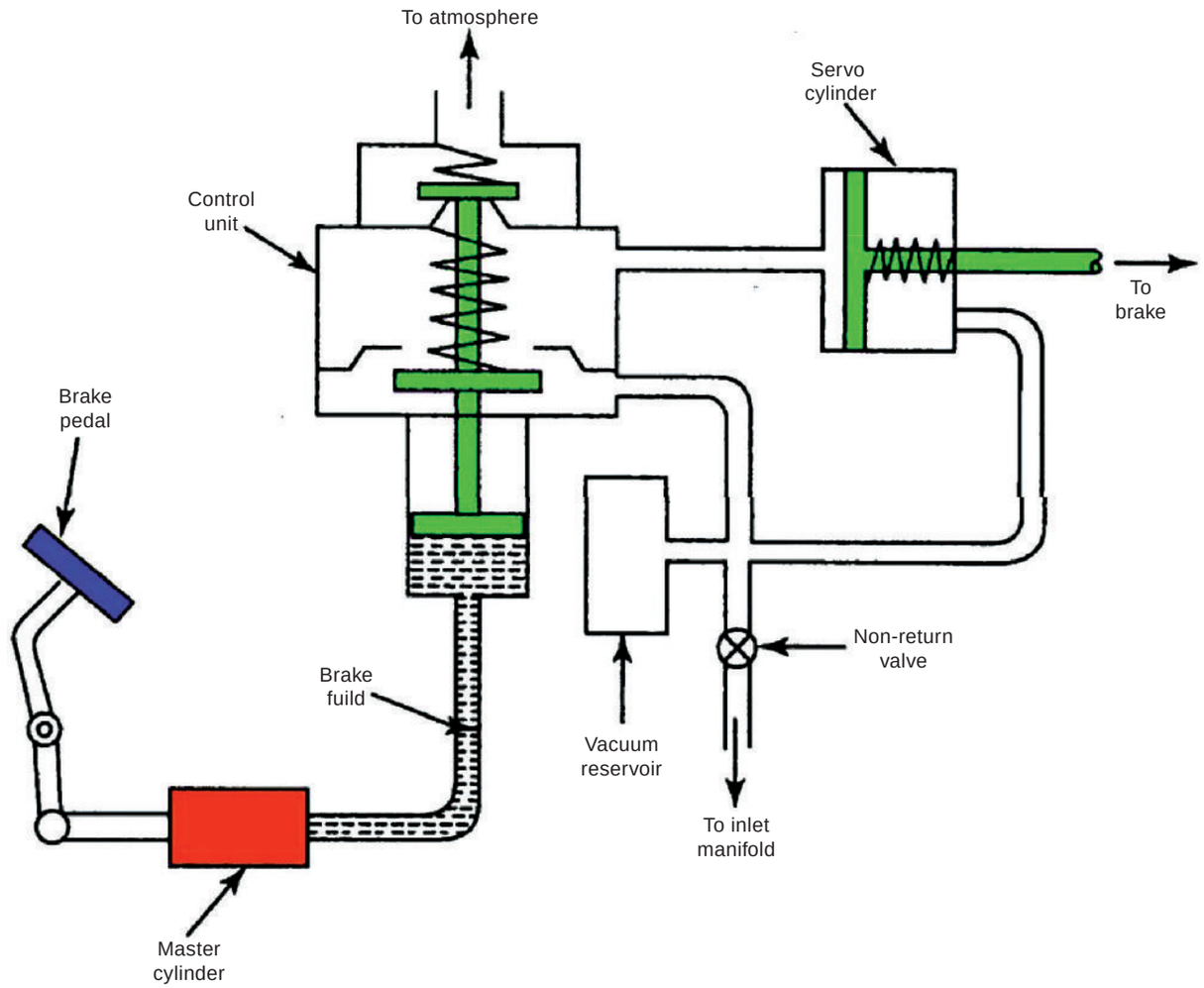


Figure 6.4.3.2 (b) Schematic of the Vacuum assisted servo Brake system

When pressing the brake pedal the pressure developed on the brake fluid inside the master cylinder pushes the piston inside the control unit in upward direction. Hence the valve in the bottom of the control unit gets closed and valve at the top get opened. Therefore right side of the piston inside the servo cylinder contacted with atmospheric air. Hence the vacuum force completely spread over the right side of the piston in the servo cylinder and moves the piston lever in the same direction. This transfer in place of piston actuates the braking system with the path of connections. By this way the braking force got reducing while the driver presses the brake pedal.

6.4.4 Engine exhaust brake

It is used as an assistant brake in heavy vehicles such as TATA .While traveling down continuously, in heavy traffic roads and when travelling for a long distance safely and slowly by applying the brake this type of brake is helpful. This type of brake is more suitable for the vehicles travelling at less than 40 km speed. However, this type of brake system is not applicable for stopping the vehicle

suddenly as the other brake systems which is the disadvantage of this brake system.

6.5 Disc type brake

In modern vehicles the disc type brake is widely used apart from drum type brake system. In this type of brake system a circular brake disc as shown in Figure 6.5 is used instead of brake drum. Moreover instead of brake shoe flat friction grip is used in this system.

The disc brake system is shown in Figure 6.12. When the brake pedal is pressed by the driver, the simple hydraulic pressure actuates the compressed brake fluid and moves the two pistons towards the caliper assembly. Hence the friction pad next to the pistons is moved inward and presses the revolving disc located in between them. Therefore, the wheel hub and wheel which is connected to the disc is stopped from rotation. When the driver releases the brake pedal, the pressure on the pistons inside the caliper assembly is reduced. Hence the piston moves back and the friction pad is released from the disc and releases the brake on the brake disc. Similar to the drum brake, there is a bleeder screw provided in the caliper assembly in a disc brake.

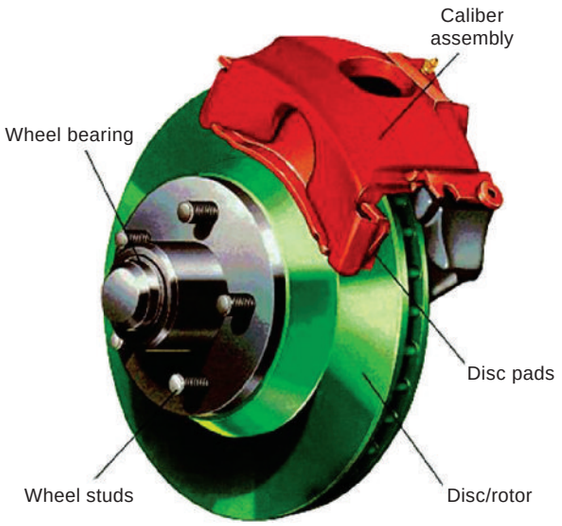


Figure 6.5 View of the Disc Brake system

Advantages in disc brake

1. Lower weight in construction than other brakes.
2. Brake force is very high.

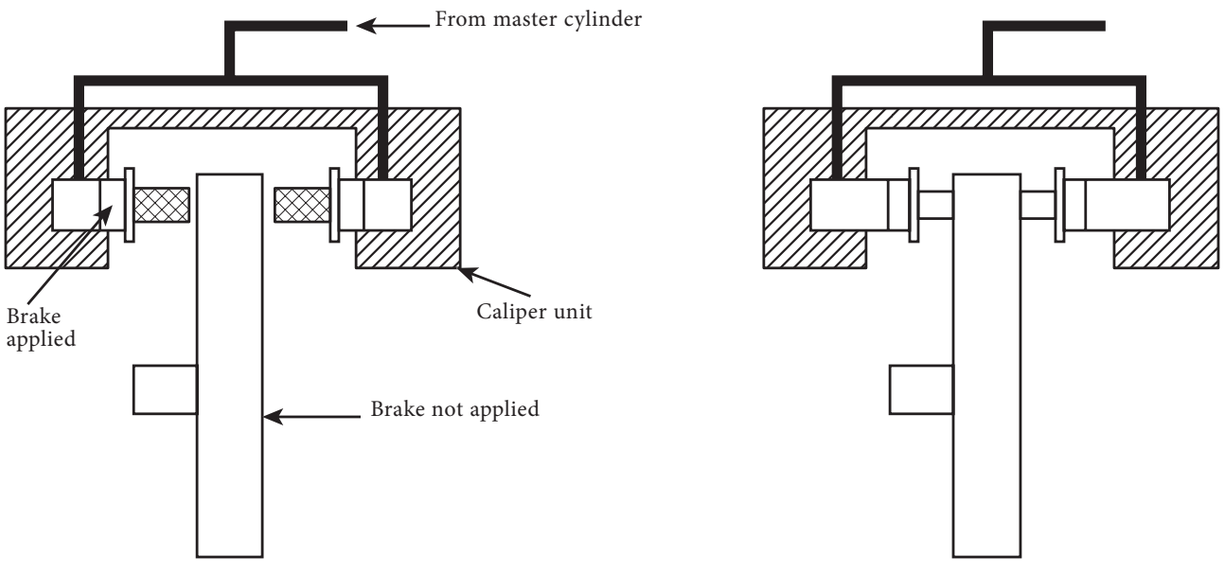


Figure 6.5 Disc type Brake

3. It is sufficient to give low pressure on a brake pedal by the driver.
4. Has less components and hence it can be easily assembled and dismantled.
5. The brake efficiency is not affected even if the vehicle goes in the water.
6. Testing and maintenance are simple.
7. As the disc is exposed to the ventilated air the heat can be immediately transfer to the atmosphere.

Disadvantages

1. As compared to normal brake shoes and linings the wear occurring in the brake pad of the disc brake is very quick.
2. It is essential to use servo unit because of more amount of hydraulic force is required to stop the vehicle.
3. If the disc brake is fitted to the rear wheels, then hand brake system is essential as the additional requirement.
4. This system cannot be efficient for heavy vehicle applications.

6.6 Anti-lock brake system

Generally the purpose of the brake is to reduce the speed of the vehicles within a particular distance. The brake system which is presently used in automobiles

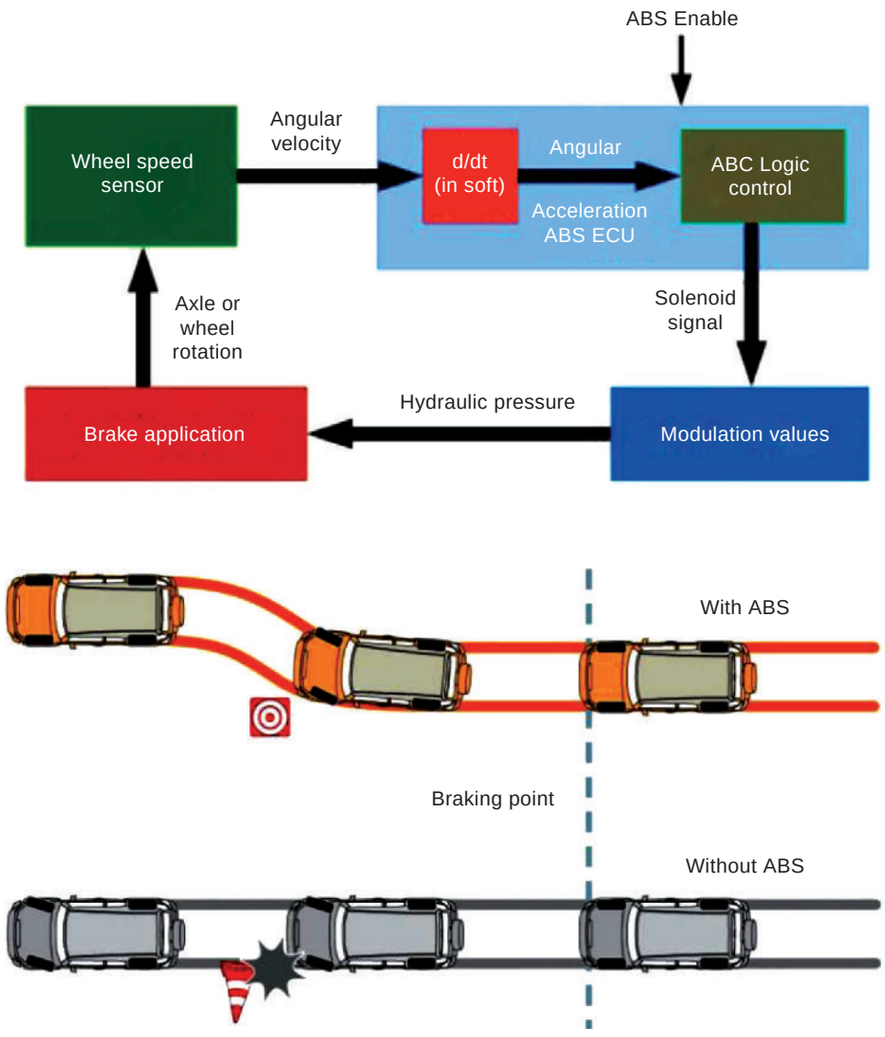


Figure 6.6 Effect of ABS on the Vehicle

DO YOU KNOW?

F1 Racing Car Disc Brake Pads for a Formula 1 car cost $250 a piece, and during the course of racing and testing, a team will use around 1000 of them each season. That makes for an annual bill of $250,000 for pads alone. Then there are the rotors, callipers, fluids and other components before you even start considering the things that make a car go rather than stop.

provides the required braking force for controlling the speed of vehicle. However, suddenly or unexpectedly when the vehicle is stopped, the vehicle is pulled away from its normal braking due to the road condition, condition of the tread and vehicle load etc. This situation leads to accidents.

To avoid this situation, before the vehicle is started to pull along one side, the antilock braking system provides braking force to stop the wheel by giving and releasing the force intermittently. It is a kind of special type of braking system called as ABS system. In this system a hydraulic control unit and an electronic control unit are considered as important components. ECU receives the signals based on the various programming situations from the wheels (input signals) under various conditions and converts them into input control signals and then sends to the hydraulic control unit.

Hence the system opens the brake fluid valve intermittently and prevent the wheel to lock completely. The block diagram of the ABS can be seen in Figure 6.6 and the effect of ABS on the vehicle during braking can be seen in Figure.

Advantages of A.B.S system

1. It prevents the vehicle pulling from one side during braking.
2. Reduces the stopping distance of the vehicle wheels.
3. Brake lining and the parts of the brake which withstand the vibration could work for long time
4. It is possible to drive and steer the vehicle under control even during risky suituations.

6.7 Hand brake

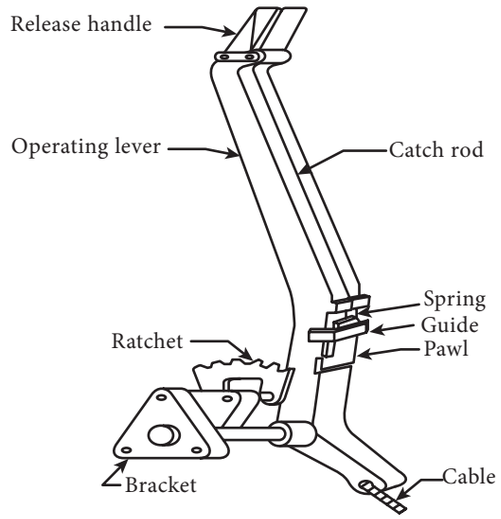


Figure 6.7 Hand Brake

During normal operating conditions, for stopping the vehicle foot brake is commonly used. However, during emergency or dangerous situations when the foot operated brake loses its ability to operate correctly, then hand brake is used to stop the vehicle. Moreover when the vehicle is climbing down on lower roads and when the vehicle is under unbalanced condition of the load, the hand brake is used to avoid movement of vehicle automatically. As the hand brake is use to stop the vehicle and bring it to its balanced condition it is also called as parking brake.

Hand brake is totally separated from the foot brake system. Mostly mechanical type brake is used in the hand brake system. The hand brake is connected with the rear wheels which receive the final drive. The hand operated brake lever is placed on the right side of the driver's seat.

Working principle

Hand brake works based on the ratchet and pawl mechanism. When the

ratchet release lever is pressed at the top of the hand brake, the pawl is moved up and releases the ratchet. However while pulling the lever in upward direction, cable is also pulled towards the upward direction. The cable actuates the mechanical brake which is connected to it and stops the rear wheel by applying force. Moreover ratchet release lever releases and moves the pawl towards downward direction with a help of spring and again connects the ratchet. By this way hand brake is operated to stop the vehicle.

6.8 Common parts of braking system

The common parts of brake system are listed below

1. Brake drum
2. Brake shoes
3. Brake linings

6.8.1 Brake drum

Brake drums are commonly opened in the inner side and closed on the outer side. The brake shoes present inside the brake drum are expanded and operate the brake. Due to the friction created while operating the brake system the brake drum is heated up and the temperature of the drum is increased. To reduce this temperature, fins are located at outside the brake drum. The brake drum should not wear due to friction caused inside while rotating and it must have high thermal conductivity to dissipate heat quickly. Moreover it must be of less weight and it must have enough strength. Brake drums are mostly made up of cast iron or nickel chromium steel alloy or Aluminium alloy materials.

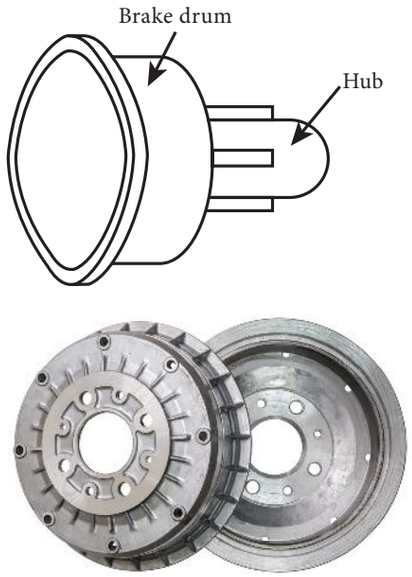


Figure 6.8.1 Brake drum

6.8.2 Brake shoes

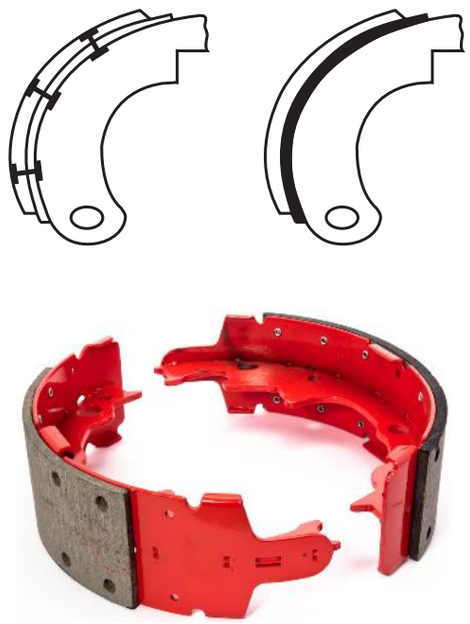


Figure 6.8.2 Brake shoes

In each brake carrier plate two brake shoes are provided. The brake shoes looks like in “T” shaped cross section. The right hand side of the brake shoe is called as the primary brake shoe and the shoe in the left hand side is is called as the secondary brake shoe. The bottom edges of the two brake shoes are connected

with carrier plate through anchor pins. In between the top edges of the brake shoe, brake cam or wheel cylinder is located.

Both the brake shoes are in the pulling position with help of the retracting spring. Brake liners are fixed on the outer face of the brake shoes by riveting or by using the lining cement. The edge of brake shoe which presses the brake drum first is called as the leading shoe and the edge which presses the brake drum later is called as the trailing shoe. Brake shoes are often made up of cast iron or steel.

6.8.3 Brake linings

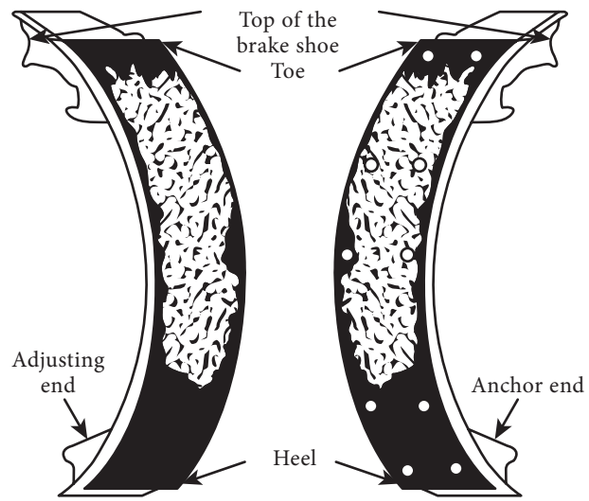


Figure 6.8.3 (a) Brake linings

Brake linings are placed on the outer face of the brake shoes. While pressing the brake pedal the brake linings are only in contact with the brake drum and reduces the speed of wheels. Therefore in brake linings the temperature reaches to about 350°C more and wear occurs. Hence the brake lining should be made to withstand very high temperature and wear resistant and should not change its shape. Brake linings are classified in to two types, they are

1. Solid woven type
2. Molded type.

Figure 6.8.3 (b) Brake linings

1. Solid woven type brake liner

It is made up of a non-metallic twisted asbestos thread. The average compression coefficient of this liner is 0.4. This type of liner is easily tolerable 260°C up to 350°C. It is manufactured by asbestos threaded fibers which are combined with brass and zinc rods that could not be easily subjected to wear. These types of brake liners are used in cars and heavy vehicles. These brake liners are attached to the brake shoes using riveting method.

2. Moulded type brake liner

This type of brake liners are made of natural asbestos fibers with resin-like synthetic paste by using moulding technology. The average friction coefficient of this liner is 0.4. This liner could be operated at the temperature between 400°C to 450°C without any wear.

6.9 Brake adjustment

Brake linings and brake joints get worn out due to the continuous usage of

the brakes. Hence the efficiency of the brakes decreases or becomes inactive. Therefore, at the particular interval of time the brake system has to be checked and adjusted for correct action if necessary. The adjustments in the brake system can be done by the following two modes:

1. Minor adjustment
2. Major adjustment

6.9.1 Minor Adjustment

In this method, without removing the wheels, the adjustments are made in the brake shoes upto the extent till the wear occurs. Generally in the vehicles front wheel brake shoes wear faster than the brake shoes in the rear wheels. Hence the brake drum has to be removed from the wheels and checked. If there are no problems (as stated below) then a small adjustment is enough.

i) Wear occurred in brake drum or brake drum leaves the center position.
ii) Brake shoes are soaked in brake fluid
iii) The brake shoes get wearer and the top of the rivet is visible outside the brake shoes.

6.9.2 Major Adjustment

In this method all the brake drum and brake shoes must be checked by removing all the brake drums. If there is any wear found in the brake drum or if the brake drum is shifted from the center position, then it has to be corrected by using the brake drum lathe and used. If the wear of the brake drum is more, then the drum must be replaced by a new drum. If there is any wear occurred in brake shoes for about 1 mm or above that, then the brake shoe must be replaced by a new one. If it is a hydraulic braking system then the paths (through which the brake fluid is circulated) have to be cleaned. Used parts of the wheel cylinder and master cylinder must be replaced by new parts. Required amount of brake fluid must be refilled.

Anchor pin and brake shoes must be corrected according to the requirement. The movement of the brake pedal should also be checked and adjusted as per the requirement. For more detailed procedures on working methods, the manual supplied by the vehicle manufacturers must be referred.

6.10 Brake pedal free play

When the brake pedal is pressed, the parts of the brake will not respond to function. First, the brake pedal will move to a certain distance. This distance is named as brake pedal free play. After this movement, further pressing of the brake pedal starts the parts of the brakes to function and stops the wheel. The "motionless movement" of the brake pedal is generally less than 10 mm. Driving and stopping the vehicles with control can be possible only by understanding this "motionless movement".

6.11 Brake Efficiency

To stop the vehicle the maximum braking force or retarding force (F) is applied on the wheel. This braking force depends on the μ- called as the co efficient of friction between the tyre tread and the road and the total load (W) acting on the vehicle. That is

$$F = \mu \times W$$

According to the above, the brake efficiency is 100%. However, in practice, 100% of the brake efficiency is considered as not safe and 50% is allowed in the foot operated brake and 30% brake efficiency for hand brakes.

6.12 Stopping distance

Brakes after applying will not stop the vehicles immediately. the vehicle moves certain distance and then only it stops. Normally if the vehicle is running at 30 km/hour the vehicle will stop after 4.5 m when the brake is actuated. This distance is calculated with an approximation. The vehicles stopping distance is varied according to the speed of the vehicle, surface of the road and the type of tread in the tire.

However, in case of emergencies and risky situations, the following factors should be taken into consideration. They are,

i. Time to think for pressing the brake pedal by the driver.
ii. Time taken for pressing brake pedal by the driver.
iii. The time taken for stopping the vehicle after the driver pressed the brake pedal.

6.13 Brake testing

Different methods are used to calculate the brake efficiency. The stop watch test is a simple method among the testing methods.

6.13.1 Stop watch test

For conducting this test the vehicle has to be operated at the speed of 40 km/hr to 50 km/hr. Any symbols in the road can be kept as a mark point. Once if the vehicle is reached that symbol, then the brake pedal has to be pressed and the time has to be noted using the stop watch. The time taken for the vehicle from the mark point and the stopping point of the vehicle should be noted. Distance from the symbol to vehicle get stoped should be noted. From this method we can identify the stopping distance.

6.14 Problems in brake systems, their causes and remedies

Problem 1: Brakes not functioning

S.No	Reasons	Fixing methods
1	If brake shoes were broken or worn out.	Have to be replaced.
2	Poor quality brake shoes	Have to fix good quality brake shoes
3	Oil leakages in the brake shoes	Stop the leakage
4	If the fluid pressure is lower in the hydraulic brake system	Check the fluid leak (or) need to remove the air bubbles.
5	Brake actuating Cable (or) connections become loose	Have to be checked or removed
6	If the brake drum is unevenly worn out.	Has to be corrected for the wear.

Problem 2: Lower braking efficiency

S.No.	Reasons	Fixing methods
1	Oil leakages from the brake drum and brake shoes	Have to change the brake shoes. Moreover the oil leakage must be stopped.
2	Connections and adjustments are away	Have to be corrected Based on the manufactures advice
3	Master cylinder damage in the hydraulic brake system	Testing should be done to repair the fault
4	Air bubbles present in the hydraulic brake system	Air bubbles have to be removed by using brake bleeding method. Required quantity of brake oil has to be filled.
5	The cam used to move the brake is damaged	New cam should be fixed

Problem 3: Brake binding

S.No.	Reasons	Fixing methods
1	If the return spring in the brake shoes or brake pedal losses its stiffness or have broken	New springs should be affixed.
2	Lack of lubrication in attachments	Exactly, the attachments should be properly lubricated
3	The size of the brake pedal free play in the brake pedal is not correct	Re-correct it
4	Any problems in wheel cylinder	Have to repair by checking or need to replace new one.
5	Bypass port in the master cylinder may get blocked	Need to clean the blockages using compressed air.

Problem 4: Noise is occurred when the is brake is operating

S.No.	Reasons	Fixing methods
1	If there is loose in Wheel bearing	Need to remove the loose connections and fix it.
2	If the brake drum and brake shoes were released from its center.	Two parts should be corrected and fixed in the same center.
3	If the wheel hub in a brake drum may be loose.	Need to accelerate the brake drum well
4	There may be a chance of occurring vibration in the brake shoes if the return springs in the brake shoes are losses.	Have to change the return spring
5	Brake shoes may be loosen in a brake disc	Change the brake shoes and fix it proper.

Student Activity

1. According to the curriculum, the students will be informed to go near by the two wheelers service station for understanding the movement, parts and repairing methods of drum type brake and need to submit a report to the organization.
2. Go to the nearest four-wheel drive workshop to know the parts, movement and maintenance of the air brake and servo brake and have to submit a report.
3. Go to the nearest small four-wheel drive workshop and take a look at the parts of hydraulic brake system and methods to removal of air from hydraulic brake system and submit the report.

Glossary

1	Brake	–	தடை
2.	Brake pedal	–	தடை மிதி
3.	Brake shoe	–	தடைக் கட்டை
4.	Brake lining	–	தடைப் பட்டை
5.	Brake drum	–	தடை உருளை
6.	Drum type brake	–	உருளை வகை தடை
7.	Disc type brake	–	தட்டு வகை தடை
8.	Power brake	–	ஆற்றல் தடை
9.	Hydraulic brake	–	திரவ தடை
10.	Air brake	–	காற்று தடை
11.	Vacuum brake	–	வெற்றிட தடை
12.	Electric brake	–	மின்சார தடை
13.	Brake cam	–	தடை கேம்
14.	Brake band	–	தடைக் கட்டு
15.	Lever	–	சுண்டி
16.	Master cylinder	–	பிரதான சிலிண்டர்
17.	Brake carrier plate	–	தடை தாங்கித் தட்டு
18.	Wheel cylinder	–	சக்கர சிலிண்டர்
19.	Brake oil	–	தடை எண்ணெய்
20.	Return spring	–	திருப்புச் சுருள்
21.	Braking force	–	தடை விசை
22.	Mechanical advantage	–	இயந்திர லாபம்
23.	Inlet port	–	உள்ளிழுக்கும் துவாரம்
24.	Bypass port	–	புற வழித் துவாரம்
25.	Check valve	–	சோதனை
26.	One way valve	–	திருப்பு வால்வு

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Evaluation

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PART - A

One mark questions
Choose the correct answer

1. What kind of energy is converted and how in the brake system.
   a) Kinetic energy into static energy
   b) Kinetic energy into electrical energy
   c) Thermal energy in to kinetic energy
   d) Frictional energy and heat energy

2. The frictional force between which two parts in the brake system is used to stop the vehicle?
   a) In between the brake drum and wheel cylinder
   b) In between the brake drum and brake shoes
   c) In between the brake drum and wheel hub
   d) In between the brake drum and brake disc

3. In which part the friction plate is connected in the disc type brake system?
   a) Piston
   b) Caliper
   c) Wheel hub
   d) Axle casing

4. The actual percentage of braking efficiency of a new vehicle should be
   a) 40%
   b) 60%
   c) 80%
   d) 100%

5. What type of brake is mostly used in cars?
   a) Mechanical brake
   b) Hydraulic brake
   c) Air brake
   d) Vacuum brake

6. Which part in the wheel cylinder is used to stop the leakage of brake fluid?
   a) Piston
   b) Spring
   c) Dust cover
   d) Cup

7. Hand brake is driven by which wheels?
   a) Rear wheels
   b) Front wheels
   c) Left side wheels
   d) Right side wheels

8. Brake linings are generally made up of which material?
   a) Asbestos
   b) Copper
   c) Cast iron
   d) Aluminum alloy

9. What is the name of the procedure for the removing of air from the hydraulic brake system?
   a) Cleaning
   b) Removing
   c) Bleeding
   d) Replacing oil

10. Brake linings are affixed to which part?
    a) Brake shoes
    b) Brake drum
    c) Wheel cylinder
    d) Master cylinder

Part - B

Three mark questions

1. What is the need of brake system?
2. What are the advantages of disc type brakes?
3. What are the general types of brakes?
4. What are the properties should be there in brake fluid?
5. What are the additives mixed in the brake fluid?
6. How the brake shoes are connected to the brake linings?
7. What is meant by servo brake? And its type?
8. What are the advantages of antilock brake system?

Part - C

Five mark questions

1. Describe the procedure of removing air bubbles in the hydraulic braking system.
2. Draw and name the parts of wheel cylinder.
3. Describe the construction of brake shoe with neat diagram.
4. Describe the manufacturing procedure of brake linings and the procedure for connecting brake lining to the brake shoes.
5. Distinguish between drum type brake and disc type brake.
6. Describe the disc type brake with neat diagram.

Part - D

Ten mark questions

1. Draw the Line Diagram of air brake and describe it.
2. Explain the master cylinder in a hydraulic brake system with neat diagram.
3. Draw and explain the vacuum type servo brake system.
4. Draw and explain about the tandem master cylinder.