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Overview of Disc Brake

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ABSTRACT

A disc brake is a type of brake that uses the calipers to squeeze pairs of pads against a disc or "rotor" to create friction. This action slows the rotation of a shaft, such as a vehicle axle, either to reduce its rotational speed or to hold it stationary. The energy of motion is converted into waste heat which must be dispersed. Disc brake system is widely used on front wheels in mid-range two-wheeler such as – commuter & sports bikes. The Disc brake system is used on the front wheels of most hatchback cars, entry-level sedans & MUVs; whereas, it is also widely used on both front & rear wheels of high-end cars and SUVs in combination with hydraulic / vacuum brake actuating systems.

KEYWORDS: *Caliper, disc brake, piston, pressure, rotor etc*

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I. INTRODUCTION

A brake system is designed to slow and halt the motion of vehicle. To do this, various components within the brake system must convert vehicle's moving energy into heat. This is done by using friction. Friction is the resistance to movement exerted by two objects on each other. Two forms of friction play a part in controlling a vehicle: Kinetic or moving, and static or stationary. The amount of friction or resistance to movement depends upon the type of material in contact, the smoothness of their rubbing surfaces and the pressure holding them together.

Disc brake is a type of brake used in the brake system.

Development of disc-type brakes began in England in the 1890s. In 1902, the Lanchester Motor Company designed brakes that looked and operated in a similar way to a modern disc-brake system even though the disc was thin and a cable activated the brake pad. Other designs were not practical or widely available in cars for another 60 years. Successful application began in airplanes before World War II.

Compared to drum brakes, disc brakes offer better stopping performance because the disc is more readily cooled. As a consequence discs are less prone to the brake fade caused when brake components overheat. Disc brakes also recover more quickly from immersion.Most drum brake designs have at least one leading shoe, which gives a servo-effect. By contrast, a disc brake has no self-servo effect and its braking force is always proportional to the pressure placed on the brake pad by the braking system via any brake servo, braking pedal, or lever. This tends to give the driver better feel and helps to avoid impending lockup. Drums are also prone to bell mouthing and trap worn lining material within the assembly, both causes of various braking problems.

The disc is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon–carbon or ceramic matrix composites. This is connected to the wheel and/or the axle. To slow down the wheel, friction material in the form of brake pads, mounted on the brake caliper, is forced pechanically, hydraulically, pneumatically, or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop.

Disc brake system is widely used on front wheels in mid-range two-wheeler such as – commuter & sports bikes. The Disc brake system is used on the front wheels of most hatchback cars, entry-level sedans & MUVs; whereas, it is also widely used on both front & rear wheels of high-end cars and SUVs in combination with hydraulic / vacuum brake actuating systems.

Some of the applications of disc brake are as follows:

- Higher cc performance bikes as their speed is more there is a need for better stopping power.
- Front or all four wheels of new vehicles are equipped with disc brakes.
- Bicycles and mountain bikes.

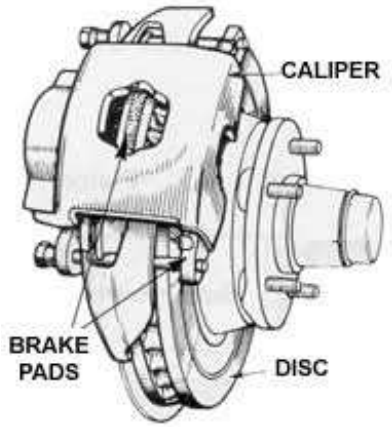

FIGURE 1: Disc Brake

II. COMPONENTS OF DISC BRAKE

The main components of a disk brake are the Brake Pads, Rotor, Caliper and Caliper Support.

A. Brake Pads

Brake pads convert the kinetic energy of the vehicle to thermal energy through friction. Two brake pads are contained in the brake caliper, with their friction surfaces facing the rotor. When the brakes are hydraulically applied, the caliper clamps or squeezes the two pads together onto the spinning rotor to slow and stop the vehicle. When a brake pad heats up due to contact with the rotor, it transfers small amounts of its friction material onto the disc, leaving a dull grey coating on it. The brake pad and disc, then stick to each other, providing the friction that stops the vehicle. In disc brakes, there are usually two brake pads per disc rotor. These are held in place and actuated by a caliper affixed to the wheel hub or suspension upright. Racing calipers, however, can utilize up to six pads, with varying frictional properties in a staggered pattern for optimum performance. Depending on the properties of the material, the weight of the vehicle and the speeds it is driven at, disc wear rates may vary. The brake pads must usually be replaced regularly to prevent brake fade. Most brake pads are equipped with a method of alerting the driver when this needs to be done. A common technique is manufacturing a small central groove whose eventual disappearance by wear indicates the end of a pad's service life. Other methods include placing a thin strip of soft metal in a groove, such that when exposed the brakes squeal audibly. A soft metal wear tab can also be embedded in the pad material that closes an electric circuit when the brake pad wears thin, lighting a dashboard warning light.

B. Rotor

The disk rotor is made of iron with highly machined surfaces where the brake pads contact it. Just as the brake pads wear out over time, the rotor also undergoes some wear, usually in the form of ridges and groves where the brake pad rubs against it. This wear pattern exactly matches the wear pattern of the pads as they seat themselves to the rotor. When the pads are replaced, the rotor must be machined smooth to allow the new pads to have an even contact surface to work with. Only a small amount of material can be machined off of a rotor before it becomes unusable and must be replaced. A minimum thickness measurement is stamped on every rotor and the technician doing the brake job will measure the rotor before and after machining it to make sure it doesn't go below the legal minimum. If a rotor is cut below the minimum, it will not be able to handle the high heat that brakes normally generate. This will cause the brakes to fade, greatly reducing their effectiveness to a point where you may not be able to stop.

C. Caliper and Support

There are two main types of calipers:

Floating calipers and fixed calipers. There are other configurations but these are the most popular. Calipers must be rebuilt or replaced if they show signs of leaking brake fluid.

1. Single Piston Floating Calipers

Single Piston Floating Calipers are the most popular and also least costly to manufacture and service. A floating caliper floats or moves in a track in its support so that it can center itself over the rotor. As you apply brake pressure, the hydraulic fluid pushes in two directions. It forces the piston against the inner pad, which in turn pushes against the rotor. It also pushes the caliper in the opposite direction against the outer pad, pressing it against the other side of the rotor. Floating calipers are also available on some vehicles with two pistons mounted on the same side. Two piston floating calipers are found on more expensive cars and can provide an improved braking feel.

2. Four Piston Fixed Calipers

Four Piston Fixed Calipers are mounted rigidly to the support and are not allowed to move. Instead, there are two pistons on each side that press the pads against the rotor. Four piston calipers have a better feel and are more efficient, but are more expensive to produce and cost more to service. This type of caliper is usually found on more expensive luxury and high performance cars.

D. Brake fluid

The brake fluid is used to create hydraulic pressure which is then used to force the piston outwards towards the disc rotor. They have high boiling point to sustain high temperature, chemically stable and have lubricating properties.

E. Fluid reservoir

A tank or reservoir where the brake fluid is stored.

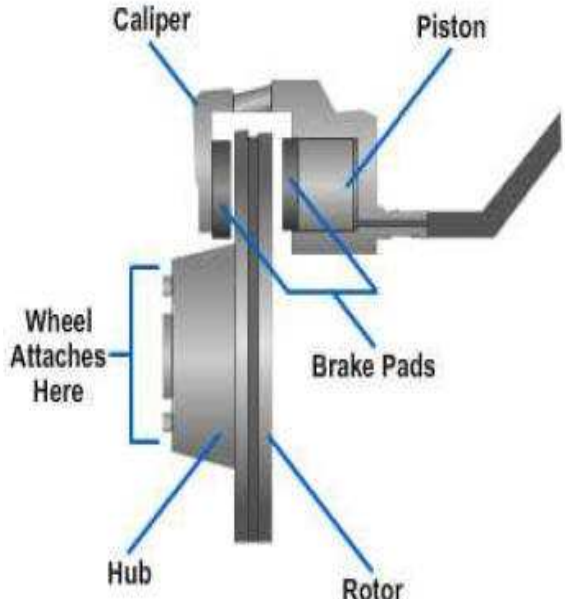

FIGURE 2: COMPONENTS OF DISC BRAKE

III. WORKING PRINCIPLE OF DISC BRAKE

A disk brake works on the principle of Pascal's Law/Principle of transmission of fluid pressure. Pascal's law developed by French mathematician Blaise Pascal states that "pressure exerted anywhere in a confined incompressible fluid is transmitted equally in all directions throughout the fluid such that the pressure ratio (initial difference) remains same."The law simply suggests that when a pressure is applied to any point in static fluid in a container then there is an equal increase in pressure at every point in container.

When a brake lever or pedal is pressed, the push rod which is connected to lever or pedal and master cylinder piston pushes the master cylinder piston. This movement allows the master cylinder piston to slide and push the return spring inside the bore of master cylinder, which generates pressure in reservoir tank. At this moment a primary seal allows the brake fluid of reservoir tank to flow over it into the brake hosepipes. A secondary seal ensures that the brake fluid does not go other side.

Then the fluid enters in to cylinder bore of caliper assembly via brake hosepipes and pushes the caliper piston or pistons. At this time the piston ring moves in rolling shape with piston. Then the caliper piston pushes brake pad. This movement causes brake pads to stick with brake disc which creates friction and stops the brake disc/rotor to rotate. This way disk brake system stops or slows down the vehicle.

When the brake lever or pedal is released the piston ring pushes the caliper piston back to cylinder bore of caliper till both, caliper piston and piston ring come into their original shape. At this time retraction spring pushes the brake pads to their original position. The return spring in master cylinder assembly pushes the master cylinder piston back into its original position and allows the fluid to flow back to reservoir via hosepipe and master cylinder bore.

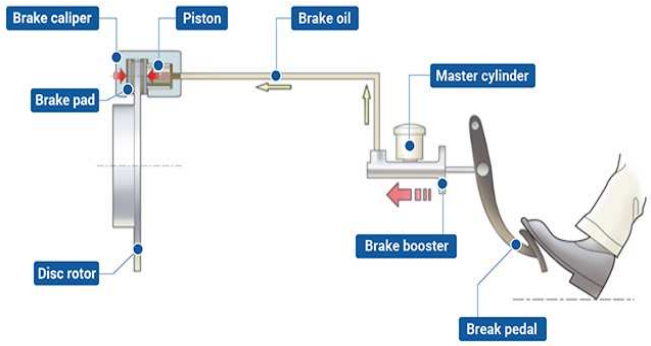

FIGURE 3: WORKING OF DISC BRAKE

IV. TYPES OF DISC BREAK

Different types of disc brake used are as follows:

A. Single piston

In the single piston design such as in two-wheelers, the brake pads are actuated by a single piston, which is attached to the brake caliper. When you press the brake lever, the brake oil pushes the piston causing the brake pads to contract and rub against the disc. The friction between the brake pads and the disc causes the disc to stop rotating, thereby the wheel to stop. When you release the brake lever, the brake pads retract to their original position. This causes a gap between them and the disc and to again spin it freely.

B. Twin Piston

The twin piston design such as in cars is almost identical to single piston one, except for the pistons which are two in numbers. In this system, the twin pistons push the brake pads to apply the brake. The brake pads fit on the caliper which holds the brakes system parts together. When the driver presses the brake pedal, the oil in the brake master cylinder multiplies the hydraulic force sent to the calipers; causing its piston to contract. The pistons, in turn, cause the brake pads to contract and rub against the disc. The friction between the brake pads and the disc causes it to stop rotating, thereby the wheel to stop.

C. Twin Caliper

The third type – Twin caliper system; actuated by two calipers which works on the same principle of that of single caliper brake system. In this design, there are two calipers instead of one. However, the high-speed luxury cars more commonly employ this type of system. This system provides more effective braking.

D. Ventilated Discs

Modern vehicles come with ventilated discs. When you apply brakes, it converts the kinetic energy of the vehicle to heat due to the friction between the brake pads and the disc. Ventilated discs have passages or an air vent that helps pass air through the disc. Thus, it provides cooling & prevents brake fading.

V. ADVANTAGES AND DISADVANTAGES OF DISC BRAKE

Advantages of disc brake are as follows:

- Disk brake requires less effort (brake torque) to stop the vehicle compare to drum brake.
- It generates less heat compare to drum brake for the same brake torque.
- Ease of maintenance as disk brake is outside the wheel rim.
- It cools down faster compare to drum brake.
- If worn out brake shoes are not changed at proper time it can cut the brake drum in drum brake. Disk brake does not have such problem.
- It is less likely to skid compare to drum brake in wet condition.
- It is much safer than drum brake in hard braking condition. Under such condition drum brake can lock up the rear wheel.
- It has brake pad wear indicator which is not there in drum brake.

Disadvantages of dis brake are as follows:

- Disc brakes are much more prone to noise. Their design tends to create squeals and squeaks.
- rotors warp easier than in drum brake systems. Since the brake pads are pressing on each side of the rotor, thickness variations of as small as 0.0003″ (0.0076 mm) can cause brake pedal pulsations, requiring resurfacing or replacement.
- Since disc brakes are not self-energizing, they need higher clamping forces, which requires a power booster. This also makes it harder to use them as effective parking brakes.

CONCLUSION

Disc brake is a complex system and this paper provides an overview for the study of disc brake. Disc brake has many advantages over other brakes which makes it preferable for many applications but one disadvantage which still needs to be handled is the squeaks or noise that the disc brakes are prone to. However this disadvantage has been lowered and tackled with further advancement but still needs more work to be done.

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