

Module 3: Hydraulic Disc Brakes and Components

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Hydraulic Disc Brakes and Components

READY FOR REVIEW

- Modern passenger vehicles are usually equipped with disc brakes on at least two wheels.
- Primary components of the disc brake system are:
 1. Rotor
 - The main rotating part of this brake system
 - Hard wearing and resists high temperatures that occur during braking
 - The manufacturer specifies the minimum thickness for the rotor.
 - Can be of solid construction or slotted. A slotted rotor is referred to as a “ventilated disc.”
 2. Rotor composition
 - Disc brakes have rotors to dissipate heat so brakes work efficiently.
 - May be made from composite materials, ceramics, or carbon fiber
 3. Directional vanes
 - Some rotors have directional vanes, which means the disc can only be fitted to one side of vehicle.
 4. Caliper
 - Straddles the rotor and houses the disc brake pads and activating pistons
 - Usually bolted to the steering knuckle and, in case of a non-steer axle, to the suspension component
 5. Disc pads
 - Located inside the caliper
 - Pads clamp onto the rotor to slow or stop the vehicle.
 - A disc pad consists of friction material bonded to the steel backing plate.

Disc Brake Operation

READY FOR REVIEW

- The disc brake system converts the hydraulic pressure generated at the master cylinder into a frictional clamping force against the rotating discs.
- Disc brakes can be used on all four wheels of a vehicle or combined with disc brakes on the front wheels and drum brakes on the rear.
- When the brake pedal is depressed, a push rod transfers the force through a brake booster to a hydraulic master cylinder.
- The master cylinder converts the force into hydraulic pressure, which is then transmitted via connecting pipes and hoses to one or more pistons at each brake caliper.
- The pistons operate on friction pads to provide a clamping force on a rotating flat disc that is attached to the wheel hub. This clamping tries to stop the rotation of the disc and the wheel.
- On nondriving wheels, the center of the brake disc or hub contains the wheel bearings, and the hub can be part of the brake disc or a separate assembly between the wheel and hub with nuts or bolts.
- On driving wheels, the disc is mounted onto the driving axle and may be held in place by the wheel. On front wheel drive vehicles, it can be mounted on the front hub and wheel bearing assembly.
- The brake caliper assembly is bolted to the vehicle axle housing or suspension, and in most cases, the brake is positioned as close as possible to the wheel.
- Some high-performance cars use inboard disc brakes on its rear wheels, and the makers claim improved vehicle handling for this design because it reduces unsprung weight.

- Applying brakes can absorb a lot of vehicle energy, so friction between braking surfaces generates great heat, and brake parts can withstand very high temperatures.
- Most of the friction area of a disc is exposed to the air so cooling is far more rapid than for a drum brake; unlike with drum brakes, brake fade is rare.
- Because of their shape, discs tend to throw off water, so after being driven through water, they operate almost immediately.
- Disc brakes need much higher pressures to operate than drum brakes, so almost all disc brake systems need a power brake booster to help reduce the pedal forces that are needed from the driver.
- Because of the high forces needed to apply a disc brake, using it as a handbrake is less common, and some vehicles build a drum brake into the center of the rear disc to provide for parking brake operation.

Disc Brake Rotors

READY FOR REVIEW

- The brake disc rotates with the road wheel, and it provides a smooth surface against which to force the brake pads, to slow or stop the vehicle.
- The brake disc or rotor is the main rotating component of the disc brake unit.
- It's usually made of cast iron because it's hard-wearing and can resist high temperatures.
- Most brake discs are stamped with the manufacturer's minimum thickness specification, such that when the pad wears, if the thickness of the disc were below this minimum, the piston may go beyond the sealing edge.
- Ventilated discs can be used to improve cooling, and these slots are designed to use centrifugal force to cause airflow when the disc is rotating.
- Some discs are drilled or slotted on their friction surface to improve cooling and assist with removing water.

Disc Brake Pads

READY FOR REVIEW

- A disc brake pad has a rigid, molded, friction material bonded to a steel backing plate for support during brake application, and it transforms the hydraulic force of the caliper into a frictional force against the disc.
- Disc brake pads consist of friction material bonded onto a steel backing plate, and the backing plate has lugs that locate the pad in the correct position in relation to the disc.
- Calipers are usually designed so that the condition of the pads can be checked easily once the wheel has been removed and to allow the pads to be replaced with a minimum of disassembly.
- Some pads have a groove cut into the friction surface, and the depth of this groove is set so that when it can no longer be seen, the pad should be replaced.
- Some pads have a wire in the friction material at the minimum wear thickness, and when the pad wears to this minimum thickness, the wire touches the disc as the brakes are applied. A warning light then tells the driver the disc pads are due for replacement.
- Composition of friction material affects brake operation, and materials providing good braking with low pedal pressures tend to lose efficiency when they get hot, which means that the stopping distance will be increased.
- The brake caliper assembly is bolted to the vehicle axle housing or suspension, and in most cases, the brake is positioned as close as possible to the wheel.
- Materials maintaining a stable friction coefficient over a wide temperature range generally require higher pedal pressures to provide efficient braking.
- Disc rotors with holes or slots in them dissipate their heat faster and also help to remove water from the surface of the pad in wet driving conditions.
- These holes or slots also help to prevent the surface of the pad from becoming hard and glassy smooth from the friction and heat of use. However, this scraping action reduces the overall life of the brake pad, so these types of discs are generally only used in high-performance or racing cars.

Disc Brake Calipers

READY FOR REVIEW

- Disc brake calipers provide a housing for the hydraulic piston or pistons that force the brake pads into contact with the disc.
- There are two main types of disc brake calipers: fixed and sliding.
- Fixed calipers can have two, three, or four pistons. Two-piston calipers have one piston on each side of the disc, and each piston has its own disc pad.
- When the brakes are applied, hydraulic pressure forces both pistons inward, causing the pads to come in contact with the rotating disc.
- The sliding or floating caliper has two pads but only one piston, and the caliper is mounted on pins or bushes that let it move from side to side.
- When the brakes are applied, hydraulic pressure forces the piston inward, which pushes the pad against the disc. The caliper is free to move on slides, so there is a clamping effect between the inner and outer pads, and equal force is then applied to both pads that clamp against the disc.
- In disc brake calipers, the piston moves against a stationary square section sealing ring, and when the brakes are applied, the piston slightly deforms the seal.
- When the brakes are released, the seal returns to its original shape. The action of this sealing ring retracts the piston to provide a small running clearance between the disc and pads, and it also makes the brake self-adjusting.

Proportioning Valves

READY FOR REVIEW

- The proportioning valve divides up the braking effort applied to the front and rear wheels under heavy braking, according to how the load is distributed across a vehicle.
- The effectiveness of the braking force is determined by tire-to-road friction, and this increases as the load increases.
- Applying the brakes causes the front of this vehicle to dip, which causes greater tire-to-road friction on the front tires, and less on the rear. This kind of change of load is called load transfer.
- So, if equal braking force is applied to the front and rear wheels, the smaller rear load can make the rear wheels lock and perhaps skid.
- The braking force applied to the wheels needs to be adjusted to allow for changes in load.

Proportioning Valve Operation

READY FOR REVIEW

- The proportioning valve adjusts the braking force applied to the wheels to allow for changes in load.
- The proportioning valve adjusts braking force to allow for load transfer, and it can be pressure-sensitive or load-sensitive.
- The pressure-sensitive valve can be in the master cylinder or in a separate unit in the rear brake circuit.
- The load-sensitive valve type can be in the body or the axle, where it can respond to load changes and change the braking effort as needed.
- Master cylinder applications usually combine the proportioning valve with a pressure differential switch.
- In normal braking, the poppet piston is held in a relaxed position by a large pressure spring. The poppet valve is held against its retainer by a light return spring, and fluid passes freely through the valve to the rear brakes.
- In heavy braking, the master cylinder pressure can reach a valve's crack-point. The pressure applied to the two different areas of the poppet piston creates unequal forces, and that moves the poppet piston against the large pressure spring. This action holds the conical section of the valve against the seat, which limits the pressure increase to the rear brakes.
- As greater pedal force increases pressure in the master cylinder, fluid pressure rises on the smaller end of the piston. This combines with the force of the pressure spring to overcome the lower pressure now on the larger end, and this forces the piston back, clear of the poppet valve.
- The increased pressure now acts on the larger end of the poppet piston and again forces the piston forward to contact the valve.
- When the pedal is released, the pressure of the rear brake fluid unseats the poppet valve, letting fluid return to the master cylinder, and the pressure spring now returns the poppet piston to its relaxed position.
- Should the front brake system fail, the warning lamp spool moves forward, taking the poppet valve with it. Pressure in the rear brakes rises and the piston moves forward, but it can't seal on the valve.

- Should the rear brake system fail, the warning lamp spool will move backwards to activate the warning light. The proportioning valve doesn't operate in this situation.
- On a diagonally-divided system, the pressure-sensitive proportioning valve is usually located away from the master cylinder, and there is one for each circuit. They each operate in a similar way to the pressure-sensitive proportioning valve located in the

master cylinder, but without the pressure-differential warning light circuit.

- The load-sensing proportioning valve is usually located in the rear brake circuit, on the chassis. A diagonally-split system may have two load-sensing proportioning valves, one for each brake, and the unit is mounted on the chassis around the rear suspension.

Brake Friction Materials

READY FOR REVIEW

- Brake pads and linings are made from materials with high coefficient of friction, and the choice of material depends on the braking application. The material must be able to absorb and disperse large amounts of heat without the braking performance being adversely affected.
- Friction is the force that acts to prevent two surfaces in contact from sliding against each other. When friction occurs, the kinetic energy (motion) of the sliding surfaces is converted into thermal energy (heat).
- Some combinations of materials, such as ice on glass, have a very low coefficient of friction with very little friction between them—almost no sliding resistance. Rubber tires against a hard road surface have a high coefficient of friction and tend to grip and resist sliding against each other.
- Disc brake pads and drum brake linings are made from materials with a high coefficient of friction, and they also need to have the ability to absorb and disperse large amounts of heat without the braking performance being adversely affected.
- As the heat in brake pads and linings builds up, the friction capability of the material, and consequently its stopping power, reduces. This is called brake fade, and minimizing or overcoming fade is a major factor in the design of brakes and the development of brake friction materials.
- Brake friction materials were commonly made from asbestos compounds because of the excellent heat resistance of that material; but as that has now been proven to be highly toxic, asbestos is generally banned and no longer used.
- Brakes are now manufactured from a variety of different materials that include nonasbestos organic, low metallic, semi-metallic, or ceramic.
- The choice of the compound depends on the application, as lighter passenger vehicles generate less heat in the brakes than heavy or high-performance vehicles.
- The optimum brake composition for any given vehicle or use will therefore be a combination of weighted attributes that include stopping power, heat absorption and dispersion, resistance to fade, recovery speed from fade, wear rate, performance when wet, and noise in operation.
- For instance, owners of small domestic vehicles will probably tend to value a longer pad life rather than higher performance in extreme conditions. In racing cars, however, fade resistance and stopping power at high speeds would be considered more important than noise levels or wear rate.

Terms and Definitions

READY FOR REVIEW

- A **disc** is the circular metal component used in some brake system designs as the friction surface for the wheel assembly during braking.
- **Noise suppressants** are devices used in conjunction with brake assemblies to reduce the noise and vibration in the assembly. Some examples include anti-rattle springs and anti-vibration clips.
- **To recondition** means to restore to a like-new condition.
- **To resurface** means to restore a surface to a specified (like-new) condition.
- **Ventilated** refers to the disc brake design in which the rotor has vanes in the edge to dissipate heat.

Parts of a Front Disc Brake

READY FOR REVIEW

- Caliper
- Caliper mounting plate
- Shield
- Rotor (with wheel)
- Rotor (with hub)
- Hub nut
- Hub nut cotter pin
- Steering knuckle

Parts of a Rear Disc Brake

READY FOR REVIEW

- Caliper
- Caliper mounting plate
- Caliper retainer
- Caliper spring
- Rear axle
- Rotor (with hub)
- Rotor (with wheel)
- Shield

Parts of a Brake Caliper

READY FOR REVIEW

- Boot
- Piston
- Caliper housing
- Inner pad shoe and lining
- Outer pad shoe and lining

Functions of Disc Brake Assembly Components

READY FOR REVIEW

- The rotor (disc) provides the portion of the wheel assembly against which the brake pads apply pressure to stop the rotation of the wheel.
- The caliper houses the hydraulic piston and related hardware that actuates the pads.
- The mounting plate and bolts hold the caliper assembled.
- The shield protects the rotor from foreign materials such as road ice or mud.
- The caliper housing support holds the caliper in position over the rotor.
- The pads (shoes and linings) exert pressure on the rotor.
- The piston transmits hydraulic force to the pads to push them against the rotor.

Types of Brake Calipers

READY FOR REVIEW

- Brake caliper types are classified in two ways: the installation method and the piston count.
 1. Classified by installation method
 - A floating caliper is mounted on bolts through rubber bushings.
 - A sliding caliper is mounted in machined grooves that allow it to move from side to side in the caliper support.
 2. Classified by piston count
 - A single-piston is one piston that pushes the pad against the rotor.
 - A double (dual)-piston is two pistons that push the pad(s) against the rotor.

Rotor Defects

READY FOR REVIEW

- Excessive runout means that the rotor does not run perpendicular to its axle.
- Lack of parallelism means the distance between the friction surfaces is not even.
- Inadequate thickness means the distance between the friction surfaces is too small.
- Grooving shallow refers to scratches in the surface of the rotor.
Note: Grooving is also referred to as scoring or gouging, if deep.
- Hard spotting refers to tempered areas of metal that become visible when the disc is machined or overheated, and may appear as blue discoloration.
- Heat checking refers to fine cracks in the surface of the rotor.
- Cracking is the separation of the metal of the rotor.
- Taper is the condition in which one or both sides of the rotor angle away from perpendicular to the axis.
- Surface roughness refers to the pits and deposits on the friction surface of the rotor.

Methods of Assembling Brake Pads

READY FOR REVIEW

- There are two methods of assembling brake pads: bonding and riveting.
 1. Bonding is the use of glues or other adhesives to hold the lining to the pad.
 2. Riveting is the use of rivets to hold the lining to the pad.

Brake Pad Defects

READY FOR REVIEW

- Excessive wear is when the thickness of the lining is less than the manufacturer's recommendations.
- Unequal wear is the condition in which the wear of the pad is uneven or the wear of the two pads is not equal.
- Tapered wear is the condition in which the pad is worn at an angle from a high spot to a low spot, either side-to-side or end-to-end.
- Grooving refers to scratches, gouges, or scoring in the pad.
- Pad separation is the condition of the lining coming off the pad or the material of the lining separating from itself.
- Pad contamination is when oil, grease, or other substances have penetrated the lining.

Methods of Determining Wear on Brake Pads

READY FOR REVIEW

- For audible signs, listen for a squeal when the metal tab on the pad contacts the rotor.
- For visual signs, look for apparent wear and defects and measure the thickness of the pads.

Functions of Noise Suppressants and Hardware Components of a Brake Pad

READY FOR REVIEW

- Noise suppressants reduce vibration and rattling of brake assembly components.
- Locator clips position parts relative to each other where excessive pressures are not present.
- Anti-rattle clips reduce vibration and rattling of parts.

Safety Guidelines for Disc Brake Service

READY FOR REVIEW

- Always follow the manufacturer's procedures and specifications.
- Be sure to keep the parts correctly oriented and installed.
- Perform all service operations on a clean bench, free from oil and other contaminants.
- Never allow a caliper to hang by the hydraulic brake line, as this could lead to leaks and possible brake failure.
- Use care not to contaminate the linings with grease, oil, or hydraulic fluid, and replace any linings contaminated with these fluids.
- Avoid getting contaminants on the surface of the rotor, and clean it off immediately if fluids are spilled onto it.
- Do not reuse old bushings, springs, cotter pins, and other small hardware parts, and always replace with new parts.
- Do not reuse brake system fluids.
- Do not mix power steering fluid with hydraulic brake fluid, as swelling and deterioration of rubber parts can result from fluid contamination, eventually leading to brake loss.
- Clean brake parts only with the cleaning solution recommended by the manufacturer.
- If a rotor must be resurfaced, resurface the other rotors on the same axle to try to maintain them at approximately the same thickness.
- Do not move the vehicle until a firm brake pedal is obtained, as failure to obtain a firm pedal before moving the vehicle could result in personal injury.