DISK BRAKE

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Suspension. On automobiles, disc brakes are often located within the wheel

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The disc brake is a device for slowing or stopping the rotation of a wheel. A braking disc (or rotor in US English), usually made of steel, is connected to the wheel or the axle. To stop the wheel, the braking pads (mounted in a device called a brake caliper) are squeezed mechanically or hydraulically against the disc on both sides. Friction causes the disc and attached wheel to slow or stop.

Characterstics

The first designs resembling modern disc brakes began to appear in Britain in the late 1940s and early 1950s. They offered much greater stopping performance than comparable drum brakes, including much greater resistance to "brake fade" (caused by the overheating of brake components), and were unaffected by immersion (drum brakes were ineffective for some time after a water crossing, an important factor in off-road vehicles). Disc brakes are also more reliable than drum brakes due to the simplicity of their mechanics, the low number of parts compared to the drum brake, and ease of adjustment. Unlike a drum brake, the disc brake has no self-servo effect and the braking force is always proportional to the pedal force being applied by the driver.

Disc brakes were most popular on sports cars when they were first introduced, since these vehicles are more demanding about brake performance.

Location

Many early implementations located the brake disc inboard, near the differential, but most discs today are located inside the wheels. (An inboard location reduces the unsprung weight and eliminates a source of heat transfer to the tires, important in Formula One racing. Discs have now become standard in most passenger vehicles, though some retain the use of drum brakes on the rear wheels to keep costs and weight down as well as to simplify the provisions for a parking brake or emergency brake. As the front brakes perform most of the braking effort, this can be a reasonable compromise.

Disc design

The design of the disc varies somewhat. Some are simply solid steel, but others are hollowed out with fins joining together the disc's two contact surfaces (usually included as part of a casting process). This "ventilated" disc design helps to dissipate the generated heat. Many motorcycle and sports car brakes instead have many small holes drilled through them for the same purpose. Additionally, the holes aid the pads in wiping water from the braking surface. Other designs include "slots" - shallow channels machined into the disc to aid in removing used brake material from the brake pads. Slotted discs are generally not used on road cars because they quickly wear down brake pads. However, this removal of material is beneficial to race cars since it keeps the pads soft and avoids vitrification of their surfaces. Some discs are both drilled and slotted.

Disc damage modes

Discs are usually damaged in one of three ways: warping, scarring, and cracking. In addition, the useful life of the discs may be greatly reduced by excessive machining.

Warping

Warping can be caused by excessive heat build up, which softens the metal and can allow it to be disfigured. However with most ventilated discs on the market today this is not the common case. Warping can happen with improperly torqued wheels, but the sensation of warped brakes (wheel shimmy under braking) most often is a matter of a brake pad material operating outside of its designed temperature range and it has left a thick(er) than normal deposit in one area of the disc surface, creating a "sticky" spot that will grab every revolution of the disk. Grease or some other foreign material usually deposited on the disc during wheel maintenance can likewise create a slipperly spot on the disc, also creating the sensation of a grab or warped brake disc.

In cars with automatic transmissions the driver has to keep the brakes applied when the car is stopped, to prevent the car from "creeping". This means that the brake pads remain in contact with the disc and the discs will cool unevenly, this may lead to warping as desribed above. In cars with a manual transmission there is much less need to keep the brakes applied when the car is stopped, the discs will cool more evenly and have less risk of warping.

All of these can result in wheel shimmy during braking. The likelihood of warping can be reduced if the car is being driven down a long grade by several techniques. Use of a lower gear to obtain engine braking will reduce the brake loading. Also, operating the brakes intermittently - braking to a slower than cruising speed for a brief time then coasting will allow the brake material to cool between applications. The suitability of this is, of course, dependent upon traffic conditions. Riding the brakes lightly will generate a great amount of heat with little braking effect and should be avoided. High temperature conditions as found in autobile racing can be dealt with by proper pad selection, but at the tradeoff of everyday drivability. But this discussion goes outside the scope of this article.

The wheel shimmy during braking is often caused by thickness variation of the rotor disc. If the rotor has runout, a thin spot will develop by the continuous touch touch touch as the rotor turns while the brakes are not applied. When this thickness variation increases to approximately 0.007 inch, the pulsation can be felt by the driver. When the thin section of the rotor passes under the pads, the pads move together. When the thicker section of the disc passes between the pads, the torque will increase. This change in torque causes the pulsation.

Scarring

Scarring can occur if brake pads are not changed promptly, all the friction material will wear away and the caliper will be pressed against the metal backing, reducing braking power and making scratches on the disc. If not excessive, this can be repaired by machining off a layer of the disc's surface. This can only be done a limited number of times as the disc has a minimum safe thickness. For this reason it is prudent to periodically inspect the brake pads for wear (this is done simply on a vehicle lift when the tires are rotated without disassembly of the components). When practical, they should be replaced before the pad is completely worn.

Cracking

Cracking is limited mostly to drilled discs, which get small cracks around outside edges of the drilled holes near the edge of the disc due to the rotors uneven rate of expansion in severe duty environments. Manufacturers that use drilled rotors as OEM, are doing so for looks if they determine that the average owner of the vehicle model will not overly stress them, or as a function of reducing the unsprung weight of the brake assembly, with the engineering assumed that enough brake rotor mass remains to absorb racing temperatures and stresses. A brake disc is a heat sink, remove mass and you increase the stresses it will have to contend with. Generally an OEM application that is not drilled, will crack, and could fail catastrophically if used over and above the original equipment design. Once cracked, these discs cannot be repaired.

Unnecessary resurfacing machining

Resurfacing machining has three purposes; to remove warps (restore planarity, or clean to the discs), to remove scoring, and to remove previously bedded material when new pads are installed, fresh pads should be freshly bedded into a fresh disc surface. Brake shops will often resurface through a machining operation regardless of the need to do so due to warping or scarring. This can reduce the useful life of the disc in cases where only a light material removal (using emery cloth) would suffice. Reducing the life of the discs is of little concern to many brake shops as they can make money on replacing discs worn (or machined) below the manufacturer's minimum specified thickness. Keep in mind that a machined rotor also has less mass, and will heat up quicker, and more rapidly, increasing the likeliness to crack (if drilled), and overheat the pad material as it cannot absorb the same amount of energy and maintain consistent temperatures as once before.

Calipers

The brake caliper is the assembly which houses the brake pads and pistons. The pistons are usually made ofaluminum or chrome plated iron. There are two types of calipers: floating or fixed. A fixed caliper does not move relative to the disc. It uses one or more pairs of pistons to clamp from each side of the disc, and is more complex and expensive than a floating caliper. A floating caliper (also called a "sliding caliper") moves with respect to the disc; a piston on one side of the disc pushes the inner brake pad till it makes contact with the braking surface, then pulls the caliper body with the outer brake pad so pressure is applied to both sides of the disc.

Floating caliper (single piston) designs are subject to failure due to sticking. This can occur due to dirt or corrosion if the vehicle is not operated. This can cause the pad attached to the caliper to rub on the disc when the brake is released. This can reduce fuel mileage and cause excessive wear on the affected pad.

Pistons & cylinders

The most common caliper design uses a single hydraulically actuated piston within a cylinder, although high performance brakes use as many as 8. Modern cars use different hydraulic circuits to actuate the brakes on each set of wheels as a safety measure. The hydraulic design also helps multiply braking force.

Failure can occur due to failure of the piston to retract - this is usually a consequence of not operating the vehicle during a time that it is stored outdoors in adverse conditions. For high mileage vehicles the piston sealsmay leak, which must be promptly corrected.

Brake pads

The brake pads are designed for high friction with brake pad material embedded to the disc in the process of bedding while wearing evenly. It is a common assumption that the pad material contacts the metal of the disc to stop the car. The pads work with a very thin layer of its own material and generate a semi-liquid friction boundary that creates the actual braking force. Of course depending on the properties of the material, disc wear could be faster, or slower than with other pads. The properties that determine material wear revolve around trade offs between performance and longevity. The brake pads must be replaced regularly, and most are equipped with a method of alerting the driver when this needs to take place. Some have a thin piece of soft metal that causes the brakes to squeal when the pads are too thin, while others have a soft metal tab embedded in the pad material that closes an electric circuit and lights a warning light when the brake pad gets thin. More expensive cars may use an electronic sensor.

Early brake pads (and shoes) contained asbestos. When working on older car's brakes, care must be taken not to inhale any dust present in the caliper (or drum).

Brake Squeal

Sometimes a loud noise or high pitch squeal occurs when the brakes are applied. Most brake squeal is produced due to vibration (resonance instability) of the brake components especially the pads and rotors. This type of squeal does not negatively affect brake stopping performance. Some simple techniques like adding chamfers to linings, greasing the contact between caliper and the pads (finger to backplate, piston to backplate), bonding insulators(damping material) to pad backplate,etc might help reduce squeal. Many times cold weather combined with high early morning humidity (dew) could make the brake squeal worse and vanishes when the lining reaches regular operating temperatures. However, some lining wear indicators are also designed to squeal when the lining is due for replacement. Overall brake squeal can be annoying to the vehicle passengers, passerby, pedestrians, etc especially as vehicles are designed to be more comfortable and quieter. Hence vehicle NVH(Noise, Vibration and Harshness) is one of the important priorities for todays vehicle manufacturers.

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