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Design and Fabrication of Hydraulic Brakes System

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ABSTRACT
The current tendencies in automotive industry need intensive investigation in problems of interaction of active safety systems with brake system equipments. At the same time, the opportunities to decrease the power take-off of single components, disc brake systems. Disc brakes sometimes spelled as "disk" brakes, use a flat, disc-shaped metal rotor that spins with the wheel. When the brakes are applied, a calliper squeezes the brake pads against the disc (just as you would stop a spinning disc by squeezing it between your fingers), slowing the wheel.The disc brake used in the automobile is divided into two parts: a rotating axis symmetrical disc, and the stationary pads. The hydraulic disc brake is an arrangement of braking mechanism which uses brake fluid, typically containing ethylene glycol, to transfer pressure from the controlling unit, which is usually near the operator of the vehicle, to the actual brake mechanism, which is usually at or near the wheel of the vehicle.The frictional heat, which is generated on the interface of the disc and pads, can cause high temperature during the braking process. Hence the automobiles generally use disc brakes on the front wheels and drum brakes on the rear wheels. The disc brakes have good stopping performance and are usually safer and more efficient than drum brakes. The four wheel disc brakes are more popular, swapping drums on all but the most basic vehicles. Many two wheel automobiles design uses a drum brake for the rear wheel. Brake technology began in the '60s as a serious attempt to provide adequate braking for performance cars has ended in an industry where brakes range from supremely adequate to downright phenomenal.One of the first steps taken to improve braking came in the early '70s when manufacturers, on a widespread scale, switched from drum to disc brakes. Since the majority of a vehicle's stopping power is contained in the front wheels, only the front brakes were upgraded to disc during much of this period. Since then, many manufacturers have adopted four-wheel disc brakes on their high-end and performance models as well as their low-line economy cars. Occasionally, however, as in the case of the 1999 Mazda Protégé's, a manufacturer will revert from a previous four-wheel disc setup to drum brakes for the rear of the car in order to cut both production costs and purchase price.

***Keywords**: Hydraulic System, Brake, disc brake*

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I. INTRODUCTION

A brake is a mechanical device which inhibits motion. Most commonly brakes use friction to convert kinetic energy into heat, though other methods of energy conversion may be employed.

Brakes are generally applied to rotating axles or wheels, but may also take other forms such as the surface of a moving fluid (flaps deployed into water or air). Some vehicles use a combination of braking mechanisms, such as drag racing cars with both wheel brakes and a parachute, or airplanes with both wheel brakes and drag flaps raised into the air during landing.

Since kinetic energy increases quadratically with velocity ($K = mv^2/2$), an object moving at 10 m/s has 100 times as much energy as one of the same mass moving at 1 m/s, and consequently the theoretical braking distance, when braking at the traction limit, is 100 times as long. In practice, fast vehicles usually have significant air drag, and energy lost to air drag rises quickly with speed.

Almost all wheeled vehicles have a brake of some sort. Even baggage carts and shopping carts may have them for use on a moving ramp. Most fixed-wing aircraft are fitted with wheel brakes on the undercarriage. Some aircraft also feature air brakes designed to reduce their speed in flight. Notable examples include gliders and some World War II-era aircraft, primarily some fighter aircraft and many dive bombers of the era. These allow the aircraft to maintain a safe speed in a steep descent. The Saab B 17 dive bomber used the deployed undercarriage as an air brake.

Friction brakes on automobiles store braking heat in the drum brake or disc brake while braking then conduct it to the air gradually. When travelling downhill some vehicles can use their engines to brake.

When the brake pedal of a modern vehicle with hydraulic brakes is pushed, ultimately a piston pushes the brake pad against the brake disc which slows the wheel down. On the brake drum it is similar as the cylinder pushes the brake shoes against the drum which also slows the wheel down.

HISTORY OF DISC BRAKE

Ever since the invention of the wheel, if there has been "go" there has been a need for "whoa." As the level of technology of human transportation has increased, the mechanical devices used to slow down and stop vehicles has also become more complex. In this report I will discuss the history of vehicular braking technology and possible future developments.

Before there was a "horse-less carriage," wagons, and other animal drawn vehicles relied on the animal's power to both accelerate and decelerate the vehicle. Eventually there was the development of supplemental braking systems consisting of a hand lever to push a wooden friction pad directly against the metal tread of the wheels. In wet conditions these crude brakes would lose any effectiveness.

The early years of automotive development were an interesting time for the designing engineers, "a period of innovation when there was no established practice and virtually all ideas were new ones and worth trying. Quite rapidly, however, the design of many components stabilized in concept and so it was with brakes; the majority of vehicles soon adopted drum brakes, each consisting of two shoes which could be expanded inside a drum."

In this chaotic era is the first record of the disc brake. Dr. F.W. Lanchester patented a design for a disc brake in 1902 in England. It was incorporated into the Lanchester car produced between 1906 through 1914. These early disc brakes were not as effective at stopping as the contemporary drum brakes of that time and were soon forgotten. Another important development occurred in the 1920's when drum brakes were used at all four wheels instead of a single brake to halt only the back axle and wheels such as on the Ford model T. The disc brake was again utilized during World War II in the landing gear of aircraft. The aircraft disc brake system was adapted for use in automotive applications, first in racing in 1952, then in production automobiles in 1956. United States auto manufacturers did not start to incorporate disc brakes in lower priced non-high-performance cars until the late 1960's.

WORKING OF A BRAKE

We all know that pushing down on the brake pedal slows a car to a stop. But we do not how does this happen, how does our car transmit the force from our leg to its wheels and how does it multiply the force so that it is enough to stop something as big as a car.

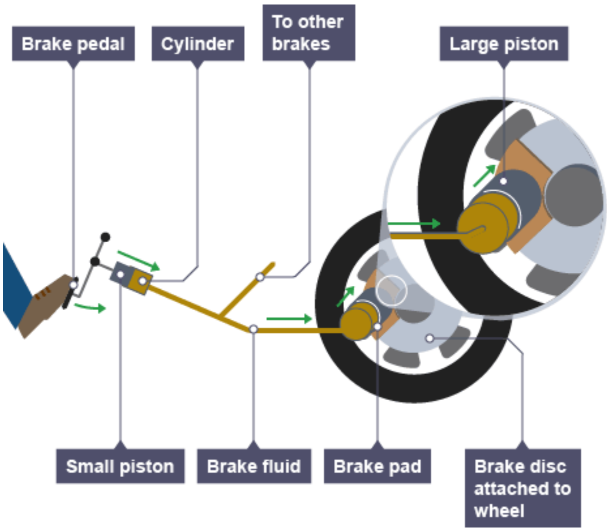

Fig 1: Braking – fundamentals

Friction and how it applies to automobiles

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.

Thus, in a nutshell a car brake works by applying a static surface to a moving surface of a vehicle, thus causing friction and converting kinetic energy into heat energy. The high-level mechanics are as follows.

As the brakes on a moving automobile are put into motion, rough-textures brake pads or brake shoes are pressed against the rotating parts of vehicle, be it disc or drum. The kinetic energy or momentum of the vehicle is then converted into heat energy by kinetic friction of the rubbing surfaces and the car or truck slows down.

When vehicle comes to stop, it is held in place by static friction. The friction between surfaces of brakes as well as the friction between tires and roads resists any movement. To overcome the static friction that holds the car motionless, brakes are released. The heat energy of combustion of in engine is converted into kinetic energy by transmission and drive train, and the vehicle moves.

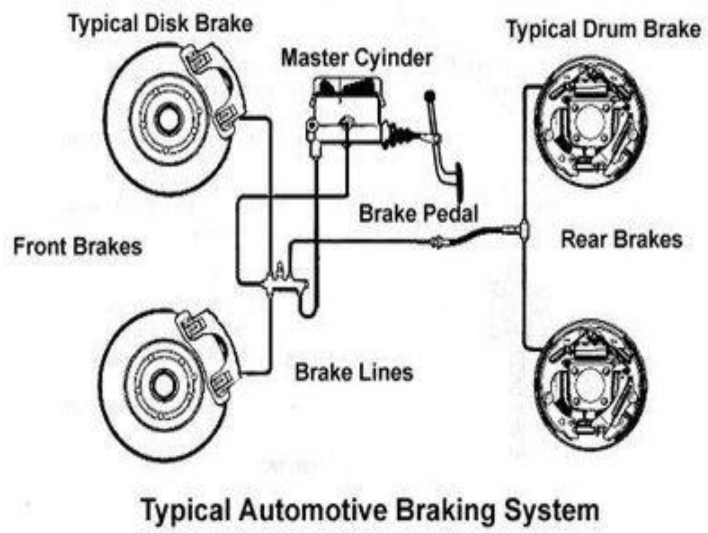

Fig 2: Typical Braking System

HYDRAULIC SYSTEMS

The basic idea behind any hydraulic system is very simple: Force applied at one point is transmitted to another point using an **incompressible fluid**, almost always an oil of some sort. Most brake systems also multiply the force in the process.

A SIMPLE BRAKE SYSTEM

The distance from the pedal to the pivot is four times the distance from the cylinder to the pivot, so the force at the pedal will be increased by a factor of four before it is transmitted to the cylinder.

The diameter of the brake cylinder is three times the diameter of the pedal cylinder. This further multiplies the force by nine. All together, this system increases the force of your foot by a factor of 36. If you put 10 pounds of force on the pedal, 360 pounds (162 kg) will be generated at the wheel squeezing the brake pads.

There are a couple of problems with this simple system. What if we have a leak? If it is a slow leak, eventually there will not be enough fluid left to fill the brake cylinder, and the brakes will not function. If it is a major leak, then the first time you apply the brakes all of the fluid will squirt out the leak and you will have complete brake failure.

COMPONENTS OF HYDRAULIC DISC BRAKE

Now that we understand hydraulics let's take a look at the different parts which make up the hydraulic brake. The entire braking system can be broken down into the following main parts:

1. Master cylinder (Lever)
2. Lines
3. Fluid
4. Slave cylinder (Calliper)
5. Pads
6. Rotor

WORKING OF HYDRAULIC DISC BRAKES

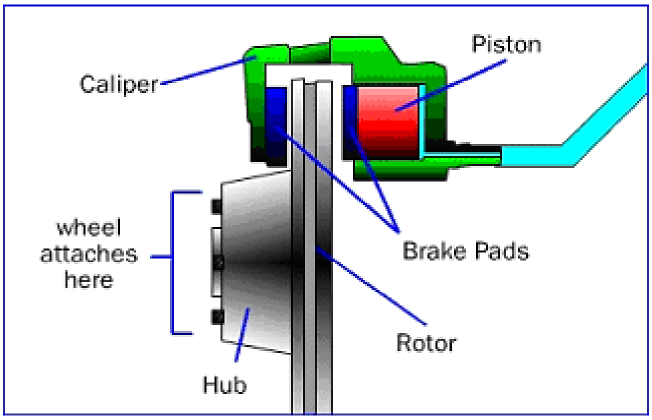

Fig 3: Working of hydraulic disc brakes

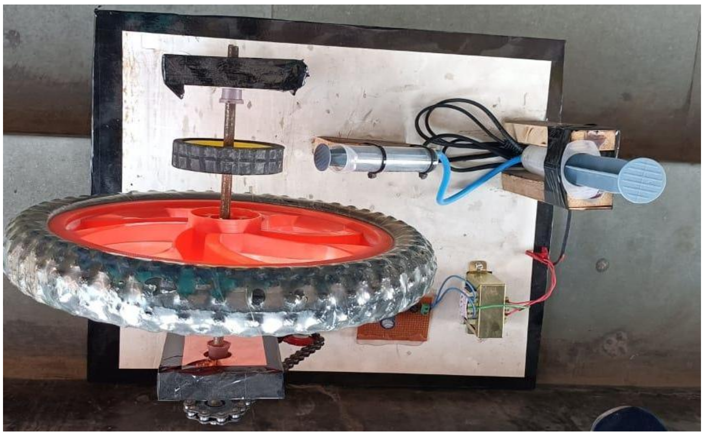

Fig 4: Protype Hydraulic Brake

The master cylinder is where the brake fluid starts. The pedal is attached to the master cylinder plunger. When the pedal is depressed it pushed the plunger which pushes the brake fluid down the brake lines. The brake lines are connected to the slave cylinders. When the brake fluid reaches the slave cylinders it presses out a piston to which is attached a brake pad. The brake pad then clamps against the rotor. All air must be bled from the system. (Air is compressible and if you have any in the system you will have a soft pedal.) As oil is virtually uncompressible it works as a solid link from pedal to brake.

8.1 THE MASTER CYLINDER IN ACTION

As you can see in figure there are two pistons (primary and secondary) and two springs inside the master cylinder.

When the brake pedal is pressed, a push rod moves the primary piston forward which begins to build pressure in the primary chamber and lines. As the brake pedal is depressed further, the pressure continues to increase.

Fluid pressure between the primary and secondary piston then forces the secondary piston forward and pressurizes the fluid in the secondary circuit.

If the brakes are operating properly, the pressure will be the same in both circuits.

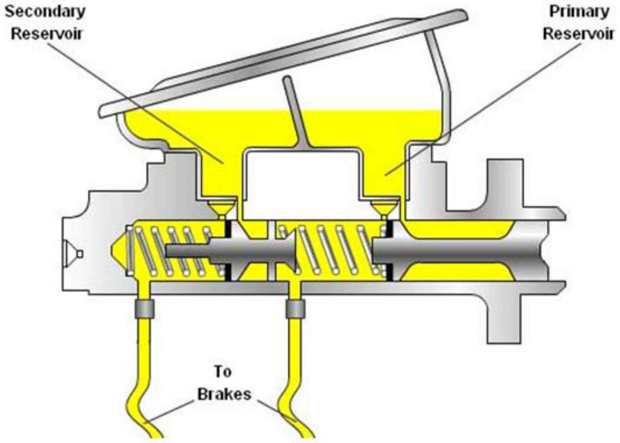

Fig 5: Brakes released

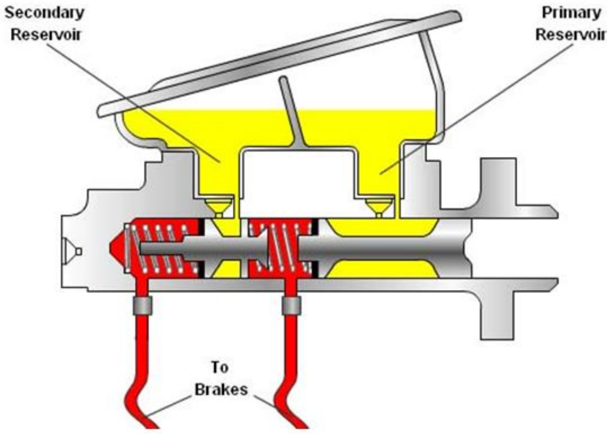

Fig 6: Brakes applied

If there is a leak in one of the brake circuits, that circuit will not be able to maintain pressure. Figure shows what happens when one of the circuits develops a leak. In this example, the leak is in the primary circuit and the pressure between the primary and secondary pistons is lost. This pressure loss causes the primary piston to mechanically contact the secondary piston and the master cylinder now behaves as if it has only one piston. The secondary circuit will continue to function correctly, however the driver will have to press the pedal further to activate it. In addition, since only two wheels now have pressure, the braking power will be reduced.

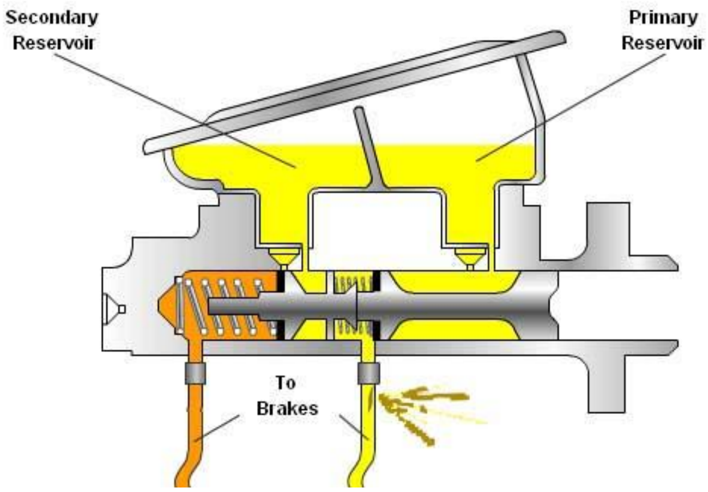

Fig 7: Functioning of the brakes

COMPENSATING PORTS
Small holes those are located between the master cylinder reservoir and the front side, or pressure side, of the master cylinder pistons.

When the master cylinder pistons are in the at-rest position (no braking-figure 9), the piston seals uncover the compensating ports and open the passages between the reservoir and the wheel brake channel.

Allow for the normal expansion and contraction of brake fluid due to changes in temperature.

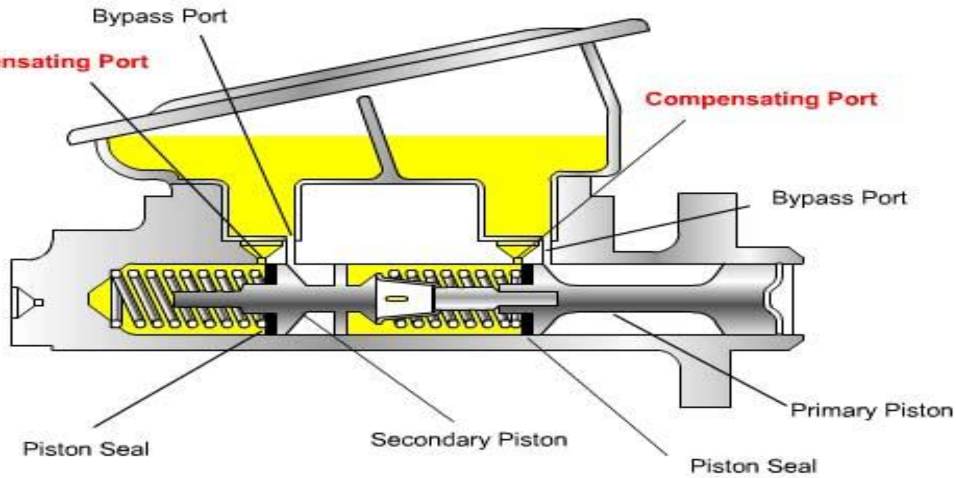

Fig 8: Compensating Ports

Assist in fluid return after brake release (See Bypass Port section below).

Note: When the brakes are released, the piston seals on both the primary and secondary pistons are located between the compensating port and the bypass port. During braking, the piston seals close the compensating port passages to the reservoir which prevents high pressure fluid from entering the reservoir.

8.3 BYPASS PORTS
The bypass ports, like the compensating ports, are passages that are open between the reservoir and the master cylinder chambers (fig. 10). However, the bypass ports are open to the low pressure or back side of the pistons. Allow the master cylinder pistons to return to the at-rest position rapidly.

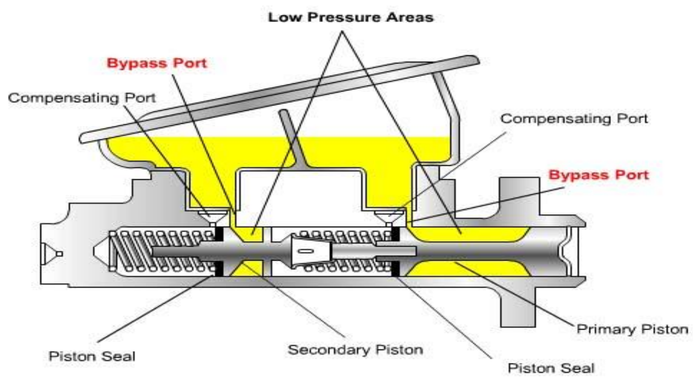

Fig 9: Bypass Ports

During brake release, the following occurs:
• Strong springs in the master cylinder force the pistons back to the at-rest position faster than the brake fluid can return through the hydraulic channels. The pistons must return rapidly so they can be ready for another forward stroke, if necessary. This rapid piston return movement could create a vacuum in the master cylinder high pressure chambers, which would delay brake release.
• The bypass ports allow brake fluid from the reservoir to fill the low-pressure piston chambers.
• Brake fluid from the low pressure chambers then passes through holes in the pistons and bypasses the piston lip seals. The pistons can then return without any "dragging".

Since this "return action" causes additional fluid to be moved to the front of the piston, it results in an excess amount of fluid being present there, as even more fluid returns from the callipers and wheel cylinders. This excess fluid is easily returned to the reservoir through the now-open compensating ports.
Note: "Piston dragging" can also occur if the seals are installed backward.

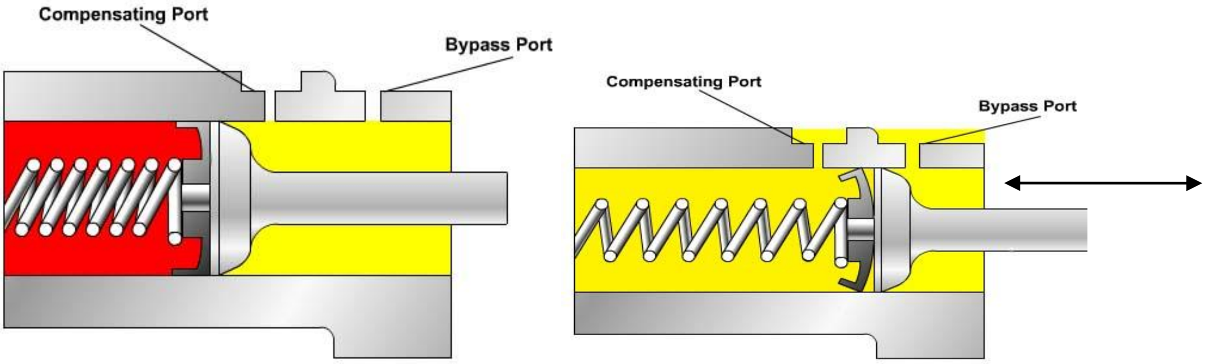

Fig 11: Master Cylinder Return Operation: applied (left); releasing (right)

SELF ADJUSTMENT OF DISC BRAKES:

Disc brakes are self adjusting. Each piston has a seal on it to prevent fluid leakage. When the brakes are applied, the piston moves toward the disc. This distorts the piston seal. When the brakes are released, the seal relaxes and returns to its original position. This pulls the piston away from the disc. As the brakes linings wear, the piston over travels and takes a new position in relation to the seal. This action provides self-adjustment of disc brakes.

EMERGENCY BRAKES:

In cars with disc brakes on all four wheels, an emergency brake has to be actuated by a separate mechanism than the primary brakes in case of a total primary brake failure. Most cars use a cable to actuate the emergency brake.

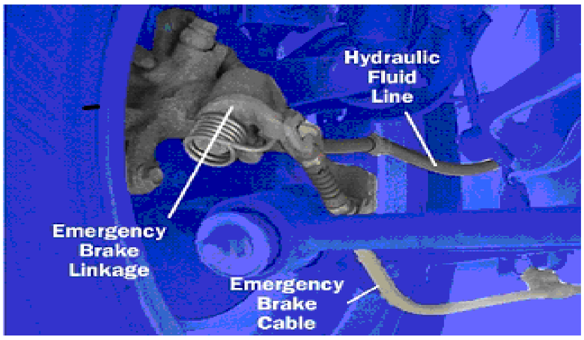

Fig 10: Emergency Brakes

Some cars with four-wheel disc brakes have a separate drum brake integrated into the hub of the rear wheels. This drum brake is only for the emergency brake system, and it is actuated only by the cable; it has no hydraulics.

BRAKE FADE

Vehicle braking system fade, or brake fade, is the reduction in stopping power that can occur after repeated or sustained application of the brakes, especially in high load or high speed conditions. Brake fade can be a factor in any vehicle that utilizes a friction braking system including automobiles, trucks, motorcycles, airplanes, and even bicycles.

Brake fade is caused by a build-up of heat in the braking surfaces and the subsequent changes and reactions in the brake system components and can be experienced with both drum brakes and disc brakes. Loss of stopping power, or fade, can be caused by friction fade, mechanical fade, or fluid fade. Brake fade can be significantly reduced by appropriate equipment and materials design and selection, as well as good cooling.

Brake fade occurs most often during high performance driving or when going down a long, steep hill. Owing to their configuration fade is more prevalent in drum brakes. Disc brakes are much more resistant to brake fade and have come to be a standard feature in front brakes for most vehicles.

BRAKE MODIFICATION TO REDUCE FADE

High performance brake components provide enhanced stopping power by improving friction while reducing brake fade. Improved friction is provided by lining materials that have a higher coefficient of friction than standard brake pads, while brake fade is reduced through the use of more expensive binding resins with a higher melting point, along with slotted, drilled, or dimpled discs/rotors that reduce the gaseous boundary layer, in addition to providing enhanced heat dissipation. Heat build-up in brakes can be further addressed by body modifications that direct cold air to the brakes.

The "gaseous boundary layer" is a hot rod mechanics explanation for failing self-servo effect of drum brakes because it felt like a brick under the brake pedal when it occurred. To counter this effect, brake shoes were drilled and slotted to vent gas. In spite of that, drum brakes were abandoned for their self-servo effect. Discs do not have that because application force is applied at right angles to the resulting braking force. There is no interaction.

Drum brake fade can be reduced and overall performance enhanced somewhat by an old "hot rudder" technique of drum drilling. A carefully chosen pattern of holes is drilled through the drum working section; drum rotation centrifugally pumps a small amount air through the shoe to drum gap, removing heat; fade caused by water-wet brakes is reduced since the water is centrifugally driven out; and some brake-material dust exits the holes. Brake drum drilling requires careful detailed knowledge of brake drum physics and is an advanced technique probably best left to professionals. There are performance-brake shops that will make the necessary modifications safely.

DISC BRAKE VENTS

A moving car has a certain amount of kinetic energy, and the brakes have to remove this energy from the car in order to stop it. How do the brakes do this? Each time you stop your car, your brakes convert the kinetic energy to heat generated by the friction between the pads and the disc. Most car disc brakes are vented.

Brake fade caused by overheating brake fluid (often called Pedal Fade) can also be reduced through the use of thermal barriers that are placed between the brake pad and the brake calliper piston. These reduce the transfer of heat from the pad to the calliper and in turn hydraulic brake fluid. Some high-performance racing callipers already include such brake heat shields made from titanium or ceramic materials. However, it is also possible to purchase aftermarket titanium brake heat shields that will fit your existing brake system to provide protection from brake heat. These inserts are precision cut to cover as much of the pad as possible. These Titanium Brake shims are an easy to install, low cost solution that are popular with racers and track day enthusiasts.

Another technique employed to prevent brake fade is the incorporation of fade stop brake coolers. Like titanium heat shields the brake coolers are designed to slide between the brake pad backing plate and the calliper piston. They are constructed from a high thermal conductivity, high yield strength metal composite which conducts the heat from the interface to a heat sink which is external to the calliper and in the airflow. They have been shown to decrease calliper piston temperatures by over twenty percent and to also significantly decrease the time needed to cool down. Unlike titanium heat shields, however, the brake coolers actually transfer the heat to the surrounding environment and thus keep the pads cooler.

REASON FOR HIGH EFFICIENCY OF DISC BRAKES

- Flat brake disc (axial brake) under high pressure versus round brake drum (radial brake) during braking
- Full friction surface of the brake pad on the plane brake disc.
- No loss of brake power due to overheating or partial contact from brake drum parts expansion.
- Disc brakes can withstand higher loads and its efficiency is maintained considerably longer even under the highest stresses
- Higher residual brake force after repeating braking
- Brake discs can withstand extremely high temperatures
- Full contact of brake pads achieves maximum effect.
- No verification of brake pads. Dangerous fading or slipping is almost completely eliminated.

BETTER BRAKING BEHAVIOUR OF HYDRAULIC DISC BRAKES

- Driver friendly braking behaviour. Sensitive braking in all situations and better
- Sensitive brake application and better brake feeling
- Uniform braking from small fluctuations in brake forces

- ❖ Retardation values retained even under heavy stresses
- ❖ Minimal "pulling to one side" due to uneven brake forces
- ❖ Disc brake axial arrangement permits a simple and compact design
- ❖ Linear characteristics lead to an even progression of brake force
- ❖ Basic design principle makes for higher efficiency
- ❖ Low hysteresis is particularly suitable to ABS control cycles

HIGHER SAFETY RESERVES

❖ Minimal braking effect from high temperatures and extreme driving requirements Minimal heat fading

❖ No brake disc distortion from extreme heat due to internal ventilation with directional stability and large power reserve under high stress

❖ The decisive safety aspects of the disc brake design are shorter braking distances

❖ High power and safety reserves for emergencies

❖ Constant braking power under high stresses

❖ Shortened braking distance under emergency braking with considerably improved directional

The limitations of hydraulic disc brakes:

❖ Braking systems fails if there is leakage in the brake lines.

❖ The brake shoes are liable to get ruined if the brake fluid leaks out.

❖ Presence of air inside the tubing ruins the whole system.

❖ Pad wear is more.

❖ Hand brakes are not effective if disc brakes are used in rear wheels also. (Hand brakes are better with mechanical brakes). CHAPTER-12

APPLICATIONS

The applications of Hydraulic Disc Brakes are:

Hydraulic Disc brakes are used primarily in motor vehicles, tanks, but also in machinery and equipment, and aircraft, bicycles, carriages and railway. The disc brakes have been widely used in cars and trucks, especially in the premium sedan. The disc brakes on the new mine hoist brake. The disc brake inertia is small, fast action, high sensitivity, and adjustable braking torque. The multi-rope friction hoist all use disc brakes.

II. CONCLUSION

Many trucks and buses are equipped with hydraulic actuated disc brakes. The high contact forces are transmitted mechanically via needle mounted actuating device.

In view of the fact that the air can circulate freely between the disc and the brake shoe, disc brakes are cooled much better, especially since it is possible to do so ventilated discs extra holes. The gases resulting from friction, dust, dirt, do not stay on the working surfaces. These brakes are not sticky.

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REFERENCES

[1]. TechCenter By Karl Brauer, Editor in Chief, Edmunds.com http://cars.about.com/od/thingsyouneedtoknow/ig/Disc-brakes

[2]. http://en.wikipedia.org/wiki/Disc_brake

[3]. http://www.kobelt.com/pdf/brochure_brake.pdf

[4]. http://auto.howstuffworks.com/auto-parts/brakes/brake-types/disc-brake.htm

[5]. http://www.sae.org/search?searchfield=brake%20system

[6]. http://www.hinduonnet.com/thehindu/2000/05/25/ceramic brake disc

[7]. Tao, J. J. and Chang, H. T. A system approach tothe drag performance of disc brake caliper. SAEtechnical paper 2003-01-3300, 2003.

[8]. Kikovic, B. Defining the optional geometry ofproportional valve using computer simulation. InProceedings of the International Conference onThe computer as a tool (EUROCON 2005), 21–24November 2005, vol. 2, pp. 1271–1274 (IEEE, NewYork).

[9]. Lee, J.-C., Shin, H.-M., and Jo, H.-Y. A study ofthe effects of entrained air in a hydraulic brakeactuator. Proc. IMechE, Part D: J. Automobile Eng-ineering, 2008, 222(2), 285–292.

[10]. Baumgartner, H. and Theiss, A. Comparison ofpneumatic and hydraulic disk brakes for heavyduty application. SAE technical paper 902202, 1990.

[11]. Wang, X. D., Li, C., and Wang, X. Dynamiccharacteristics analysis of brake system for heavy-duty, off-highway vehicle. SAE technical paper2004-01-2638, 2004.

[12]. Galaktionov, A. M. and Poluektov, V. V. Anti-lockbraking system and operation of brake drive (inRussian). Automot. Ind., 1990, (5), 13.
[13]. Ren, L., Chen, H., and Wang, T. Dynamic systemidentification of Audi disc brake under anti-lockcondition. In Proceedings of the IEEE InternationalVehicle Electronics Conference (IVEC '99), 6–9September 1999, vol. 1, pp. 78–81 (IEEE, New York).
[14]. Dupuis, V. Development of new drum brake. InProceedings of the 25th International m-Sympo-sium – Brake Conference, Bad Neuenahr, Germany,17–18 June 2005, pp. 95–101 (VDI Publishing,Du¨sseldosf).
[15]. Trutschel, R. Analytische und experimentelleUntersuchung der Mensch–Maschine-Schnittstellenvon Pkw-Bremsanlagen, 2007, p. 189 (Universita¨ts-verlag Ilmenau, Ilmenau).
[16]. Ballinger, R. S. Disc brake corner system modelingand simulation. SAE technical paper 1999-01-3400,1999.
[17]. Yamada, T. Development and implementation ofsimulation tool for vehicle brake system. SAEtechnical paper 2001-01-0034, 2001.
[18]. Fortina, A., Velardocchia, M., and Sorniotti, A.Braking system components modelling. SAE tech-nical paper 2003-01-3335, 2003.
[19]. Petruccelli, L., Velardocchia, M., and Sorniotti, A.Electro-hydraulic braking system modeling andsimulation. SAE technical paper 2003-01-3336,2003.
[20]. Doi, S. I., Nagiri, S., and Amano, Y. Evaluation ofactive safety performance of man-vehicle system.National Highway Traffic Safety Administrationpaper 98-S2-O-05, 2003.
[21]. Tarko, L. M. The wave process in pipelines ofhydromechanisms (in Russian), 1963 (State Scien-tific and Technical Publishing House of Machine-Building Literature, Moscow).
[22]. Watton, J. Fluid power systems, 1989, pp. 244–283(Prentice-Hall, Englewood Cliffs, NewJersey).