

Final Thesis

AUTOMOBILE BRAKE SYSTEM

Author: Shenshen Shi

2016-05-24

Bachelor' s degree (UAS)

Field of Study Technology, Communication and Transport			
Degree Programme Degree Programme in Industrial Engineering and Management			
Author(s) Shenshen Shi			
Title of Thesis Automobile brake system			
Date		Pages/Appendices	
Supervisor(s) Principal Lecturer Harri Heikura, Markku Kosunen			
Client Organisation /Partners			
<p>Abstract</p> <p>Nowadays, most people have realized the necessity and significance of the existence of brakes in vehicles. In order to let drivers get automobile brake system, this thesis introduces basic principle and composition, structure of automobile brake system.</p> <p>But meanwhile, because of using brake, there is also more pollution. Such as noise pollution, air pollution and resource waste. For avoid wasting source and make less pollution, we should avoid overusing the brakes.</p> <p>The thesis also discusses about the international market of the brakes with ideas about the future market.</p> <p>As we know, if the brakes fail, the result will be disastrous. For making sure the brakes are in good condition, the drivers need check the brake systems regularly, and replace the broken and badly worn parts of the brakes.</p>			
<p>Keywords Vehicle, Brake, NAO, semi-metallic, Pads, Pollution</p>			

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1 THE TARGET OF THE THESIS AND MAIN CONTENT

It is well-known that the automobile brake system is the most important system in vehicles. If the brake fails, there may be a crash, people may be injured and even die.

In order to guarantee personal safety, the driver should have some basic knowledge about brake system and inspect the brake regularly, make sure it is in good condition.

In addition, automobile brake system is an essential element to measure the performance of an automobile. The performance of brake system directly affects the other properties of the vehicles.

The target of this thesis is to help people get more information about automobile brake system and study some basic maintenance methods.

The main contents include the basic physics principle used in brake system and the basic components of brake system will be introduced. It is explained how the brake system works. The difficult professional concepts of the brake system are not discussed in this thesis.

In addition, this article also displays the current market situation and some ideas of the possible development of brake market in the future.

The final part will introduce some pollution caused by brake system and some simple methods for daily brake maintenance.

2 THEORETICAL BACKGROUND

At first, this chapter introduces the basic physics principle used in brake system and the basic components of brake system.

2.1 Definition of automobile brake system

Actually, vehicle can be regard as energy conversion device, which transfers the momentum into heat, in other words, which transfers the kinetic energy into thermal energy. The brakes are used to reduce the speed of the vehicle, and the speed of conversion determines the rate of the vehicle slows down.

2.2 The basic physics principle used in brake system

As we know when we step the brake pedals or handbrakes, the cars transmit the force from our feet or hands to the brakes. Actually the car commands a stopping force ten times as powerful the force that puts the car in motion. Because the brakes need a much greater force than drivers could apply with legs, the car must multiply the force of the foot. How could it be achieves? These two physics principles could be used: Leverage and Hydraulic system.

And how do the brakes transmit the force to the tires? How do the tires transmit the force to the road? Both answers are using friction.

Therefore, this part will introduce these three physics principle by first: Leverage, Hydraulics, Friction.

2.2.1 Leverage

As the picture below shows, there is a force applied on the left end of the lever. The length of the left end is twice ($2X$) as long as the right end (X). Therefore, there is a force $2F$ on the right end. And it acts via the distance (Y), while the left end moves twice ($2Y$) as long as the

right end. Consequently, with the change of the relative lengths of the left and right ends of the lever, the multipliers are also changing.

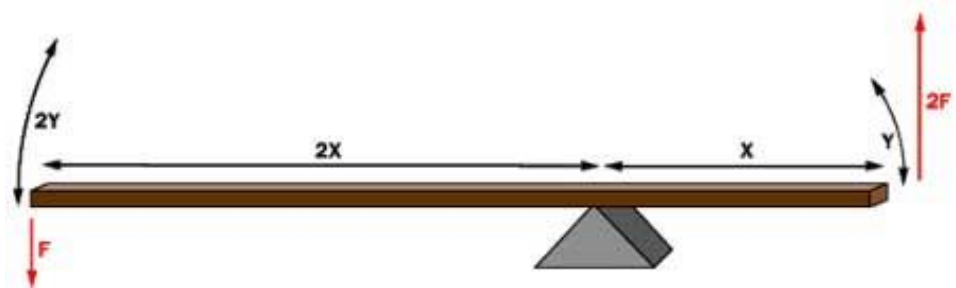


FIGURE 1. Simple leverage (How Stuff Works, 2000)

2.2.2 Hydraulics system

In addition, a hydraulic system is applied the brakes. The hydraulic system connects the brake pedal to the brake parts at each wheel.

The basic hydraulic system principle is simple. We can regard it as a process that force applied at one point is transmitted to another point by using an incompressible fluid, which almost always is an oil of some sort.

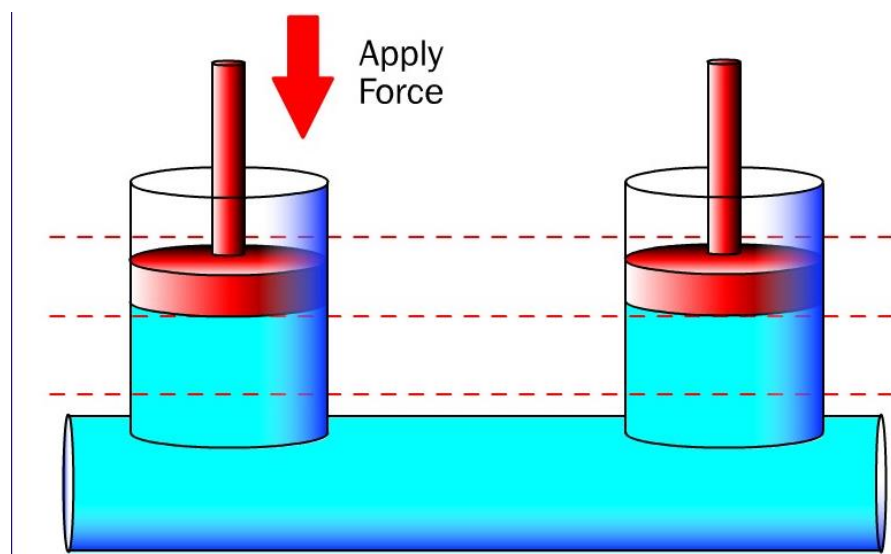
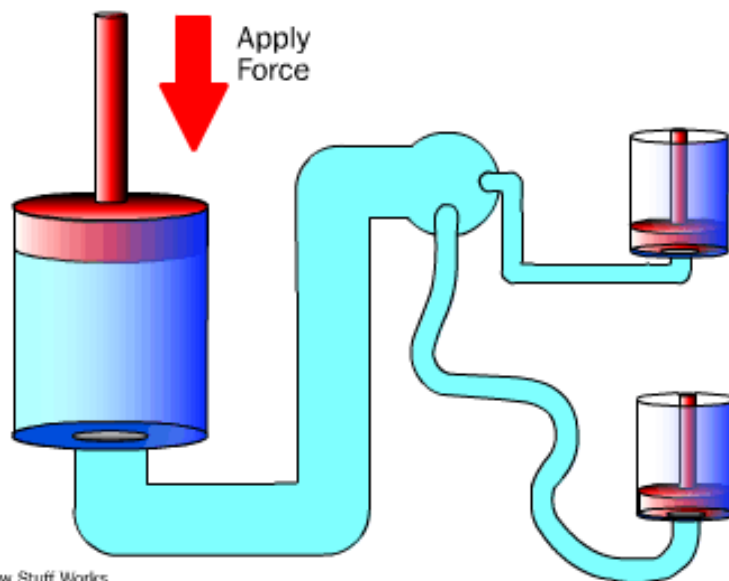


FIGURE 2. Simple hydraulic system (How Stuff Works, 2000)

As the picture above shows, 2 pistons (shown in red) are fitted into two oil-filled glass cylinders (shown in light blue) and connected to another one with a pipe filled with oil. When a downward force is applied to a piston, then the force is transferred to another piston via the oil in the pipe. The oil is almost incompressible, so that the transfer efficiency is high.

And one advantage of the hydraulic system is that the pipe can be any length and shape, therefore it could snake through all sorts of components separating the two pistons. The pipe can also fork, so that one master cylinder can drive many slave cylinders if need.



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FIGURE 3. Master cylinder with two slaves of the hydraulic system (How Stuff Works, 2000)

In the figure above, the master cylinder drives two slave cylinder. One of the advantages of the hydraulic system is that it is easy to achieve force multiplication or force division. In a hydraulic system, you just need to change the size of one piston and cylinder relatively. As shown here:

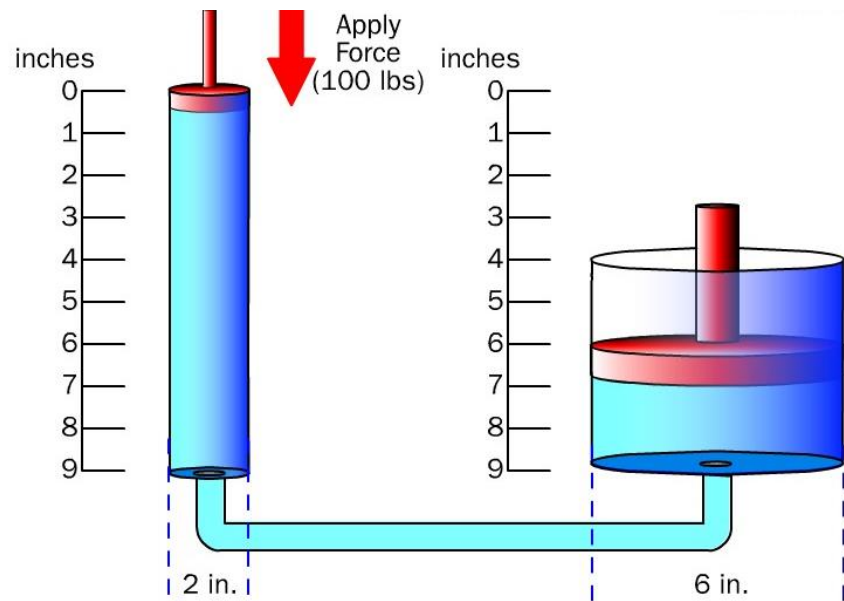


FIGURE 4. Hydraulic multiplication (How Stuff Works, 2000)

In order to make sure the multiplication factor in the figure above, start by knowing the size of the pistons. It could be assumed that the piston on the left is 2 inches (5.08 cm) in diameter (1-inch / 2.54 cm radius), while the piston on the right is 6 inches (15.24 cm) in diameter (3-inch / 7.62 cm radius). The area of the two pistons is $\text{Pi} * r^2$. Therefore, the area of the left piston is 3.14, the right one is 28.26. The piston on the right is nine times larger than the piston on the left. It means that any force applied to the left hand piston will come out nine times greater on the right-hand piston. When applying a 100 pound downward force to the left piston, a 900pound upward force will appear on the right. The only thing changed is that the left piston needs to be depressed by 9 inches (22.86 cm), in order to raise the right piston by 1 inch (2.54 cm)

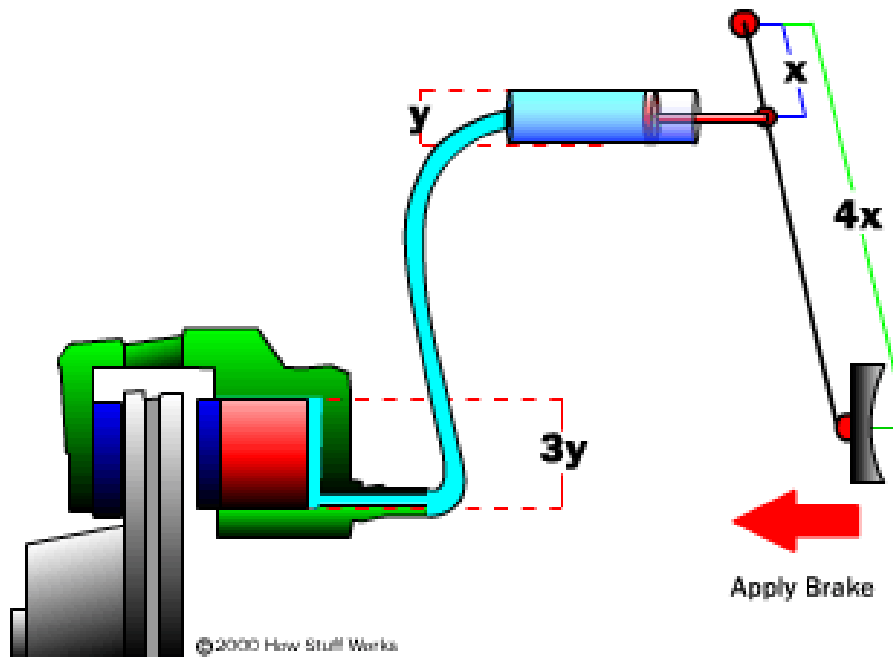


FIGURE 5. Simple brake system (How Stuff Works, 2000)

Then it is easy to understand a simple brake system as shown above. It can be seen that the distance from the pedal to the pivot is 4 times the distance from the cylinder to the pivot, so that the force at the pedal will be increased by a factor of 4 before it is transmitted to the cylinder.

And the diameter of the brake cylinder is 3 times the diameter of the pedal cylinder. It means the force is further multiplied by 9. In total, the system increases the force from your foot by a factor of 36.

Specifically, when you put 1 pounds force on the pedal, 36 pounds (about 16.2 kg) will be generated at the wheel squeezing the brake pads.

2.2.3 Friction

Friction is measured on how hard it is to slide one object over another.

In the figure below, both of the blocks are made from the same material, but one is heavier. Imagine which one will be harder for the bulldozer to push? The idea is the heavier one.



FIGURE 6. Friction (How Stuff Works, 2000)

To understand why this is, let's take a close look at one of the blocks and the table.

The blocks look smooth to the naked eye, but actually they are quite rough at the microscopic level. When the block is set down on the table, the little peaks and valleys get squished together, and some of them may actually weld together. The weight of the heavier block causes it to squish together more, so it is even harder to slide.

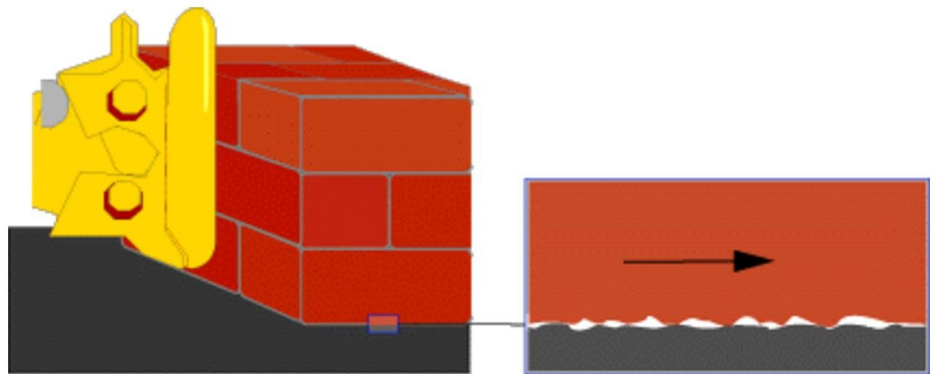


FIGURE 7. Block in microscopic level (How Stuff Works, 2000)

So the amount of force it takes to move the given block is proportional to that block's weight. The more weight, the more force is required.

This concept applies for devices like brakes and clutches, where a pad is pressed against a spinning disc. The more force that presses on the pad, the greater the stopping force.

2.3 Basic components of the brake system

The brake system is composed of the following basic components: the energy-supplying device, the control device, the transmission device,

the brake and additional retarder device, brake line (connecting different devices), and ABS (Anti-lock Braking System)

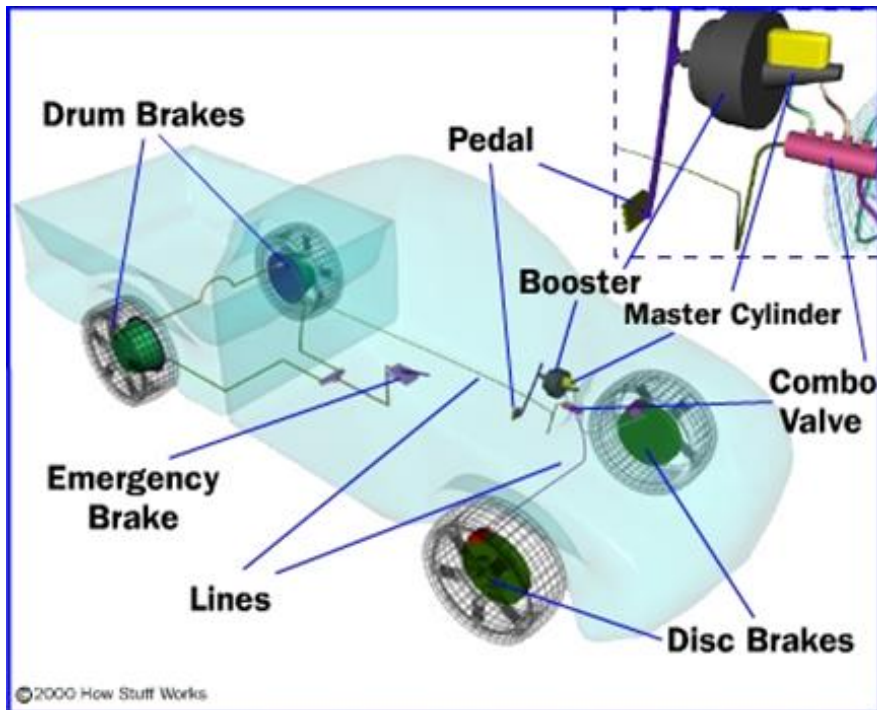


FIGURE 8. Brake system components (How Stuff Works, 2000)

2.3.1 The energy-supplying device

The energy-supplying device means supplying and adjusting the necessary energy of braking. According to the types of energy-supplying, there are three types used in automobile braking system:

muscular energy braking system (non-power braking system)

When we step the brake pedals or the handbrakes, the cars transmit the force from our feet or hands to the brakes. The force from driver supplies the basic energy to brakes. This is non-power braking; it just uses the force from human. For example, the bicycle is only using the no-power braking system to supply energy.

energy assisted braking system (power assisted braking system)

The power assisted braking system use the force from drivers and the kinetic energy of engines together.

The braking force of power assisted system increases through using the vacuum booster unit. Atmospheric pressure helps to push the brake pedal. Thus, less muscle effort is required.

In spark-ignition engines, vacuum is generated through connecting intake manifold to the engine, while the diesel engines use the vacuum pump.

non-muscular energy braking system (power braking system)

The power braking system only uses the engines for transforming the kinetic energy into the potential energy of the atmospheric pressure or the hydraulic pressure.

2.3.2 The control device

The main two control devices of braking systems are the service braking system and the parking braking system. They have separate control and transmission devices. The services braking system is foot-operated, while the parking braking system is hand-operated.

The service brake acts to slow, stop, or hold the vehicle during normal driving. They are foot-operated by the drivers pressing or releasing the brake pedal. The primary purpose of the brake is to hold the vehicle stationary while it is unattended.

The parking brake is mechanically operated, when a separate parking brake foot pedal or hand lever is set.

2.3.3 The transmission device

The transmission device is used to transmit the brake energy to brake actuator components. According to different transfer modes, the transmission device includes mechanical braking system, hydraulic braking system and pneumatic braking system

2.3.4 The brake

According to the different functions of braking system, two types of brakes are used in modern cars: drum brakes and disc brakes. All cars used disc brakes on the front wheels, most cars use drum brakes on the rear wheels. In other words, the typical brake system consists of disc brakes in front and either disc or drum brakes in the rear connected by a system of tubes and hoses that link the brake at each wheel to the master cylinder.

The basic components of drum brakes include: brake drum, an expander, pull back springs, a stationary back plate, two shoes with friction linings, and anchor pins.

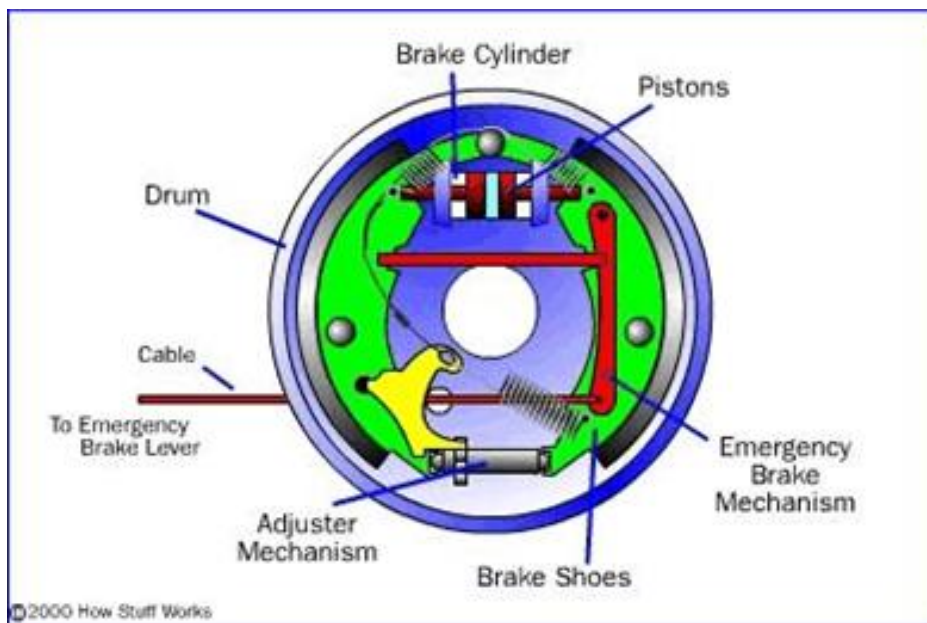


FIGURE 9. The composition of drum brake (How Stuff Works, 2000)

When using brakes, the driver needs to push the pedal, then the expander expands the shoes and presses them to the drum. So that the friction will appear, between the brake drum and the friction linings. Then the friction brakes the wheels, then the vehicle stops. When the driver releases the pedal, the brakes are released, the pullback spring will retract the shoes, thus the wheels will be rotating freely.



FIGURE 10. Drum brake (Baidu, 2016)

Main types of drum brakes include: Simplex drum brake (Leading trailing shoe brake), Duo-trailing shoe brake (Two trailing shoe brake), Double leading shoe brake, Duo-duplex drum brake (Duo two leading shoe brake), Uni-servo drum brake, Duo-servo drum brake.

Instead of a drum, the disc brake has a metal disc and a flat shoe or disc-brake pad, which is located on each side of the disc.

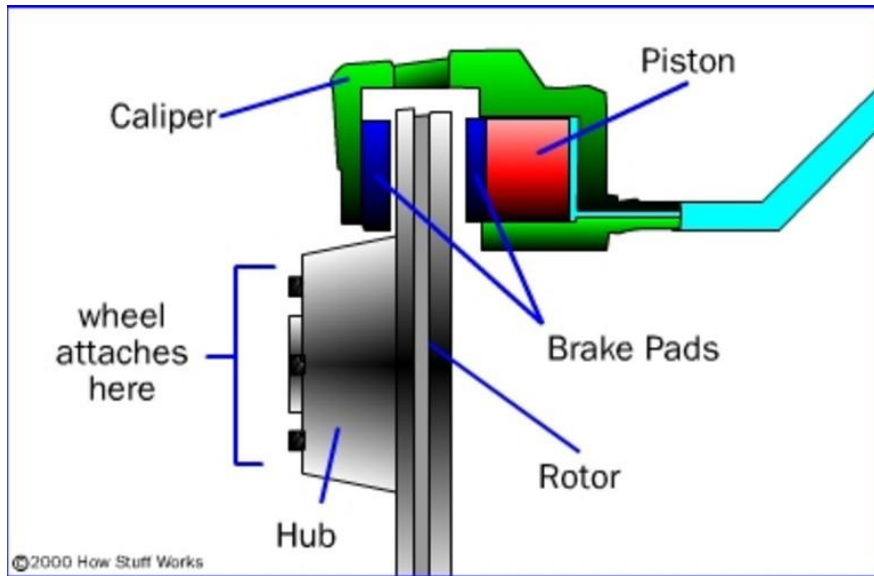


FIGURE 11. The composition of disc brake (How Stuff Works, 2000)

When the drivers step the pedals, the shoes squeeze the rotating disk to stop the car. The fluid from the master cylinder forces the pistons to move in, toward the disc. This action pushes the friction pads tightly against the disc. And then the friction between the shoes and disk slows and stops it. This provides the braking action. Pistons are made of either plastic or metal.



FIGURE 12. Disc brake (Baidu, 2016)

There are three general types of disc brakes: floating-caliper type, the fixed-caliper type and the sliding-caliper type.

2.3.5 Additional retarder device

Additional retarder device is used to make the vehicles slow or keep a speed on a range during driving.

The different types of retarders include: Exhaust retarder, Hydrodynamic retarder, Electromagnetic retarder, Traction motor retarder, Aerodynamic retarder.

2.3.6 Anti-lock Brake System

Anti-lock brake systems make braking safer and more convenient, Anti-lock brake systems modulate hydraulic pressure of brake system to prevent the brakes from locking and the tires from skidding on slippery pavement or during a panic stop. So some sources predict that all cars will offer anti-lock brakes to improve the safety of the car.

Anti-lock systems modulate brake application force several times per second to hold the tires at a controlled amount of slip; all systems accomplish this in basically the same way. One or more speed sensors generate alternating current signal whose frequency increases with the wheel rotational speed. An electronic control unit continuously monitors these signals and if the frequency of a signal drops too rapidly indicating that a wheel is about to lock, the control unit instructs a modulating device to reduce hydraulic pressure to the brake at the affected wheel. When sensor signals indicate the wheel is again rotating normally, the control unit allows increased hydraulic pressure to the brake. This release-apply cycle occurs several times per second to "pump" the brakes like a driver might but at a much faster rate.

In addition to their basic operation, anti-lock systems have two other things in common. First, they do not operate until the brakes are applied with enough force to lock or nearly lock a wheel. At all other times, the system stands ready to function but does not interfere with normal braking. Second, if the anti-lock system fails in any way, the brakes continue to operate without anti-lock capability. A warning light on the instrument panel alerts the driver when a problem exists in the anti-lock system. (Automobile Brake System, 2016)

3 THE IMPACT ON THE ENVIRONMENT

As we know, all automobile brakes are friction brakes. When drivers use brakes, the control device forces brake shoes, or pads, against the rotating brake drum or disks at wheel. Friction between the shoes or pads and the drums or discs then slows or stops the wheel so that the car is braked.

Because of the friction, there are some problems. The main pollution made by automobile brake system can be divided into three groups.

3.1 Air pollution

Air pollution is mainly made by the brake wear particle emissions.

Traffic-related sources have been recognized as a significant contributor of particulate matter particularly within major cities. Non-exhaust particles can be generated either from non-exhaust sources such as brake, tier, clutch and road surface wear or already exist in the form of deposited material at the roadside and become resuspended due to traffic-induced turbulence. Among non-exhaust sources, brake wear can be a significant particulate matter (PM) contributor, particularly within areas with high traffic density and braking frequency. (Environment Science and Pollution Research, February 2015, Volume 22, issue 4, pp 2491-2504)

Nowadays, the drakes are composites of many different and even unknown ingredients, so the brake wear particle emissions are also complicated.

TABLE 1. Trace element concentrations found in emitted brake wear dust (Values in brackets refer to PM10 brake wear, Hildemann et al. 1991)

<i>Metal</i>	<i>Brake dust (mg/kg)</i>	<i>Metal</i>	<i>Brake dust (mg/kg)</i>
<i>Al</i>	<i>330-20,000</i>	<i>Mg</i>	<i>(1700)-83,000</i>
<i>As</i>	<i><2.0-(110)</i>	<i>Mn</i>	<i>620-5640</i>
<i>Ba</i>	<i>(5800)-140,000</i>	<i>Mo</i>	<i>5.0-740</i>
<i>Ca</i>	<i>500-8600</i>	<i>Na</i>	<i>80-(5100)</i>
<i>Cd</i>	<i><0.06-11</i>	<i>Ni</i>	<i>80-730</i>
<i>Co</i>	<i>12-42.4</i>	<i>Pb</i>	<i>4.0-1290</i>
<i>Cr</i>	<i>135-12,000</i>	<i>Sb</i>	<i>4.0-19,000</i>
<i>Cu</i>	<i>70-210,000</i>	<i>Sn</i>	<i>230-2600</i>
<i>Fe</i>	<i>1300-637,000</i>	<i>Ti</i>	<i>100-110,000</i>
<i>K</i>	<i>190-39,000</i>	<i>Zn</i>	<i>120-27,300</i>

Some brake wear particle emissions involve the respiratory function. In addition, some particles from brake wear are harmful or potentially harmful for human health.

3.2 The waste of resources

The biggest drawback of braking is that it will lead to an increase in fuel consumption. If you use brakes, then the cars need to use gas to speed up. If you don't use brakes, the cars can run farther.

And because all car brakes are friction brakes, this will lead to many problems. Such as the wear of tires, brake pads and shoes. So overuse of brakes will lead to wear faster and have to change these component sections have to be changed.

3.3 Noise pollution

Although ideally a brake would convert all the kinetic energy into heat, in practice a significant amount may be converted into acoustic energy instead, contributing to noise pollution.

Brakes usually create some minor noise when applied, but often create squeal or grinding noises that are quite loud.

For road vehicles, the noise produced varies significantly with tire construction, road surface, and the magnitude of the deceleration. Noise can be caused by different things. These are signs that there may be issues with brakes wearing out over time. (C.Michael Hogan, Analysis of highway noise, Journal of Water, Air, & Soil Pollution, Volume 2, Number 3, Biomedical and Life Sciences and Earth and Environmental Science Issue, Pages 387-392, September, 1973, Springer Verlag, Netherlands ISSN 0049-6979)

4 MARKET

According to different components of brakes, there are disc brakes and drum brakes on the market. According to different materials of brake pads, there are four most common types: non-asbestos organic(NAO), ceramics, semi metallic and low metallic brake pads. This chapter will introduce the market of different brakes and brake linings.

4.1 Disc brake and drum brake

The main disadvantage of drum brakes is that the friction area is almost entirely covered by a lining, so most heat must be conducted through the drum to reach the outside air to cool. Because of being exposed to the air, the disc brakes radiate the heat to air easier, the disc brakes have a greater resistance to fade (fall-off in brake efficiency due to heat) than drum brakes. It means the disc brake could be operated continuously for a long period.

And the disc brakes have better gradual braking efficiency. There are also some other advantages of disc brakes, such as: equal wear of the inboard and outboard brake pads, relatively constant brake factor performance with lower susceptibility to fading.

But the disc brakes also have some disadvantages. For example, the disc brake has short brake pad life when used on heavy-duty commercial vehicles, it needs higher acquisition and operating costs, it will cause brake noise easily.

Meanwhile, drum brakes have more parts than disc brakes and are harder to service, but they are less expensive to manufacture, and they easily incorporate an emergency brake mechanism. The effective brake friction area of drum brakes is bigger than that of disc brakes, so that

the drum brakes have higher braking efficiency. It is necessary for the heavy-duty commercial vehicles.

Since 1976, all cars have used disc brakes on the front wheels, most cars use drum brakes on the rear wheels. Because of the car is center of gravity will move forward when braking, the front brakes need higher braking force and better gradual braking efficiency. With the development of economy, even though the disc brake is more expensive to manufacture and operate, in modern passenger vehicles are usually disc front and rear brakes are used. For saving costs, many cars still use drum brakes.

Disc brakes have been used in most passenger cars, and now they are being adopted to commercial vehicles too. Besides being used in fast coaches, the occurrent disc brakes used in commercial vehicles are primarily limited to front-axle brakes. Because when the weight of commercial vehicles is up to about 7.5 t, which are driven in a manner similar to passenger cars.

4.2 Brake linings

Brake linings generally comprise five main components: binders, fibres, fillers, frictional additives or lubricants and abrasives. (Boulter 2006)

Binders hold the components of the brake pad together and ensure the structural integrity of the lining under mechanical and thermal stress. They account for 20–40 % of the lining material. Reinforcing fibers provide mechanical strength and structure to the lining. They usually account for 6–35 % (by mass) of the lining material. Fillers are used in order to improve thermal and noise pad properties and also to reduce the manufacturing cost. They account between 15 and 70% (by mass) of the lining material. Lubricants influence the wear characteristics of the lining. They usually make up 5-29% (by mass) of the brake lining.

Abrasives are used in order to increase friction, maintain cleanliness between contact surfaces and limit the buildup of transfer films. They typically account for up to 10% (by mass) of the lining.

According to different lining types, there are four most common lining types are usually found in passenger vehicles: non-asbestos organic(NAO), ceramics, semi metallic and low metallic types.

4.2.1 Asbestos and organic brake pads

For many years in the past, brake linings were composed of asbestos fibers. They could offer good strength, temperature and chemical resistance, and are cheap compared to other materials that are used for the same purpose. But at present, no asbestos is used anymore. Because asbestos fibers will cause serious health concerns. As the linings wear, asbestos fibers are exposed and released as dust into the air. Asbestos fibers are long, thin and extremely small. Exposed fibers easily shred into thin needle like strands that can drift in the air and be inhaled. The size of the fibers is such that they are not easily filtered out by the mucus linings in the nose and lungs. Hence, the fibers lodge deep in the lungs where their sharp needle like presence becomes a source of constant irritation. To make matters worse, the human body cannot rid itself of these fibers because they are impervious to biochemical assault. So over time, exposure to asbestos dust may result in lung disease or cancer. So many countries have banned using asbestos fibers.

Organic brake pads were developed as an alternative to asbestos. The organic brake pads also known as NAO (non-asbestos organic) brake pads. This type of brake pads were popular on pre-FWD (front-wheel drive) vehicles. Some common materials are used as fibers in this type pads, such as glass, rubber, carbon, and Kevlar. The materials and tools used to manufacture organic brake pads are still the least expensive

today, which is why the majority (roughly 70%) of new cars sold in the US still come with them from the factory.



FIGURE 13. Organic brake pads (What are the best brake pads, 2016)

These pads are softer, create less noise, are easy on brake rotors, produce less dust than metallic pads, and have low manufacturing cost. These pads are suitable for normal driving/ commuting across many environments and perfect for every day vehicles and drivers.

But meanwhile, they wear faster and create more dust than ceramic pads, only operate well within a relatively limited temperature range, wear out quickly compared to other types of brake pads, and quickly lose their coefficient of friction when overheated, they are not suitable for performance driving at all.

4.2.2 Semi-metallic and low metallic brake pads

Semi-metallic brake pads are currently the most widely used brake pads, especially in north America, almost all cars use them. They contain about 30 to 65 percent metal, typically include chopped steel wool or wire, iron powder, copper or graphite mixed with inorganic fillers, and friction modifiers that bond all the ingredients together.

Because of higher metallic content, they are more durable and with excellent heat transfer. They can adapt to high performance requirements, or extreme braking conditions. Therefore, they are suitable for sports cars, ambulances, police cars. \

On the other hand, they tend to wear rotors down faster, can be noisy, and may not perform optimally at low temperatures, and are more expensive than organic pads (generally cheaper than ceramic pads).



FIGURE 14. Semi-metallic brake pads (What are the best brake pads, 2016)

Low metallic brake pad is one kind of semi-metallic brake pads, they are made from an organic formula mixed with small amounts (10 to 30 percent) of copper or steel to help with heat transfer and provide better braking. Similarly, with the added metal, there is more dust and they are slightly noisier.

4.2.3 Ceramics brake pads

Ceramics brake pads are composed of ceramic fibers, nonferrous filler materials, bonding agents, and possibly small amount of metal. Since the 1980s, ceramic pads were designed to replace organic and semi-metallic brake pads, because organic and semi-metallic brake pads will produce more noise and dust.

The ceramic brake pads is quieter and cleaner than semi metallic pads. It will make light colored brake dust which won't even stick to wheels. That means the wheels look more clear than other wheels with organic and semi metallic brake pads. It will remain stable under a wide range of temperatures for consistent performance, so that it has longer life period than organic and semi metallic brake pads.

However, the ceramic brakes also are the most expensive brake pad and in some ways they have some problems. Such as, they won't produce as much cold bite as semi metallic brake pads, and won't absorb heat as well as semi metallic brake pads which can increase brake system temperatures. That means they may not be suitable for using in an extremely cold environment.



FIGURE 15. Ceramic brake pads (What are the best brake pads, 2016)

4.2.4 Choosing the suitable pads

As the above shown, metallic, organic and ceramic pads, these three types of brake pads have different advantages and disadvantages. Therefore it can be said that there is no single brake pad that can reign supreme in every single situation. We cannot easily say which type of pads are the best.

Nowadays, there is a wealth of offering to choose brake linings in aftermarket. Because of different specific characteristics of each type

pads, the drivers need to choose the most suitable pads to match their own driving style.

The semi metallic brake pads are most widely used in cars. They are more versatile, more effective over a wider range of temperatures and have a much higher thermal threshold. They provide better cold bite than other type pads and maintain much more consistent friction characteristics throughout their operating range. So they are more suitable for using on a racetrack or a spirited mountain run. But for every day driving, in a casual city, highway driving and commuting, the ceramic and organic brake pads are a better choice. Because they can offer enough stopping power with quieter, cleaner wheels, and longer life period.

4.3 International market situation and possible development in the future

At present, with the development of number of cars all over the world, the demand for brake linings is huge. In 2006, the world market demand of brake linings was at 2.2 billion, including 170 million for new cars, 2.03 billion brake pads for maintenance and replacement. It is assumed that current amount of cars in the world is about 1300 million, average annual per vehicle need four sets of brake pads annually, the annual demand will reach 5200 billion units of brake pads.

The brake industries in some developed countries are in a leading position in the aspect of process technology and quality management. For the current worldwide development of brake pads, the research and application of semi-metallic formulations is most successful in North America, that of low-metallic pads is most successful in Europe, and that of NAO (non-asbestos organic) is most successful in Japan. Throughout the market trend of the whole world, although each type of pads have their own market share, the low-metallic and NAO brake pads have been guiding the development trend of friction materials. Now the NAO materials have occupied more than a 60% market share

in North America. Although in Europe, the low-metallic materials still occupy the main pads materials market, there have been a quite number of demands about NAO pads in new cars and aftermarket.

The demand of brake pads is close to car production and sales. In 2013, 70% of global car production was made in North America (18%), Japan (16%) and Europe (27%). These three areas also have the highest number of car population all over the world. So the demand of brake pads is mainly concentrated in these three areas.

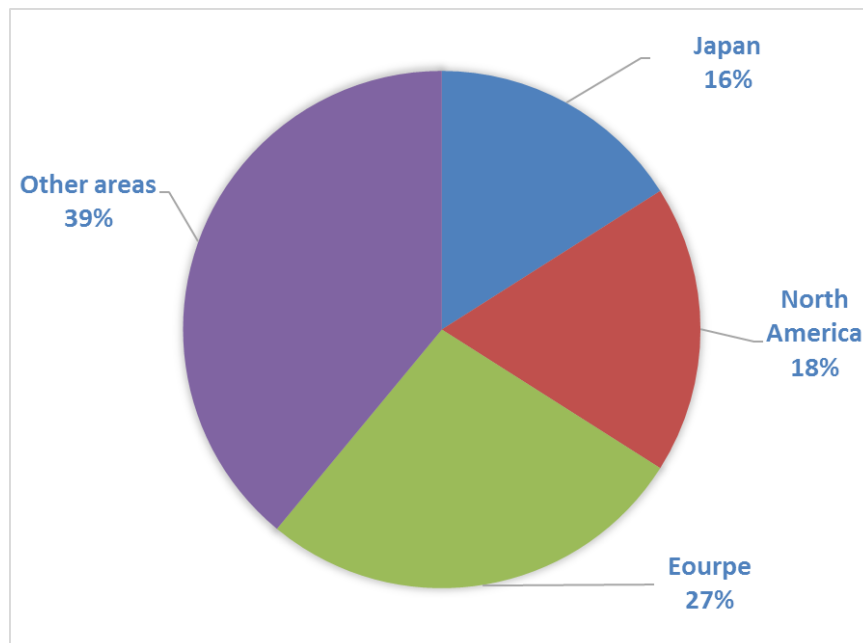


FIGURE 16. Structure of global car market demand in 2013

With the development of the number of global cars, the automobile brakes make more pollution. In the future, the brake pads will be more environmentally friendly. Maybe new materials are found which will be less noisy, less wear particles.

4.4 SWOT analysis of brakes on market

Because the automobile brake system has a long period history, the technology of manufacturing and maintenance is mature enough

nowadays. With the development of car demand, the demand of brakes is higher and higher. Therefore, the market value of brake system is huge, and the prospects of application are broad.



FIGURE 17. SWOT analysis of brakes in market

On the other hand, the technology does not have no a lot of room for technical improvement. And all the brakes have their own defects, and decreasing particle emission and less noise is a big challenge. Since designing innovation and discovering new materials for brakes are difficult.

5 MAINTENANCE AND REPLACEMENT

As we know, if the brake fail, the result will be disastrous. In order to make sure the brake is in good condition, the drivers need to check the brake system regularly, and replace the broken and badly worn parts of the brake.

5.1 Brake calipers, pads and rotors

The braking effect of a car depends on how brake calipers, pads and rotors work together. Keeping them in good condition is the most important and direct way of maintenance. When the calipers squeeze, the brake pads clamp down on the rotors. If the brake pads are worn, they can't connect with the rotors smoothly and this can damage the rotors with rough spots and uneven grooves. Actually the rotor repairs are expensive. Because of the wear of brake pads, the drivers need to review them regularly. Which are sized to specification, they won't wear down. There are wear indicators of brake pads in most modern cars. There will be squealing sound when the brake pads need to be replaced. Of course it is better that you often check them before there is irregular wear or damage or you hear the warning tone. The average working life of brake pads is about 25 thousand kilometers, but the specific situation depends on the usage of cars. In suggestion, drivers could check the wear of brake pads every 10 thousand kilometers.

It is estimated that front brakes have to provide approximately 70% of total braking power and therefore the components of front brakes have to be replaced more frequently than the rear ones.

5.2 Brake fluid

The brake fluid is hygroscopic; it will absorb water. In order to keep the high quality of brake fluid, the driver needs to check and change the

brake fluid regularly and keep the indicated level of brake fluid. By changing it every 24 thousand kilometers or every 2 years, may double or triple the life cycle of modern automatic transmissions. If the cars are often driven in wet areas, the replacement period is shorter.

5.3 The leak of hydraulic system

The hydraulic system is used in both drum and disc brakes, there is an eventuality of a leak. If it is a slow leak, there may not be enough fluid left to fill the brake cylinder, and the brakes may 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 a complete brake failure. So it is necessary to regular check the system regularly whether there is a leak.

6 CONCLUSION

Nowadays, most people have realized the necessity and significance of the existence of brakes in vehicles. Besides the cars, the brake system is also used in many ways, such as in airplanes, bicycles. The technology of brake system will be better in the future. So it is good for drivers to know some basic principles and composition, structure of automobile brake system.

But meanwhile, because of using brakes, there is more pollution, for example, the brakes will emit more particles, noise and waste resource. For better environment, we need to avoid the overuse the brakes.

Different brakes and different brake pads have different advantages and disadvantages. When the drivers choose these parts, they need to think carefully of the actual driving conditions, and find the most suitable ones.

In the future, there will be new materials which can decrease wear particles and noise. Maybe the electric car will occupy a bigger portion in automobile market.

For drivers' safe, they also need to know the basic knowledge about daily maintenance of the brakes, and need to inspect the brakes regularly. In order to make sure the brakes are in good condition, it is necessary to check and replace the broken and badly worn parts of the brakes.

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