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Design of Wedge Braking System

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ABSTRACT: A brake is a device which inhibits motion. Its opposite component is a clutch. Most common brakes use friction to convert kinetic energy into heat, though other methods of energy conversion may be employed. For example regenerative braking converts much of the energy to electrical energy, which may be stored for later use. Other methods convert kinetic energy into potential energy in such stored forms as pressurized air or pressurized oil. Still other braking methods even transform kinetic energy into different forms, for example by transferring the energy to a rotating flywheel. 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.

I. INTRODUCTION

A brake is a device which inhibits motion. Its opposite component is a clutch. Most common brakes use friction to convert kinetic energy into heat, though other methods of energy conversion may be employed. For example regenerative braking converts much of the energy to electrical energy, which may be stored for later use. Other methods convert kinetic energy into potential energy in such stored forms as pressurized air or pressurized oil. Still other braking methods even transform kinetic energy into different forms, for example by transferring the energy to a rotating flywheel.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 = mv22), an object travelling at 10 meters per second has 100 times as much energy as one travelling at 1 meter per second, 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 traveling downhill some vehicles can use their engines to brake. When the brake pedal is pushed a piston pushes the pad towards the brake disc which slows the wheel down. On the brake drum it is similar as the cylinder pushes the brake shoes towards the drum which also slows the wheel down.

II. PRINCIPLE OF BRAKING SYSTEM:

The principle of braking in road vehicles involves the conversion of kinetic energy into thermal energy (heat). When stepping on the brakes, the driver commands a stopping force several times as powerful as the force that puts the car in motion and dissipates the associated kinetic energy as heat. Brakes must be able to arrest the speed of a vehicle in short periods of time regardless how fast the speed is. As a result, the brakes are required to have the ability to generating

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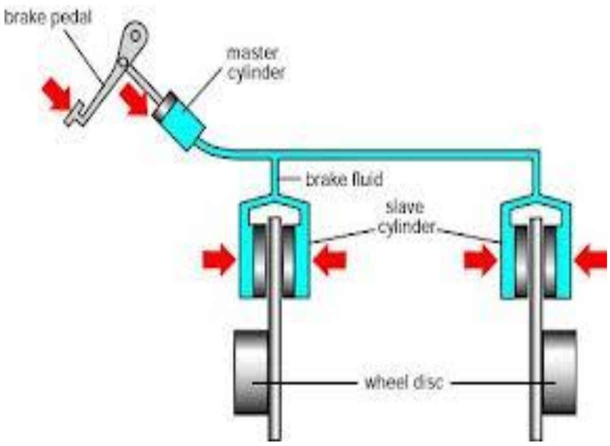
high torque and absorbing energy at extremely high rates for short periods of time. Brakes may be applied for a prolonged periods of time in some applications such as a heavy vehicle descending a long gradient at high speed. Brakes have to have the mechanism to keep the heat absorption capability for prolonged periods of time.



III. TYPES OF BRAKING SYSTEM

Brakes may be broadly described as using friction, pumping, or electromagnetic. One brake may use several principles: for example, a pump may pass fluid through an orifice to create friction.Frictional brakes are most common and can be divided broadly into "shoe" or "pad" brakes, using an explicit wear surface, and hydrodynamic brakes, such as parachutes, which use friction in a working fluid and do not explicitly wear. Typically the term "friction brake" is used to mean pad/shoe brakes and excludes hydrodynamic brakes, even though hydrodynamic brakes use friction.

Friction (pad/shoe) brakes are often rotating devices with a stationary pad and a rotating wear surface. Common configurations include shoes that contract to rub on the outside of a rotating drum, such as a band brake; a rotating drum with shoes that expand to rub the inside of a drum, commonly called a "drum brake", although other drum configurations are possible; and pads that pinch a rotating disc, commonly called a "disc brake". Other brake configurations are used, but less often. For example, PCC trolley brakes include a flat shoe which is clamped to the rail with an electromagnet; the Murphy brake pinches a rotating drum, and the Ausco Lambert disc brake uses a hollow disc (two parallel discs with a structural bridge) with shoes that sit between the disc surfaces and expand laterally.

Pumping brakes are often used where a pump is already part of the machinery. For example, an internal-combustion piston motor can have the fuel supply stopped, and then internal pumping losses of the engine create some braking. Some engines use a valve override called a Jake brake to greatly increase pumping losses. Pumping brakes can dump energy as heat, or can be regenerative brakes that recharge a pressure reservoir called an hydraulic accumulator. Electromagnetic brakes are likewise often used where an electric motor is already part of the machinery. For example, many hybrid gasoline/electric vehicles use the electric motor as a generator to charge electric batteries and also as a regenerative brake.

Some diesel/electric railroad locomotives use the electric motors to generate electricity which is then sent to a resistor bank and dumped as heat. Some vehicles, such as some transit buses, do not already have an electric motor but use a secondary "retarder" brake that is effectively a generator with an internal short-circuit.

IV. CONVENTIONAL FRICTION BRAKE

The conventional friction brake system is composed of the following basic components: the "master cylinder" which is located under the hood is directly connected to the brake pedal, and converts the drivers' foot pressure into hydraulic pressure. Steel "brake hoses" connect the master cylinder to the "slave cylinders" located at each wheel. Brake fluid, specially designed to work in extreme temperature conditions, fills the system. "Shoes" or "pads" are pushed by the slave cylinders to contact the "drums" or "rotors," thus causing drag, which slows the car. Two major kinds of friction brakes are disc brakes and drum brakes.

Disc brakes use a clamping action to produce friction between the "rotor" and the "pads" mounted in the "calliper" attached to the suspension members Disc brakes work using the same basic principle as the brakes on a bicycle: as the calliper pinches the wheel with pads on both sides, it slows the vehicle Drum brakes consist of a heavy flat-topped cylinder, which is sandwiched between the wheel rim and the wheel hub (see Figure 2.2.1). The inside surface of the drum is acted upon by the linings of the brake shoes. When the brakes are applied, the brake shoes are forced into contact with the inside surface of the brake drum to slow the rotation of the wheels (Limpert 1992).

V. CLAMPING FORCE

The Hybrid electro-hydraulic systems have been introduced which meet all existing requirements, and improve the controllability and performance of the brakes. However these systems are relatively complex and expensive, and still rely on hydraulic fluid. Because of the potential benefits of dry systems, most manufacturers have also been researching electro-mechanical brakes.

In floating calliper brakes, a large clamping force must be produced between two brake pads to create a frictional torque on the rotating assembly. For electro-mechanical actuators, the clamping force is typically generated by coupling a motor through a gear box onto a ball or roller-screw. For the actuator to produce a force, a current is required, resulting in a power drain.

A Compromise has therefore to be found between the high gear ratio needed to minimise the current for continuous braking and the low gear ratio which minimised the current for dynamics. This requires optimisation of the motor, the gearbox ratio, and the ball-screw lead, subject to the available space and the performance requirements.

VI. FACTORS TO BE CONSIDERED

Although the principle of a controlled wedge brake is relatively simpe, the mechanical implementation is critical to its success. Major factors that need to be considered are

- Elimination of free-play within the drive-train, regardless of component wear,
- Minimisation of friction in the direction of the wedge travel,
- Operation in both directions.
- Effective stopping at high speeds
- To avoid skidding
- To have resistance to frictional heat

WEDGE BRAKES:

The technology dates back to the days of horse-drawn carriages, where a wooden wedge was used to slow the wheel.The modern version relies on a set of interlocking triangular teeth that set between the caliper and the disc, and is said to require only one tenth of the energy that conventional brakes require. The most innovative attribute is the fact that faster the car is going, the better the braking performance.

COMPARISON:

Conventional ABS takes between 140 and 170 milliseconds to generate full braking power, the EWB needs only about 100 milliseconds and therefore shortens the braking distance because a car covers the distance of 1.40 meters in one

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second at a speed of 100 kilometers per hour. The wedge brake will play an important role in making it possible for drivers to keep vehicles under control even in difficult situations.stopping of cars is never a problem by this system.

SHAFT:

A shaft is an element used to transmit power and torque, and it can support reverse bending (fatigue). Most shafts have circular cross sections, either solid or tubular. The difference between a shaft and an axle is that the shaft rotates to transmit power, and that it is subjected to fatigue. An axle is just like a round cantilever beam, so it is not subjected to fatigue. Shafts have different means to transmit power and torque. For example, it can use gears, sprockets, pulleys, etc., and also have some grooves to keep these elements rigid and avoid their vibration, such as key seats, retaining ring grooves, etc. Also, to be able to avoid vibration of the elements, and assure an efficient transmission of power and torque, some changes in the cross-section of the shaft can be made. All these elements, because of their weight, of the torque they are transmitting, and of the grooves made to avoid excessive axial movement, produce stresses, and as a consequence, strains. It has been demonstrated that stresses and strains are directly related if they are in the elastic range (by Hooke's law), and that if a strain is produced, then as a consequence a stress has to be produced, and vice versa.

It would be clearly beneficial if the steady actuation force could be reduced, since this would make this compromise between static and dynamic performance much easier to reach.This problem is solved by elegantly using a wedge to generate the clamping forces. This explits self-reinforcement of the braking forces by the rotating brake disc to minimise the tangent of the wedge angle, the steady-state actuation force required to generate any braking torque is zero.

BRAKE FLUID LEAKAGE

If your vehicle has worn brake pads or brake shoes, the fluid level in your brake fluid reservoir will be low. But let's say you have relatively new brake pads and you recently topped-off your brake reservoir only to notice a few days later that the fluid level has dropped noticeably. If that's the case, it's a good bet you have a leak somewhere in your brake system -- which means that you likely have bigger brake issues than something as simple as worn brake pads.

Your braking system is comprised of series of rubber and steel hoses, check valves, pistons and cylinders. They're all joined together, and work in concert to slow and stop your vehicle. It may help you to understand it all a little better if you imagine your brake system as a cardiovascular system, pumping blood to several different areas of the body. The vehicle's master cylinder acts as the heart and pumps brake fluid through brake lines to the extremities, in this case, the calipers and drums. This is where a lot of brake problems originate. At all four corners of your vehicle, brake lines -- with fittings that serve to connect the master cylinder to the different parts of the brake system that actually slow or stop your wheels -- quite simply, can leak. In fact, every part within the braking system that connects to another part has the potential to become yet another leak. Parts can become worn out or punctured or even pulled apart by road debris. Whatever the situation, if you have a brake fluid leak, you need to find and repair it as soon as possible.

Remember, brake fluid is essential for the brake system to operate properly. Leaks in the system release fluid, causing reduced (or even complete loss of) brake pressure. If you don't address the problem, your vehicle will eventually run out of brake fluid; however, chances are you won't get to that point, as the brakes won't continue to work after the fluid level drops beyond a certain level.

VII. WORKING PRINCIPLE

WEDGE:

The Wedge is a piece of hard material with two principal faces meeting in a sharply acute angle, for raising, holding, or splitting objects by applying a pounding or driving force. The wedge brake works by a similar principle to that used in brakes for horse-drawn carriages, where a wedge was used to bring the wheel to a standstill. The wedge uses a

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vehicle's kinetic energy, converting it into braking energy. By reinforcing itself this way, the EWB needs only one tenth of the actuating energy required by today's hydraulic braking systems.

Also, there are four types of shafts, and each one of them has a different way to calculate their corresponding stresses. In this chapter, there will be analyzed four cases: uniform shaft, multiple-section shaft, variable-cross-section shaft and relative rotation. All of these shafts are subjected to torsion, so we will review first the concepts of it.

Safety Factor :

An important thing to consider when designing any engineering element is the safety factor. "The maximum load that a structural member or a machine component will be allowed to carry under normal conditions of utilization is considerably smaller than the ultimate load." (Beer & Johnston, 2001). This smaller load is known as allowable load, working load or design load. So, when an element is working (transmitting torque, for example), it is going to be working safely until a limit (the allowable load), and only a capacity of the element to support load is "kept in reserve" to assure that the element is portion of the ultimate-load capacity is going to be used. The remaining part of the To choose the correct factor of safety, some considerations are required :

1. Variations that may occur in the properties of the member under consideration.
2. The number of loadings that may be expected during the life of the structure or machine.
3. The type of loadings that are planned for in the design or that may occur in the future.
4. The type of failure that may occur.
5. Uncertainty due to methods of analysis.
6. Deterioration that may occur in the future because of poor maintenance or because of unpreventable natural causes.
7. The importance of a given member to the integrity of the whole structure.

The factor of safety for shafts is 3. This factor was chosen by considering the variations in material properties, the effects of size of the shafts, the type of loading, the effect of machining or forming, the effect of heat treatment, the effect of shear on function, the effect of operating environment, the specific operating requirements and the concern for the human safety.

VIII. MATERIALS FOR SHAFTS

From the above discussion the materials for the shaft would be required to possess
(a) High strength,
(b) Low notch sensitivity,
(c) Ability to be heat treated and case hardened to increase wear resistance of journals, and
(d) Good mach inability.

IX. ADVANTAGES

- Faster and more effective, Fewer components, lower costs.
- The intelligently controlled wedge converts the kinetic energy of the vehicle directly into braking energy.
- A vehicle with EWB has a separate intelligent brake module at each wheel.
- The intelligent controls eliminate any risk of the wedge unintentionally locking up the brakes.
- To offer overall system weight reduction—with simplified service.
- Greater reliability, increased safety.
- Improved ABS performance especially on slippery roads and shorter stopping distance.
- Continuous brake power distribution.
- No brake fluid leads to long maintenance intervals and environmental friendly brake system.
- Independent mounting position (left and right-steering).
- Continuous brake power distribution.

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X. CONCLUSION

As the wedges tighten against each other, the force of the vehicle’s forward momentum actually presses the pad tightly against the brake disc, rather than hydraulic pressure. This system achieves vastly improved stopping power over traditional hydraulic systems with the additional benefit of significant weight and power savings.Wedge Brake performs better than today’s hydraulic braking systems, achieving about 15 percent shorter braking distances on ice. The average braking distance from a speed of 80 km/h on roughened ice, was 15 percent shorter than the average braking distance of the four comparison vehicles. While the test vehicle required an average of 64.5 meters to reach a full stop, the stopping distance for the vehicles with hydraulic brakes ranged from 71.8 to 78.4 meters. That means that in an emergency situation, traditional mass-produced vehicles with hydraulic brakes would still be going at a speed of 27 to 34 kilometers per hour, even after a vehicle equipped with the Wedge Brake had already come to a stop.

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