



Braking Systems : Past, Present & Future

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ABSTRACT

Humans have always been fascinated by the idea of going faster than before. With advancements in the IC engine technologies and then Jet Propulsion Engine the highest speed that vehicles can reach has multiplied manifold. However as the speeds of vehicles go up the technology required to safely stop these vehicles must evolve. Braking systems have had tremendous transformations from lever type brakes on horse carriages to multi layered carbon ceramic disc type brakes to air brakes used on land speed record braking cars. While the technology used to power vehicles to higher than ever speeds is what catches popular imagination the same has not been the case with evolution of braking systems.

This paper aims to sketch a history of braking systems over the years and make a study of the present and future of the same

Keywords: Braking systems, history of braking systems

I. INTRODUCTION

As vehicles have developed over the years the technology required to stop these vehicles has also undergone a massive evolution. The first type of brakes were external type brakes used on horse carriages which were actuated by means of a lever which brought a rubber pads in contact to axle. These were followed by internal brakes using drums or disks attached to each wheel. This paper sketches a history of these braking systems. It also discusses about the present trends and future prospects in the world of brakes.

II. HISTORY OF BRAKING SYSTEMS

A major test of brake systems took place in 1902 on an unpaved road in New York City called Riverside Drive. Ransom E. Olds had arranged to test a new brake system against the tire brake of a four-horse coach and the internal drum brake of a Victoria horseless carriage. His Oldsmobile sported a single flexible stainless-steel band, wrapped around a drum on the rear axle. When the brake pedal was applied, the band contracted to grip the drum. A vast improvement on brakes was born, one that would pave the way for the systems afterwards. The repercussions of which spread to every facet of the industry, even something like being able to compare car insurance without the advancements in brakes that have taken place. Olds had entered his car in the Blue Ribbon Contest, a 100-mile race scheduled for August and wanted to be sure his external brake was a match for the Victoria's expanding-shoe internal drum design and the coach's tire brake -- a pad that was applied to the tire by a long lever.

The problems associated with the external brake were overcome by the internal brake. As long as the brake shoes were under pressure, they stayed against the drums to keep the car from rolling backward on hills. And, since brake parts were inside drums and protected from dirt, drivers could go over 1,000 miles between brake overhauls. The drum brake, as it is now known, became all-dominant in the United States. In Europe, particularly in Great Britain, it had to share the stage with disc brakes. Disc brakes became more or less standard on European cars during the '50s, about 20 years before they were adopted by American manufacturers in 1973. This is ironic, because the spot-type disc brake is an American

invention. In 1898, Elmer Ambrose Sperry of Cleveland designed an electric car having front-wheel disc brakes.



Fig. 1. An Oldsmobile horse carriage using lever type external brakes[1]

He made a large disc integral with the hub on each wheel. Electromagnets were used to press smaller discs, lined with a friction material, against spots on the rotating disc to bring the wheel to a stop. Springs retracted the spot discs when current was interrupted. Meanwhile in Great Britain, a patent was issued in 1902 to F. W. Lanchester for a nonelectric spot disc braking system that's similar in principle to what we have today. The biggest problem that Lanchester encountered was noise. Metal-to-metal contact between his copper linings and the metal disc caused an intense screech that sent chills through anyone within earshot. The problem was solved in 1907 when Herbert Froom, another Englishman, came up with the idea of lining pads with asbestos. The new material was quickly adopted by car manufacturers on both drum and disc brakes. Asbestos linings also outlasted other friction materials by a wide margin. The 10,000-mile brake job had arrived. As roads improved and cars began to be driven at high speeds, manufacturers recognized the need for even greater braking power.

One solution to the problem became apparent during the Elgin road Race of 1915. A Duesenberg took the flats at 80 mph, then screeched to a virtual crawl to negotiate the hair-

pin curves. Duesenberg's secret for such magnificent braking power was to simply use an internal brake on each front wheel as well as each rear wheel. In 1918, a young inventor named Malcolm Lougheed (who later changed the spelling of his name to Lockheed) applied hydraulics to braking. He used cylinders and tubes to transmit fluid pressure against brake shoes, pushing the shoes against the drums. In 1921, the first passenger car to be equipped with four-wheel hydraulic brakes appeared -- the Model A Duesenberg. Carmakers as a group were not quick to adopt hydraulics. Ten years after the Model A Duesie, in 1931, only Chrysler, Dodge, Desoto, Plymouth, Auburn, Franklin, Reo, and Graham had hydraulic brakes. All the others still had cable-operated mechanical brakes. In fact, it was not until 1939 that Ford finally gave in, becoming the last major manufacturer to switch to hydraulic brakes.

III. PRESENT TRENDS

Talking about the present trends in braking systems there are two types of them that are predominantly being used on all vehicles, be it two, three or four wheeler vehicles. Disc brakes and drum brakes. While drum brakes are the cheaper of the two, they tend to wear more and have a high cost of maintenance. Thus they have a lower economic as well as overall efficiency. Disc brakes on the other hand have become synonyms for exceptional braking power, vehicles with disc brakes are considered high end since they are costlier and are much more effective than drum brakes. The mechanism used for driving the disc or drum brakes is what mainly differentiates the vehicles today. Let us first discuss the drum and disc brakes in detail first :-

1). Drum Brakes:-

A drum brake is a brake that uses friction caused by a set of shoes or pads that press against a rotating drum-shaped part called a brake drum. The term drum brake usually means a brake in which shoes press on the inner surface of the drum. When shoes press on the outside of the drum, it is usually called a clasp brake. Where the drum is pinched between two shoes, similar to a conventional disc brake, it is sometimes called a pinch drum brake, though such brakes are relatively rare. A related type called a band brake uses a flexible belt or "band" wrapping around the outside of a drum.

The modern automobile drum brake was invented in 1902 by Louis Renault. He used woven asbestos lining for the drum brakes lining, as no alternative dissipated heat like the asbestos lining, though Maybach has used a less sophisticated drum brake. In the first drum brakes, levers and rods or cables operated the shoes mechanically. From the mid-1930s, oil pressure in a small wheel cylinder and pistons (as in the picture) operated the brakes, though some vehicles continued with purely mechanical systems for decades. Some designs have two wheel cylinders. The shoes in drum brakes wear thinner, and brakes required regular adjustment until the introduction of self-adjusting drum brakes in the 1950s. In the 1960s and 1970s, disk brakes gradually replaced drum brakes on the front wheels of cars. Now practically all cars use disc brakes on the front wheels, and many use disc brakes on all wheels.

However, drum brakes are still often used for handbrakes, as it has proven very difficult to design a disc brake suitable for holding a parked car. Moreover, it is very easy to fit a drum handbrake inside a disc brake so that one unit serves as both service brake and handbrake. Early brake shoes contained asbestos. When working on brake systems of older cars, care must be taken not to inhale any dust present in the brake assembly. The United States Federal Government began to regulate asbestos production, and brake manufacturers had to switch to non-asbestos linings. Owners initially complained of poor braking with the replacements; however, technology eventually advanced to compensate. A majority of daily-driven older vehicles have been fitted with asbestos-free linings. Many other countries also limit the use of asbestos in brakes.

2).Disc-brakes:-

The disc brake is a wheel brake which slows rotation of the wheel by the friction caused by pushing brake pads against a brake disc with a set of calipers. The brake disc (or rotor in American English) is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon-carbon or ceramic matrix composites. This is connected to the wheel and/or the axle. To stop the wheel, friction material in the form of brake pads, mounted on a device called a brake caliper, is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc.

There are different mechanisms used to drive the discs or drum brakes some of them are:-

Air brakes:-

Air brakes or more formally a compressed air brake system is a type of friction brake for vehicles in which compressed air pressing on a piston is used to apply the pressure to the brake pad needed to stop the vehicle. Air brakes are used in large heavy vehicles, particularly those having multiple trailers which must be linked into the brake system, such as trucks, buses, trailers, and semi-trailers in addition to their use in railroad trains. George Westinghouse first developed air brakes for use in railway service. He patented a safer air brake on March 5, 1872. Westinghouse made numerous alterations to improve his air pressured brake invention, which led to various forms of the automatic brake. In the early 20th century, after its advantages were proven in railway use, it was adopted by manufacturers of trucks and heavy road vehicles.

Electromagnetic brake:-

Electromagnetic brakes (also called electro-mechanical brakes or EM brakes) slow or stop motion using electromagnetic force to apply mechanical resistance (friction). Both electromagnetic brakes and eddy current brakes use electromagnetic force but electromagnetic brakes ultimately depend on friction and eddy current brakes use magnetic force directly. Recent design innovations have led to the application of electromagnetic brakes to aircraft applications. In this application, a combination motor/generator is used first as a motor to spin the tires up to speed prior to touchdown, thus reducing wear on the tires, and then as a generator to provide regenerative braking.

Vacuum brake:-

The vacuum brake is a braking system employed on trains and introduced in the mid-1860s. A variant, the automatic vacuum brake system, became almost universal in British train equipment and in countries influenced by British practice. Vacuum brakes also enjoyed a brief period of adoption in the USA, primarily on narrow gauge railroads. Its limitations caused it to be progressively superseded by compressed air systems starting in the United Kingdom from the 1970s onward. The vacuum brake system is now obsolete; it is not in large-scale usage anywhere in the world, other than in South Africa, largely supplanted by air brakes.

IV. FUTURE PROSPECTS

The future of braking systems focuses on making the process of braking more energy efficient. Here we discuss three methods, Aerodynamic braking, regenerative braking and brake-by-wire. While aerodynamic braking is aircraft technology which is now being used in some supercars, while regenerative braking is the method of recovering the heat that is lost from brake pads. Brake-by-wire is the technology that aims to replace direct use of pneumatic, mechanical, or hydraulic systems by electronics, it is a part of a larger drive by wire technology revolution. Let us discuss them in detail:-

Aerodynamic Braking:-

Aerodynamic braking is a spaceflight maneuver that reduces the high point of an elliptical orbit (apoapsis) by flying the vehicle through the atmosphere at the low point of the orbit (periapsis). The resulting drag slows the spacecraft. Aerodynamic braking is used when a spacecraft requires a low orbit after

arriving at a body with an atmosphere, and it requires less fuel than does the direct use of a rocket engine.

A derivative method from this technology is used in some high performance cars along with the conventional disc brakes used. In The Bugatti Veyron, designed and developed by the Volkswagen Group and manufactured in Molsheim, France by Bugatti Automobiles S.A.S., at speeds above 200 km/h (120 mph), the rear wing also acts as an airbrake, snapping to a 55° angle in 0.4 seconds once brakes are applied, providing an additional 0.68 g (6.66 m/s²) of deceleration[11]



Regenerative braking:-

A regenerative brake is an energy recovery mechanism which slows a vehicle or object down by converting its kinetic energy into another form, which can be either used immediately or stored until needed. This contrasts with conventional braking systems, where the excess kinetic energy is converted to heat by friction in the brake linings and therefore wasted. The most common form of regenerative brake involves using an electric motor as an electric generator. In electric railways the generated electricity is fed back into the supply system, whereas in battery electric and hybrid electric vehicles, the energy is stored chemically in a battery, electrically in a bank of capacitors, or mechanically in a rotating flywheel. Hydraulic hybrid vehicles use hydraulic motors and store energy in form of compressed air.

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