

UNIT -IV

Braking System & Steering System

1. Braking System

A brake is a mechanical device which inhibits motion, slowing or stopping a moving object or preventing its motion. The rest of this article is dedicated to various types of vehicular brakes. Most commonly brakes use friction between two surfaces pressed together to convert the kinetic energy of the moving object 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. Eddy current brakes use magnetic fields to convert kinetic energy into electric current in the brake disc, fin, or rail, which is converted into heat. Still other braking methods even transform kinetic

The fundamental purpose of a braking system is to convert the kinetic energy of a moving vehicle into thermal energy through friction, safely bringing the vehicle to a stop or controlling its speed.

Types of Braking Systems

- **Mechanical Brake System:**

Relies on physical linkages, cams, levers, and cables to transmit force from the brake pedal to the brake shoes or pads. Mostly limited to parking brakes (handbrakes) due to mechanical wear and uneven force distribution.

- **Hydraulic Brake System:**

Utilizes an incompressible fluid to transmit force from the brake pedal to the wheels. It operates on **Pascal's Law**, which states that pressure applied anywhere in a confined incompressible fluid is transmitted equally in all directions throughout the fluid.

Key Hydraulic Components

- **Master Cylinder:**

The heart of the hydraulic system. It converts the mechanical force from the brake pedal into hydraulic pressure.

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- **Tandem Master Cylinder:**

A critical safety evolution featuring two separate pistons and fluid chambers inside a single bore. It splits the braking circuit into two independent loops (e.g., front wheels on one circuit, rear wheels on the other). If one circuit leaks or fails, the other circuit retains braking power.

- **Wheel Cylinder:**

Located at each wheel in drum brake setups. It receives high-pressure fluid from the master cylinder, pushing two internal pistons outward to press the brake shoes against the rotating brake drum.

Brake Fluid Requirements

Brake fluid must operate reliably under extreme temperature and pressure conditions. Key requirements include:

- **High Boiling Point:**

Must resist boiling due to the intense friction heat generated at the wheels (prevents vapor lock, which leads to a spongy pedal and loss of braking force).

- **Low Freezing Point:**

Must remain fluid and function perfectly in sub-zero temperatures.

- **Incompressibility:**

Must not compress under high pressure to ensure instantaneous braking response.

- **Lubricating Properties:**

Must lubricate the moving pistons and rubber seals within the cylinders.

- **Non-corrosive:**

Must not degrade metal lines, cylinders, or rubber seals.

Advanced Actuation Systems

- **Pneumatic (Air) Brakes:**

Uses compressed air (generated by an engine-driven compressor and stored in reservoirs) to apply braking force. Commonly used in heavy commercial vehicles (trucks and buses) because a small force on the pedal can regulate massive pneumatic forces, and any line leakage doesn't drain a finite reservoir of fluid.

- **Vacuum Brakes:**

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Utilizes the pressure differential created between atmospheric pressure and the engine intake manifold vacuum (or a dedicated vacuum pump) to assist in applying the brakes. This is the underlying principle behind modern passenger car **brake boosters**.

2. Steering System

The steering system allows the driver to precisely control the vehicle's direction while maintaining directional stability and minimizing tire wear.

Steering Geometry

Steering geometry refers to the angular relationships between the front wheels, the suspension components, and the ground.

- **Camber:**

The inward or outward tilt of the front wheels from the vertical when viewed from the front.

- *Positive Camber:* Wheels tilt outward at the top. Reduces steering effort and load on steering knuckles.
- *Negative Camber:* Wheels tilt inward at the top. Improves cornering performance by keeping the tire tread flat against the road during body roll.

- **Castor:**

The backward or forward tilt of the steering axis (kingpin) from the vertical when viewed from the side.

- *Positive Castor:* Steering axis tilts backward. It provides directional stability and creates a self-centering force that automatically returns the wheels to a straight-ahead position after a turn.

- **King Pin Rake (Inclination):**

The inward tilt of the kingpin or steering axis from the vertical when viewed from the front. It reduces steering effort and helps achieve center-point steering.

- **Combined Angle:**

The total angle formed by adding the Camber angle and the King Pin Inclination.

- **Toe-In and Toe-Out:**

The lateral alignment of the wheels when viewed from above.

- *Toe-In:* The front of the wheels are closer together than the rear. Used on rear-wheel-drive cars to counteract the natural tendency of the wheels to splay outward under driving forces.

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- **Center Point Steering:**

Achieved when the centerline of the steering axis intersects the center of the tire contact patch exactly at the ground level. This reduces steering effort and eliminates "scrubbing" when turning.

Steering Linkage Mechanisms

To turn smoothly without the tires scrubbing or slipping sideways, the inner wheel must turn at a sharper angle than the outer wheel because it follows a smaller turning radius.

- **Ackerman Steering Mechanism:**

A mechanical linkage system consisting of turning tracks and cross-rods. It achieves the varying turning angles by angling the steering arms inward so that lines drawn through them intersect near the center of the rear axle. It provides accurate turning geometry primarily at one specific turning angle.

- **Davis Steering Mechanism:**

Uses sliding pairs rather than turning pairs to achieve mathematically perfect steering at all turning angles. However, it is rarely used in practice due to rapid wear and tear on the sliding components.

Steering Gears & Linkages

The **steering gear** converts the rotational motion of the steering wheel into the angular, reciprocating motion needed to turn the road wheels, while providing a mechanical advantage.

- **Types of Steering Gears:**

- *Rack and Pinion:* Highly precise and compact. The steering wheel turns a pinion gear, which moves a linear rack left or right. Standard on modern passenger cars.
- *Recirculating Ball:* Uses a worm gear surrounded by ball bearings inside a nut block. Highly robust and capable of handling massive loads, making it common in heavy trucks and SUVs.

- **Steering Linkages:**

The network of rods and joints (including the pitman arm, drag link, tie rods, and track rods) that transmits the directional output from the steering gear box across to the front steering knuckles.