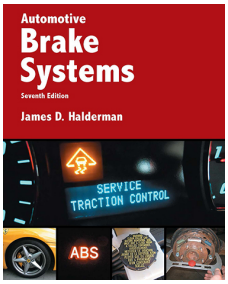
Automotive Brake Systems



CHAPTER 04

Brake Principles and Friction Materials

OBJECTIVES

- Discuss the energy principles that apply to brakes.
- Discuss the friction principles that apply to brakes.
- Describe how brakes can fade due to excessive heat.

OBJECTIVES

- Describe how deceleration rate is measured.
- Discuss the mechanical principles that apply to brakes.

ENERGY PRINCIPLES

- Energy is ability to do work
  - Chemical, mechanical, electrical energy most familiar kinds in operation of vehicle
- Work is transfer of energy from one physical system to another
  - Especially transfer to an object through application of force

ENERGY PRINCIPLES

- What occurs when vehicle's brakes are applied
  - Force of actuating system transfers energy of vehicle's motion to brake drums or rotors
  - Friction converts it into heat energy and stops vehicle
- Kinetic Energy
  - Fundamental form of mechanical energy

ENERGY PRINCIPLES

- Energy of mass in motion
- Every moving object possesses kinetic energy, and amount determined by object's mass and speed
- The greater the mass of an object and faster it moves, the more kinetic energy it possesses
- When speed of vehicle is doubled, its kinetic energy is quadrupled

ENERGY PRINCIPLES

- If vehicle A weighs twice as much as vehicle B, it needs brake system twice as powerful

- Kinetic Energy and Brake Design
  - If vehicle C has twice the speed potential of vehicle D, it needs brakes four times more powerful

MECHANICAL PRINCIPLES

- Levers in Braking Systems
  - Levers in brake systems increase force (are either first- or second-class)
  - Second-class levers most common
  - Service brake pedal good example
    - Pedal arm is lever
    - Pivot point is fulcrum
    - Force applied at foot pedal pad

MECHANICAL PRINCIPLES

- Force applied to master cylinder by pedal pushrod attached to pivot is much greater than force applied at pedal pad, but pushrod does not travel nearly as far

FRICTION PRINCIPLES

- Wheel brakes use friction to convert kinetic energy into heat energy
- Friction is resistance to movement between two surfaces in contact
- Brake performance improved by increasing friction (at least to a point)

FRICTION PRINCIPLES

- Brakes that apply enough friction to use all the grip tires have will have potential to stop vehicle faster than brakes with less ability to apply friction

FRICTION PRINCIPLES

- Coefficient of Friction
  - Amount of friction between two objects expressed as coefficient of friction (μ)
- Surface Finish Effects
  - If 100 lb force required to pull 200-lb wood block across concrete floor:
    - Coefficient of friction: 100 lb/200 lb = 0.5

FRICTION PRINCIPLES

- Surface Finish Effects
  - Block of wood sanded smooth, improving surface finish and reducing force required to move it to only 50 lb
    - Equation for coefficient of friction:
      - 50 lb/200 lb = 0.25
- Friction Material Effects
  - If 200-lb block of ice substituted for wood block

FRICTION PRINCIPLES

- Only 10-lb force needed to pull the block across concrete
  - Equation for coefficient of friction:
    - 10 lb/200 lb = 0.05
- Coefficient of friction decreases dramatically
- Type of materials being rubbed together have very significant effect on coefficient of friction

FRICTION PRINCIPLES

- Iron and steel used most often for brake drums and rotors
  - Relatively inexpensive; can stand up under extreme friction
- Brake lining material does not need as long a service life
  - Brake shoe and pad friction materials play major part in determining coefficient of friction

FRICTION PRINCIPLES

- Several fundamentally different materials to choose from
- Friction Contact Area
  - Tires are example where contact area makes difference
  - All other things being equal, wide tire with large contact area on road has higher coefficient of friction than narrow tire with less contact area

FRICTION PRINCIPLES

- Tire conforms to and engages road surface
- During hard stop, portion of braking force comes from tearing away tire tread rubber
- Rubber's tensile strength (internal resistance to being pulled apart) adds to braking efforts of friction

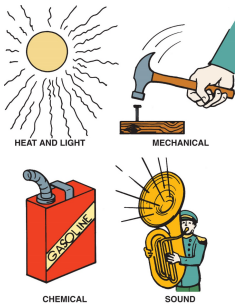
FRICTION PRINCIPLES

- Static and Kinetic Friction
  - Static value: coefficient of friction with two friction surfaces at rest
  - Kinetic value: coefficient of friction while two surfaces sliding against one another
  - Coefficient of static friction always higher than of kinetic friction
    - Explains why harder to start object moving than keep it moving

FRICTION PRINCIPLES

- Function of brake system to convert kinetic energy into heat energy through friction

Figure 4-1 Energy which is the ability to perform work exists in many forms.



FRICTION AND HEAT

- Change in kinetic energy determines amount of temperature increase
- Faster and heavier a vehicle is, the more heat to be dissipated by brake system
- Thicker and heavier the brake rotors and drums, the more heat they can absorb

FRICTION AND HEAT

- Deceleration rates measured in units of "feet per second per second"
  - Abbreviated "ft/sec2" or m/sec2

DECELERATION RATES

- Typical Deceleration Rates
  - Comfortable deceleration about 8.5 ft/ sec2 (3 m/sec2)
  - Loose items in vehicle will "fly" above 11 ft/sec2 (3.5 m/sec2)
  - Maximum deceleration rates for most vehicles and light trucks: 16–32 ft/sec2 (5–10 m/sec2)

DECELERATION RATES

- Average deceleration rate of 15 ft/sec2 (3 m/sec2) can stop a vehicle traveling at 55 mph (88 km/h) in about 200 ft (61 m) in less than 4 seconds
  - Standard brake system test
    - Vehicle braked at this rate 15 times
    - Front brake pad temperatures can reach 1,300°–1,800°F (700°–980°C)
    - Brake fluid and rubber components may reach 300°F (150°C) or higher

SUMMARY

- Work is the transfer of energy from one physical system to another.
- Levers in brake systems increase force (are either first- or second-class).
- Wheel brakes use friction to convert kinetic energy into heat energy.
- Change in kinetic energy determines amount of temperature increase.