Brakes

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Brake theory

- A brake is a device by means of which artificial frictional resistance is applied to a moving machine member, in order to retard or stop the motion of a machine.
- In the process of performing this function, the brake absorbs either kinetic energy of the moving member or potential energy given up by objects being lowered by hoists, elevators etc.
- The energy absorbed by brakes is dissipated in the form of heat. This heat is dissipated in the surrounding air, water etc

Break Capacity

- The design or capacity of a brake depends upon the following factors:
  - The unit pressure between the braking surfaces,
  - The coefficient of friction between the braking surfaces,
  - The peripheral velocity of the brake drum,
  - The projected area of the friction surfaces,
  - The ability of the break to dissipated heat equivalent to the energy being absorbed.

Energy Absorbed by a brake

- Translation kinetic energy E_1

$$E_1 = 0.5\, m\, [v_1^2 - v_2^2]$$

- Rotation kinetic energy E_2

$$E_2 = 0.5\, I\, [w_1^2 - w_2^2]$$

- Potential energy E_3

$$E_3 = m\, g\, v\, t \qquad \text{Where:} \quad v = \frac{v_1 - v_2}{2}$$

- Total energy absorbed $E = E_1 + E_2 + E_3$

Breaking loads

Ft = Tangential braking force or frictional force acting tangentially at the contact surface of the brake drum,

d = Diameter of the brake drum,

N_1 = Speed of the brake drum before the brake is applied,

N_2 = Speed of the brake drum after the brake is applied,

N = Mean speed of the brake drum = (N1+N2)/2

the total energy to be absorbed by the brake

$$E = F_t \, \pi \, d \, N \, t$$

Tangential braking force $$F_t = E / (\pi \, d \, N \, t)$$

Braking torque $$T = F_t \times (d/2)$$

Heat Generated in Brake

- The energy absorbed by the brake and transformed into heat must be dissipated to the surrounding air in order to avoid excessive temperature rise of the brake lining.
- The permissible temperatures for brake lining materials
  - For leather, fiber and wood facing = 65 - 70°C
  - For asbestos and metal surfaces that are slightly lubricated = 90 - 105°C
  - For automobile brakes with asbestos block lining = 180 - 225°C
- Heat generated in the brake
  - $E = Hg = f \times F_N \times v = f \times p \times A \times v$

f = Coefficient of friction,
F_N = Normal force acting at the contact surfaces, in N,
p = Normal pressure between the braking surfaces in N/m^2,
A = Projected area of the contact surfaces in m^2, and
v = Peripheral velocity of the brake drum in m/s.

Heat Dissipated from brake

- Heat dissipated $H_d = H_g = C\,(t_1 - t_2)\,A_r$
  - C = Heat dissipation factor or coefficient of heat transfer in $W/m^2/\ ^\circ C$
    - C may be of the order of 29.5 $W/m^2/^\circ C$ for a temperature difference of 40°C **and** 44 $W/m^2/^\circ C$ for a temperature difference of 200°C.
  - $t_1 - t_2$ = Temperature difference between the exposed radiating surface and the surrounding air in °C,
  - A_r = Area of radiating surface in m^2.
- Temperature rise of brake drum (Δt)
  - $\Delta t = (\ k\ .\ H_g\ )\ /\ (\ m\ .\ c\ )$
    - m = mass of the brake drum in kg
    - c= specific heat of the material of the drum in J/kg °C
      - For C.I. c = 460 J/kg °C
      - For steel c = 490 J/kg °C
    - k = factor in the order of 0.8

Recommended pv value

- In brakes, it is very difficult to precisely calculate the temperature rise. In preliminary design analysis, the product pv is considered in place of temperature rise., where:
  - p = braking pressure, N/mm^2
  - v = tangential speed, m/sec
- If the pv is high, the rate of wear of brake lining will be high and the brake life will be low.

Type of service	Recommended value of pv in $N\text{-}m/m^2$ of projected area per second
Continuous application of load as in lowering operations and poor dissipation of heat.	0.98×10^6
Intermittent application of load with comparatively long periods of rest and poor dissipation of heat.	1.93×10^6
For continuous application of load and good dissipation of beat as in an oil bath.	2.9×10^6

Characteristic of brake lining materials

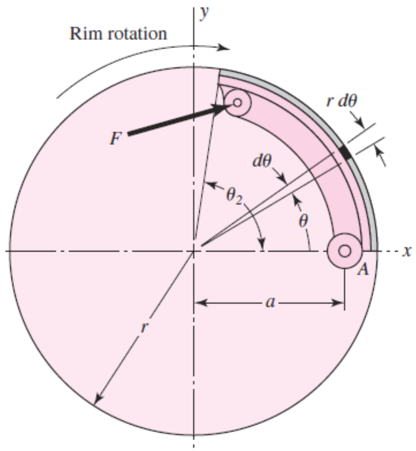
- High coefficient of friction
- The coefficient of friction should remain constant over the entire surface with change in temperature.
- Low wear rate.
- High heat resistance.
- High heat dissipation capacity.
- Low coefficient of thermal expansion.
- Adequate mechanical strength.
- It should not be affected by moisture and oil.

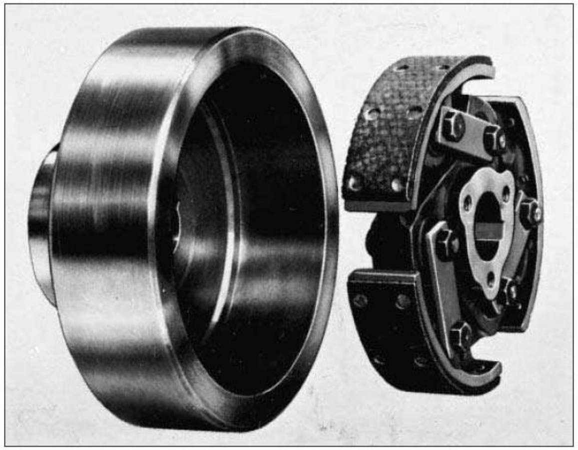
Break lining materials

Material for braking lining	*Coefficient of friction (μ)*			*Allowable pressure (p)*
	Dry	*Greasy*	*Lubricated*	*N/mm²*
Cast iron on cast iron	0.15 – 0.2	0.06 – 0.10	0.05 – 0.10	1.0 – 1.75
Bronze on cast iron	–	0.05 – 0.10	0.05 – 0.10	0.56 – 0.84
Steel on cast iron	0.20 – 0.30	0.07 – 0.12	0.06 – 0.10	0.84 – 1.4
Wood on cast iron	0.20 – 0.35	0.08 – 0.12	–	0.40 – 0.62
Fibre on metal	–	0.10 – 0.20	–	0.07 – 0.28
Cork on metal	0.35	0.25 – 0.30	0.22 – 0.25	0.05 – 0.10
Leather on metal	0.3 – 0.5	0.15 – 0.20	0.12 – 0.15	0.07 – 0.28
Wire asbestos on metal	0.35 – 0.5	0.25 – 0.30	0.20 – 0.25	0.20 – 0.55
Asbestos blocks on metal	0.40 – 0.48	0.25 – 0.30	–	0.28 – 1.1
Asbestos on metal (Short action)	–	–	0.20 – 0.25	1.4 – 2.1
Metal on cast iron (Short action)	–	–	0.05 – 0.10	1.4 – 2.1

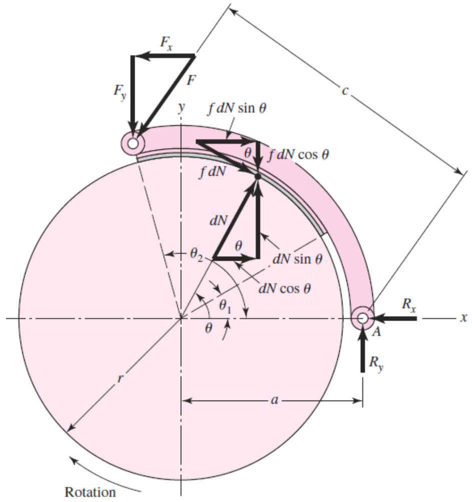
Brake types

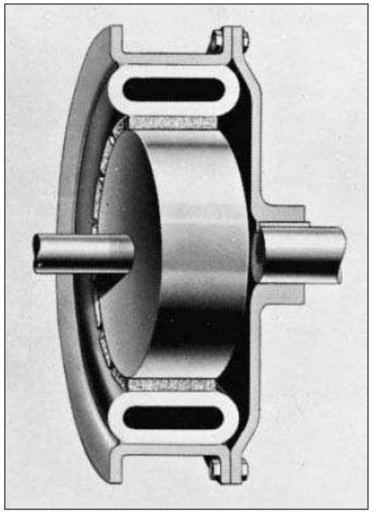
Internal Expanding Rim Brakes





External Contracting Rim Brakes





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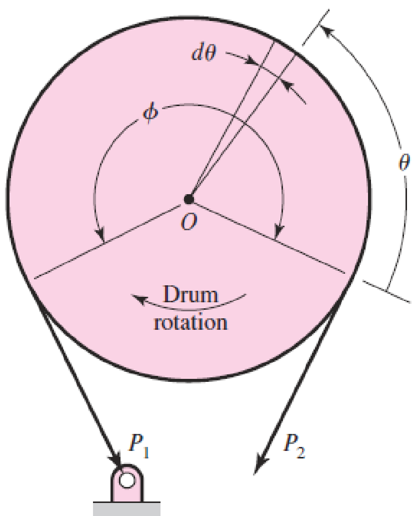
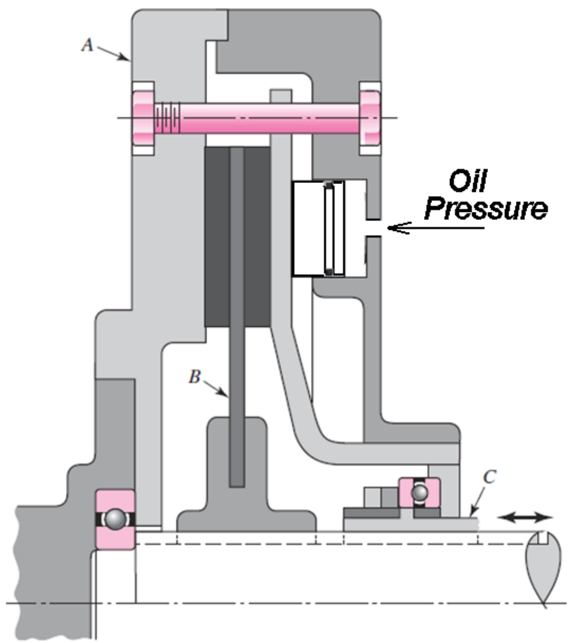
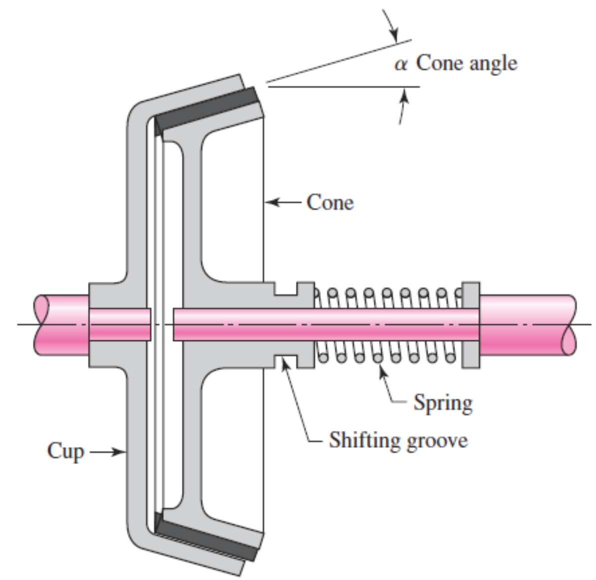


Band-Type Brakes



Frictional-Contact Axial brake



Cone Brakes