SAE NITK Project Report

Project: Disc Brakes Design and Analysis

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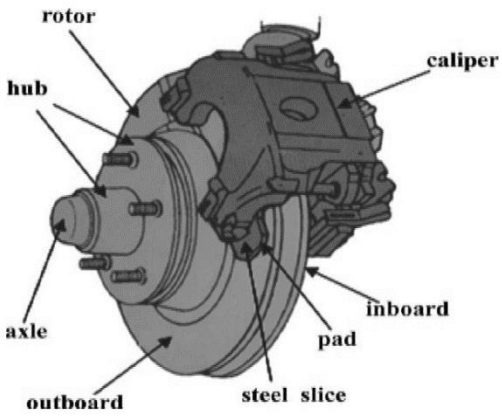
Introduction:

Each single system has been studied and developed in order to meet safety requirement. Instead of having air bag, good suspension systems, good handling and safe cornering, there is one most critical system in the vehicle which is brake systems. Without brake system in the vehicle will put a passenger in unsafe position. Therefore, it is must for all vehicles to have proper brake system.



Working:

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 callipers. 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 calliper, is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop. Brakes convert motion to heat, and if the brakes get too hot, they become less effective, a phenomenon known as brake fade.

Why Disc Brakes?

Better reflux and quick responses of braking and retracting. Heat dissipation is faster because of drilled holes and cavities on the disc brake and also due to the hollow shape of the piston. It can support ABS.
Still most of the automobiles use drum brakes at the rear wheels. The reason is disc brakes don’t support parking brakes.

Calculation of brake forces in Disc brake:

Brake pedal Force

$$F_{bp} = F_d \times \left(\frac{l_2}{l_1}\right)$$

$$F_{bp} = 400 * \left(\frac{6}{1}\right) = 2400\ N$$

MASTER CYLINDER PRESSURE $= P_{mc} = \frac{F_{bp}}{A_{mc}} = \frac{2400}{285.02} = 8.42\ \frac{N}{mm^2}$

$$\therefore A_{mc} = \frac{\pi b^2}{4}$$

$$= \frac{\pi \times 19.05^2}{4} = 285.02\ mm^2$$

b = Bore diameter of piston, mm

$$F_{cal} = P_{cal} * A_{cal}$$

$$= 8.42 \times 1017.87$$

$$F_{cal} = 8570.46\ N$$

$$A_{cal} = \frac{\pi * b_p^2}{4} = \frac{\pi \times 36^2}{4} = 1017.87\ mm^2$$

b_p = Bore dia of caliper piston, mm

Caliper clamp load $= F_{cl} = F_{cal} * 2$

$$F_{cl} = 8570.46 \times 2 = 17140.93\ N$$

Force on disc pads = $F_{friction} = F_{cl} \times \mu_{brake\ pads}$

For dry pads $F_{fric} = 17140.93 \times 0.4$

$$= 6856.37\ N$$

For Wet pads $F_{fric} = 17140.93 \times 0.1$

$$= 1714.093\ N$$

Torque of rotor = T_r = $f_{friction}$ × R_{eff}.

$T_r = 6856.37 * (.170) = 1165.588$ Nm

R_{eff} = Effective rolling radius = 170 mm

$$F_{tire} = \frac{T_t}{R_t}$$

$$= \frac{1165.58}{0.2921} = 3990.34 N$$

$$F_{Total} = F_{tire} \times 4 = 15961.36 N$$

Deceleration = $a_v = \frac{F_{total}}{m_v} = \frac{15961.36}{210 \times 9.81} = 7.74 \frac{m}{s^2}$

Stopping dist : $\frac{V_x^2}{2a_v} = \frac{11.12^2}{2 \times 7.74} = 7.97 m$

Stopping time : $S_t = \frac{V_v}{a_v} = \frac{11.12}{7.74} = 1.438 s$

Drum Braking System Mathematical Analysis with Same specifications.

$f_{pedal} = 400\ N$ mechanical efficiency = 6

$f_{cam} = 400 \times 6 = 2400\ N$

Max force by brake shoes = $2 \times f_{cam} = 2 \times 2400 \times \mu$

$= 4800\ \mu$

dry ~~Het~~ $\mu = 0.4 \Rightarrow F_{brake} = 4800 \times 0.4$

$= 1920\ N$

τ = Drum diameter $\times f_{brake}$

$= 1920 \times 0.13 = 249.6\ N\text{-}m$

$F_{tire} = \frac{249.6}{0.2921} = 854.50188\ N$

$F_{total} = F_{tire} \times 4 = 3418\ N$

Deceleration: $a_v = \frac{F_{bt}}{m_v} = \frac{3418}{210 \times 9.81} = 1.66\ m/s^2$

Stopping distance: $\frac{V_v^2}{2a_v} = \frac{11.12^2}{2 \times 1.66} = 37.245m$

Stopping time: $S_t = \frac{V_v}{a_v} = \frac{11.12}{1.66} = 6.699\ sec$

Conclusion:

We can say that there is a huge difference in disc and drum brakes.

References:

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2. Design and Optimisation of Disc Brake Rotor by Yogesh H. Mishra, Research Scholar, Dept of Mechanical Engineering. G.S.Moze College of Engineering, Balewadi. Pune, India; Prof. Vikas R. Deulgaonkar, Professor, Dept of Mechanical Engineering. M.M.College of Engineering, Pune, India.; Dr. P.A. Makasare, HOD, Dept of Mechanical Engineering. G.S.Moze College of Engineering, Pune, India.

3.Disc Brake Caculations: https://www.youtube.com/watch?v=Oa6A2Acq-H4&t=252s

4. Disc Brake Caculations: https://www.youtube.com/watch?v=zVuAkMeoPoc