

DESIGN OF BRAKE CALIPER

Sanket P. Golhar¹, Amit R. Rakhonde², Ajay M. Tayde³, Shital R. Ughade⁴, Ankur S. Sakhare⁵

^{1,2,3,4} Student, Department of Mechanical Engineering, PRMIT&R, Badnera, Amravati University, Maharashtra (INDIA)

⁵Assistant Professor, Department of Mechanical Engineering, PRMIT&R, Badnera, Amravati University, Maharashtra (INDIA)

ABSTRACT: Effective braking is a critical factor determining the performance of any vehicle. With enhancement in the performance, need of an effective braking system increases. Brake caliper being the heart of a braking system, the whole system is built considering its size, weight and strength. An optimized design of a brake caliper thereby ensures reduced size of wheel assembly, reduced weight and effective braking. This paper studies a conceptual design of a brake caliper for an All-Terrain Vehicle (ATV), primarily focusing on reducing the size and weight.

KEYWORDS: Caliper, scrapper seal, bleed port, piston, seal

1. INTRODUCTION

Braking system is an energy converting system that converts vehicle movement into heat while on application of clamping force using friction pads on brake rotor. This is done by applying pressure on back side of piston pushing the brake pads against the rotor disc causing frictional force at contact and inhibiting the motion of the vehicle. The components of a brake caliper are as follows:

- Caliper body
- Piston
- Scrapper seal
- Friction pads
- Bleed port
- Fluid inlet port

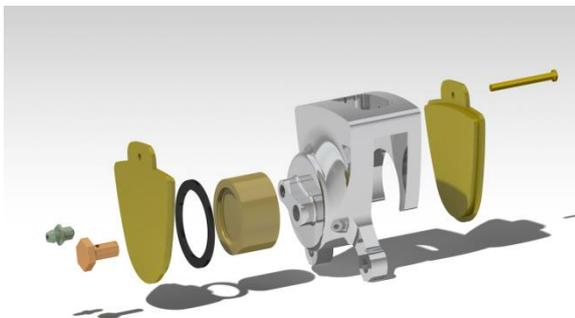


Figure 1 - Exploded View of Brake Caliper

The main function of the caliper is to support the brake pads and the clamping force is applied by the piston. Important aspects of a caliper is low weight but at the same time high stiffness. High stiffness and an evenly distributed pressure on the pads are necessary to achieve optimal braking force. An evenly distributed pressure results in evenly heat distribution which is crucial for wear and to avoid noise which occurs by variations in disc temperature. These characteristics are a result from the choice of material, manufacturing precision and the design of caliper

2. TYPES OF CALIPERS

2.1 Depending on Working Mechanism

2.1.1 Floating Caliper

2.1.2 Fixed or Opposed Piston Caliper

2.1.1 Floating Caliper

In a floating caliper, piston is on the inboard side of the caliper while the caliper is mounted on a guiding pin which acts as a cylindrical support. The guiding pin allows linear movement of the caliper along its axis. The friction pads on the outboard side are continuously in contact with the brake rotor which prevents the bending of the rotor. When brake pedal is actuated, the pressure is applied on back side of the piston which forces the friction pads against the rotor. The reaction force forces the caliper to slide over the guide pin leading to clamping of the rotor.

2.1.2 Fixed Caliper

Fixed type caliper has pistons on both sides of the rotor and can be directly fixed to the mountings on the uprights. Pistons from both the sides force the friction pads to apply force on brake rotor. Fixed caliper does not require extra mounting bracket which is necessary in floating type caliper for sliding. The major advantage of fixed caliper over a floating caliper is the even wear of the friction pads.

3. MATERIAL SELECTION OF CALIPER

Caliper is a component of braking system which is used for applying the required torque on the rotor. The customized caliper housing must be light weight.

Aluminium materials are only allowed because they are lightweight and higher grade of aluminium gives us higher strength to sustain under loading. From different materials high grade aluminium 7075 T6 is finalized.

4. SEAL GROOVE GEOMETRY

The pressure in the brake fluid is lead through brake lines down to the caliper. The caliper is mounted on the brake corner and holds the brake pads. The cylinder in the caliper has a seal groove where a seal fits into. This seal prevent the brake fluid from leaking out between the cylinder and the piston. During brake apply, pressure forms inside the cylinder and pushes the piston and the brake pad out towards the disc and creates friction which generate braking torque. The seal groove has a special geometric design which helps the piston to retract after braking. The seal sticks to the piston and deforms with the piston travel, see figure 3. When the pressure is removed the seal will strive to return to its origin shape and create a rollback of the piston. This rollback can be controlled depending on how the groove is designed geometrically.

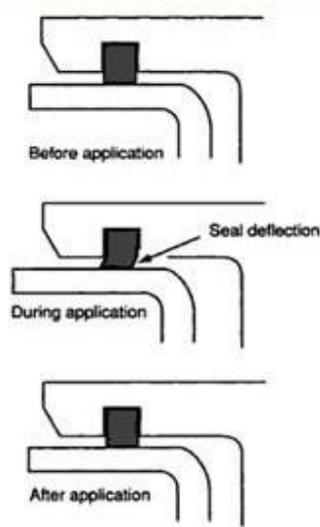


Figure 2 - Deformation of seal in seal groove

5. CALCULATIONS

- 1) Force applied on pedal (F) = 350N
- 2) Bore diameter of master cylinder (d_b) = 0.01905 m
- 3) Piston diameter of caliper (d) = 0.032 m
- 4) Number of pistons (n) = 1

a) Bore area of master cylinder

$$(A_{cb}) = \frac{\pi}{4} \times d^2$$

$$= \frac{\pi}{4} \times (0.01905)^2$$

$$= 0.0002848m^2$$

- b) Pressure at caliper end

$$(P) = \frac{F}{A_{cb}}$$

$$= \frac{350}{0.0002848}$$

$$= 1228932.58 \text{ N}$$

- c) Area of caliper piston

$$(A_p) = \frac{\pi}{4} \times d^2$$

$$= \frac{\pi}{4} \times (0.032)^2$$

$$= 0.00080424m^2$$

- d) Total force on brake pad by single piston (F_t) = P × A_p

$$= 1228932.58 \times 0.00080424$$

$$= 988.356 \text{ N}$$

- e) Clamping force on disc

$$(F_{clamp}) = F_t \times n$$

$$= 988.356 \times 1$$

$$= 988.356 \text{ N}$$

6. MODELING OF CALIPER

Modeling of caliper was done as per requirement of the piston diameter and assembly constraints in the wheel rim. Parametric modeling was used in modeling of caliper.

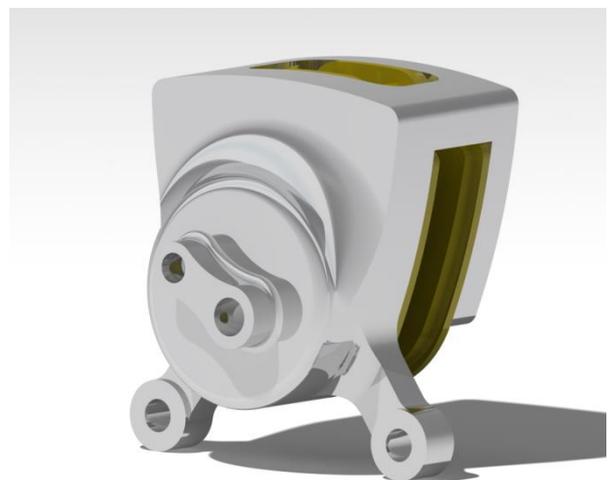


Figure 3 - CAD Model of Brake Caliper

7. CONCLUSIONS

The following comments could be concluded:

- 1) Determination of the braking force is the most crucial aspect to be considered while designing any braking system. The generated braking

force should always be greater than the required braking force.

- 2) The calculation of required clamping force helps us to decide the diameter and the number of pistons to be used. Space and assembly constraints are also an important factor while designing the caliper body.
- 3) The seal groove geometry is pivotal to the operation of the caliper as it allows the piston to retract after the required clamping force has been applied.

8. ACKNOWLEDGEMENT

The design process is not a single handed effort but a team effort. We would also like to express our gratitude towards the Mechanical department and on whole towards the college for support. The team would also like to recognize the valuable assistance of the project guide Prof. A.S.Sakhare sir, Mechanical Engineering department, PRMIT&R.

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10. BIOGRAPHIES



Sanket Pandit Golhar, Researcher, Designer. He is now pursuing Bachelor of Mechanical Engineering in final year at Prof. Ram Meghe Institute of Technology and Research, Badnera Amravati.



Amit Ramdas Rakhonde, He is now pursuing Bachelor of Mechanical Engineering in final year at Prof. Ram Meghe Institute of Technology and Research, Badnera Amravati.



Ajay Manikrao Tayde, Researcher, He is now pursuing Bachelor of Mechanical Engineering in final year at Prof. Ram Meghe Institute of Technology and Research, Badnera Amravati.



Shital Ravindra Ughade, Researcher, She is now pursuing Bachelor of Mechanical Engineering in final year at Prof. Ram Meghe Institute of Technology and Research, Badnera Amravati.



Prof. Ankur S. Sakhare, Researcher. Assistant professor, Department of Mechanical Engineering at Prof. Ram Meghe Institute of Technology and Research, Badnera. Recieved M.E Degree in CAD/CAM and has published 4 research papers.