ANALYSIS OF DISC BRAKE

Nishant Barik¹, Sayyad Abdul Razak Khadari ²
¹,²B. Tech Mechanical (specialization in Automotive) Engineering, Vellore institute of technology

Abstract. This paper deals with the structural analysis of the rotor disc of disc brake. The rotor disc of a disc brake goes through many forces that are applied on it to stop the wheel. The deterioration of the disc brake is a major factor which should be kept in mind during a designing and choosing of the material of disc brake. The material properties are taken in context with the type of forces that act on the brake. In this paper all the disc brakes from past year few years have been analyzed and on the basis of that new model has been designed. The materials taken are compared and to see which shows the best result in the new model disc. The disc brake modelling in done on SOLIDWORKS followed by analysis in ANSYS WORKBENCH 18.1. The dimensions are taken with respect to the MOTO GP brakes.

1. INTRODUCTION

Braking system is a very important part in a vehicle as it helps in slow down or stop the vehicle. Brakes are mechanical devices which absorbs the energy of a moving wheel to inhibit its motion. The kinetic energy of the wheels is converted to heat energy due to friction because of the surface of pads and the rotor disc. Greater the force applied on the disc more will be the heat deliberation and better will be the stopping tendency. The pressure applied on the disc brake also depend on inertia of the car. Braking system not is just help during motion it also help during parking of the car. If braking system are classified on the basis of friction contact basis, we have drum brakes and disc brakes.

In drum breaks the drum (housing of the brake shoes) and the wheel hub are attached to each other. So, when the wheel moves the outer part of the drum rotate and the inner part which consist of the brake shoes are held constant. When we apply the brake the brake shoe comes in contact with the friction surface of the outer surface. This contact with the rotating drum deaccelerates the wheel.

In disc brake in place of drum we have disc rotor which is attached with the wheels is shown in figure 1. The rotor is fixed between two calipers. The calipers had brake shoes which comes in contact with the friction part when brakes are applied.

Figure 1. Disassembly Disc Rotor
A disc brake consists of:

1. Brake pads
2. Caliper (piston in fitted in it)
3. Rotor

**Mechanism of disc brake:**

When the brake pedal which is connected to the master cylinder is pressed. The brake fluid (filled in master cylinder) is pressurized and creates a pressure (pascal’s law) in the piston inside the caliper. This moves the brake pads to the friction surface of the rotating disc. This help in stopping the car. Nowadays we also have ABS (anti-lock braking system) fitted with the assembly.

![Figure 2. Assembly Disc Rotor](image)

The rotor disc is the part of the disc brake which has the friction surface. This part come in contact with the brake pads when brake pedal is pushed. If the material used in not sufficient enough to handle the stress then this will lead to rotor disc breakdown. Also, the size and the holes for cooling of the disc brake is very important for proper functioning of the disc brake. Generally, manufactures try to keep the rotor disc as small and as light as possible for better efficiency. The rotor discs are commonly made by grey iron steel but nowadays new metals and alloys are made which give better performance than grey iron steel is shown in figure 2.

2. METHODOLOGY

SOLIDWORKS are used for making the models of various disc brakes. After the disc are made the disc thermal analysis has been done in ANSYS workbench 18.1. Three model , 1990, 2000, 2014 model has been made and analyzed on the basis of the negative and positive factors new 2019 model has been made.

The dimensions and the design of old model of the disc brake are taken from *MOTOGP BRAKE INFOGRAPICS of BREBO* special edition. Also, some assumptions are taken with respect to the design. But the final design (2019) is made on the report study of the old models. Basic dimension is assumed. After this the models are exported to the ANSYS workbench 18.1.
During analysis *in ANSYS* we have taken few assumptions that the material is isotropic and the stresses are applied on all the wheels only if the brake are applied and there is a contact between the friction pad and the rotor disc.

**FACTORS:**

The factors what was kept in mind during modelling of the disc brake are:

1. Light weight
2. Better cooling
3. Environment friendly
4. Cost efficient
5. Availability of the material
6. Size and structure with reference to the brake pads.

### 3. RESULTS AND DISCUSSION

#### 1990:

![Figure 3. Analysis of 1990’s Disc Rotor](image)

**Result**

- This is the rotor model used in 1990.
- These kind of rotor does not have holes at the area of contact of friction pads.
- They have holes just after the contact patch, this helps in little cooling.
- Since there is no air flow at the contact, so temperature increase that in turn decrease the friction.
- Due to less cooling ability there is maximum detrition on the friction pads shown in figure 3.
- In 80’s the discs are not at the outside or at the edge of the wheel they are a bit inside of the wheel, which makes it even harder to the air to get inside and cool the discs.
2000:

Figure 4. Analysis of 2000’s Disc Rotor

Result

➢ This is a disc rotor used in 2000.
➢ These disc rotors have slits instead of holes.
➢ This increases the air flow at the area of contact, which decreases the temperature shown in figure 4.
➢ This has more friction than 1990 model
➢ 2000 is the year when people started thinking about heating of break discs.
➢ The slit formation in the break disc increased the rate of cooling but it decreased the strength and life of break disc.
➢ The slits decrease the structural integrity of the break disc.

2014:

Figure 5. Analysis of 2014’s Disc Rotor

Result

➢ This is disc rotor model used in 2014
➢ This model is the combination of 2000 and 1990.
➢ This model has long and wide slits along with holes, and a thin structural design at the center.
➢ In 2014 technology and power of engine has developed very much, which also increases the complication in breaking shown in figure 5.
➢ This intern effects the cooling of the of the break disc.
➢ We have to apply more effective system of cooling which could suppress the upraise of the power of engine.

![Figure 5](image-url)

**Figure 6.** Analysis of 2019 Disc Rotor

Result:

➢ In 2019 model we added fins to the disc
➢ These fins are design similar to a diffuser
➢ Area of intake is smaller than output
➢ Which causes drop in pressure between the fins.
➢ To cover the low-pressure air flows through the holes in the break contact patch
➢ which causes increase in the rate of cooling shown in figure 6.
➢ This disc brake has more volume than other which causes to decrease the heat per unit volume

| Parameters       | Grey cast Iron | Aluminum metal matrix composites | Stainless steel | Carbon ceramic |
|------------------|----------------|----------------------------------|-----------------|----------------|
| Density (kg/m³)  | 7100           | 2820.6                           | 7750            | 1800           |
| Poison’s         | 0.25           | 0.35                             | 0.3             | 0.31           |
| Young’s modulus  | 125            | 113.7                            | 190             | 195            |
| Specific heat    | 586            | 828.43                           | 500             | 755            |
| Thermal conductivity | 84            | 147.95                           | 26              | 40             |

Table 1. Material Properties

Grey cast iron:

Grey cast iron type of iron with grey color due to the presence of graphite fractures in it. It has fine flakes which give extra strength to the material. It has 2.5-4% carbon and 1-3% silicon. It
is used to make gears, automotive suspension etc. it has high thermal conductivity that means the has easy heat flow movement.

Aluminum metal matrix composites:

This material has gained popularity in automobile aerospace etc. this composite has high strength, low density and good resistance when compared to other metals. This metal is a reinforcement of material like fly ash, silicon, graphite, organic material etc.

Stainless steel:

This material contains 16-26% chromium, 6-22% nickel (Ni) and low carbon. It has excellent corrosion resistance, ductile and readily formable, good performance at high temperature.

Carbon ceramic:

Majority application in aerospace derived technology and powerful cars. The component main matrix is silicon carbide and silicon element. Light weight and better thermal resistance. This is a carbon fiber reinforced silicon carbide composite. Give extra stress and shear resistance.

4. CONCLUSION:

In this paper we have done the analysis of disc of disc brake. After the whole analysis it was proven that the 2019 model had better design than the rest of the disc brake. It has small holes in the place where there will be the contact of the friction pads also fins to suck in air so that it can give better cooling than rest of the model. Also due to more area of contact with the rotor and the friction pad it will give better friction and braking efficiency will increase. On the basis of material Carbon composite is the best material as is 50 % less weight than grey cast iron. It also gives better braking response and higher stability due to high Young’s Modulus than other material. Also due to less wear resistance it will give longer life of the brakes. And high thermal stability giving better control.

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