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# MODELING AND ANALYSIS OF TWO WHEELER DISK BRAKE FOR OPTIMUM PERFORMANCE

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*Abstract*

***Brakes are most important safety parts in the vehicles. To stop the wheel, Braking pad are forced against the rotor disc on both sides of surface. Now a day's most of the vehicles are high speed vehicles and therefore it is essential to design the braking disc for optimum to have effective Braking system.***

***The disc Brake is a device for slowing the rotation of wheel. Friction is a base for this process which generates heat and undergoes breakages or seizes due to high stress.***

***In the present work disc brake model is carried using CATIA V5 and thereafter analysis is done using ANSYS. The main intension of this project is to analyze deformation, strain & development over the disc plate.***

***In this present attempt, the holes size & shape on the rotor plate disc brake in the existing model are changed to study the behaviour on strength basis. Variable holes sizes ranging from 8 to 11mm are considered for the analysis. Also elliptical shape holes have been analyzed numerically.***

***At the end smaller sized circular hole of 8mm diameter is found to be effective compared to remaining circular holes of disc brake rotor plate. Comparing & elliptical shaped holes on the rotor plate, elliptical shaped holes rotor plate of disc brake is decided to be optimum.***

## I. INTRODUCTION

A **disc brake** is a type of brake that uses calipers to squeeze pairs of pads against a disc in order to create friction that retards the rotation of a shaft, such as a vehicle axle, either to reduce its rotational speed or to hold it stationary.

Close-up of a disc brake

On automobile disc brake are often located within the wheel.

A drilled motorcycle on a car brake disc

The energy of motion is converted into waste heat which must be dispersed. Hydraulic disc brakes are the most commonly used form of brake for motor vehicles but the principles of a disc brake are applicable to almost any rotating shaft.

Compared to drum brakes, disc brakes offer better stopping performance because the disc is more readily cooled. As a consequence discs are less prone to the brake fade caused when brake components overheat. Disc brakes also recover more quickly from immersion (wet brakes are less effective than dry ones).

Most drum brake designs have at least one leading shoe, which gives a servo-effect. By contrast, a disc brake has no self-servo effect and its braking force is always proportional to the pressure placed on the brake pad by the braking system via any brake servo, braking pedal, or lever. This tends to give the driver better "feel" and helps to avoid impending lockup. Drums are also prone to "bell mouthing" and trap worn lining material within the assembly, both causes of various braking problems.

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 retard the wheel, friction material in the form of brake pads, mounted on the 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.

The development of disc-type brakes began in England in the 1890s, but they were not practical or widely available for another 60 years. Successful application required technological progress, which began to arrive in the 1950s, leading to a critical demonstration of superiority at the Le Mans auto race in 1953. The Jaguar racing team won, using disc brake equipped cars, with much of the credit being given to the brakes' superior performance over rivals from firms like Ferrari, equipped with drum brakes. Mass production quickly followed with the 1955 Citroën DS.

## II. TYPES OF DISC BRAKES

Mechanical Disc Brake
Hydraulic Disc Brake

**Mechanical Disc Brake:**
Mechanical discs use the same cables and housing found on traditional cantilevers and V-brakes. Cables offer certain advantages over hydraulic systems, including simpler installation and adjustment, lighter weight, and less complicated maintenance (cables can be found at any bike shop and are less expensive than hydraulic lines).

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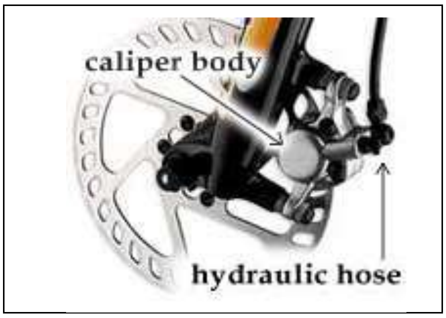
The main drawback to mechanical brakes is cable stretch, which causes a spongy feel, reduces braking power, and forces more frequent adjustment. Cables and housing are also susceptible to rust, dirt, and debris buildup that can bind the braking system.
These problems are completely avoidable though. And the basic maintenance tips that we offer here will keep your mechanical discs strong and reliable.


**Hydraulic Disc Brake:**

Hydraulic discs feature a closed system of hoses and reservoirs containing special hydraulic fluid to operate the brakes. When the lever is activated, a plunger pushes the fluid through the hoses and into the caliper where the pads are pushed onto the rotor, stopping the bike.
The advantage of hydraulic systems is being sealed (or "closed") so that water, dirt or debris can't compromise the brakes, making them very maintenance free once they've been properly installed. Also, hydraulic brakes have a silky smooth feel at the lever and incredible gripping power at the business end.

For drawbacks, hydraulic brakes must withstand extremely high pressure, so expert set-up and frequent inspections are essential. The smallest air bubble or leak in hydraulic discs can cause a loss of power or complete failure. And, the process of removing air from the braking system, called "bleeding," varies between individual systems and can be a delicate process. So it's best to bring your bike in and have us help.




## III. WHY DISC BRAKE USE

Mountain bikes first used **cantilever brakes**; next, **direct-pull brakes**, which avoided the risk of snagging a **transverse cable** on a knobby tire. But mountain-bike rims are often wet, muddy and warped, making for problems with any rim brakes.

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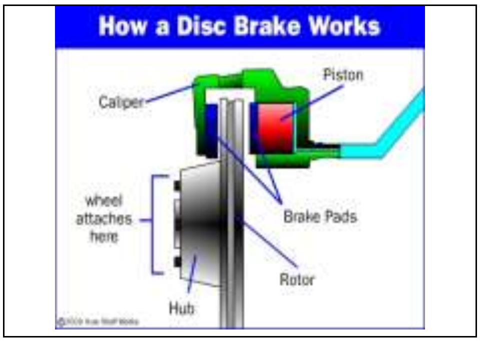
Disc brakes have become increasingly popular on mountain bikes and are gaining some popularity for other bicycles..
John Olsen, expert mountain bike rider and engineer (and who supplied the photo at the left here), reports:
"When I got my first mountain bike disc brake that worked, the advantages off road were so overwhelming that I changed every bike I had over to them as rapidly as possible. Hub and rim and spoke design essentially didn't change, except for disc mount provisions on the hubs."
For bicycles used on-road, the advantages of disc brakes aren't as compelling. To some extent, they are a fashion statement, imitating motor-vehicle practice.
But be aware: disc brakes can't be retrofitted without frame modification. A front disc brake stresses the fork heavily and can tear the front wheel out of the dropouts unless special measures are taken.

- The **brake pads**
- The **calliper**, which contains a piston
- The **rotor**, which is mounted to the hub

### 3.2 HOW DISC BRAKE WORKS IN BIKES:



*Parts of a disc brake*

*Vented disc brake*

Two common brake system used in auto mobiles are drum brakes and disc brakes.
Disc system is more reliable. Disc brakes works on principle of applying friction or resistance to rotating disc. The brake has three major elements.
1. Cast Iron disk attached to wheels
2. Brake pads on both sides which apply resistance.
3. Hydraulic piston which pushes each pad against disc.
When you apply disc brakes, Fluid is push through the tunnel cord, the fluid is pushed from master cylinder to piston in each wheel. the the piston applies equal force to both the sides of the drake pads. hydraulic system is used because it applies equal force to each cylinders. Thus the brake pads applies resistance to rotating disc.
.A moving car has a certain amount of kinetic energy, and the brakes have to remove this energy from the car in order to stop it. How do the brakes do this? Each time you stop your car, your brakes convert the kinetic energy to heat generated by the friction between the pads and the disc. Most car disc brakes are **vented**.

Vented disc brakes have a set of vanes, between the two sides of the disc, that pumps air through the disc to provide **cooling**.

## IV. ADVANTAGES AND DISADVANTAGES OF DISC BRAKES

**Advantages of Disc Brakes:**

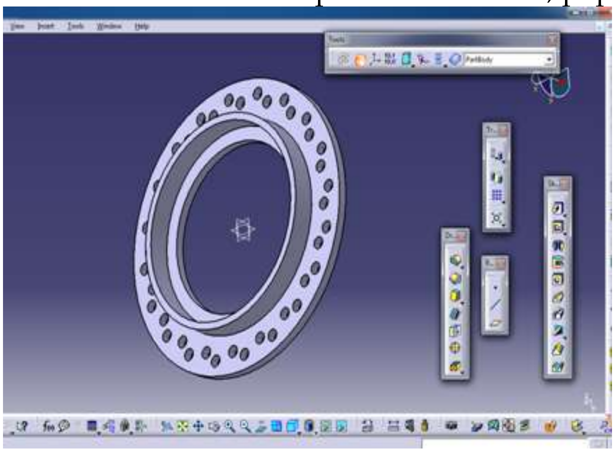
- They are strong.
- They are little affected by wet conditions.
- They don't get clogged with mud and snow.
- They aren't affected by rim damage or out-of-true.
- They don't risk brake shoes' damaging the tire or diving under the rim and locking the wheel.
- Being external to the hub, they don't impose special lubrication requirements like a coaster brake, or risk contamination by lubricants like an integral drum brake, or overheat the hub on long, steep downhill runs.
- They also dissipate heat without overheating the tire -- of special importance when used as a downhill drag brake on a tandem or cargo bike.
- They don't wear rims -- especially an issue in sand and mud, or with carbon-fiber composite rims. They don't leave black dust (wear particles) on aluminum-alloy rims, to get all over your hands when you remove or replace a wheel.

**Dis-advantages of Disc Brake:**

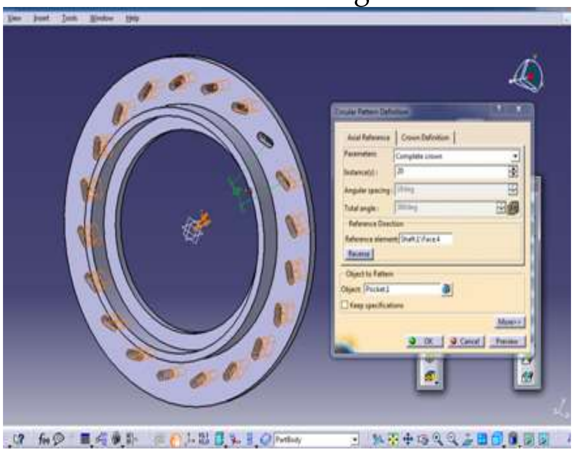
- A front disc brake stresses one blade of the front fork very heavily, requiring a stronger, heavier fork, resulting in a bumpier ride with a non-**suspension** fork, and if a fork isn't quite rigid enough, producing 'brake steer".
- A front disc brake **caliper** behind the fork **blade** generates a powerful force tending to loosen a **quick release** and pull the wheel out of the fork. Special hub and fork designs are needed to surmount this problem.
- Disc brakes are generally heavier than rim brakes.
- Disc brakes are more complicated, expensive and difficult to maintain than rim brakes or drum brakes.
- Some disc brakes are grabby. This problem is likely if dirt gets trapped between the calipers.
- Disc brakes require special fittings on the frame and fork, and special hubs.
- They can interfere with baggage racks and **fender stays**.
- The disc is vulnerable and easily bent. Other hub brakes do not have this weakness.

## V. INTRODUCTION OF CATIA

It is important to understand the format of the manual in order to use it effectively. This manual is designed to be used along with an instructor; however, you will need to do a lot of reading as well, in order to fully understand CATIA Version 5. The exercises in this book will list steps for you to complete, along with explanations that inform you what you have just done and what you are getting ready to do. The actual steps are in bold type and the information that follows the steps is for your benefit. Anything that appears in italics refers to a message CATIA provides—this includes information in pull-down menus, pop-up windows and other messages.



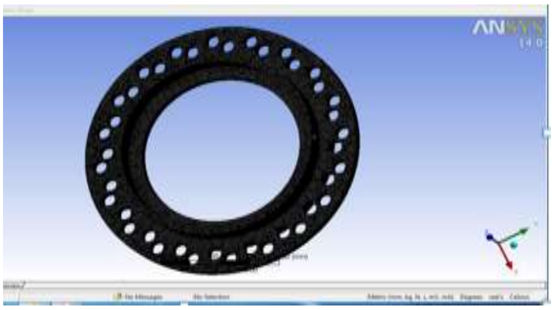
Disc Brake model as in circular shape



Disc Brake model as in elliptical shape

## VI. INTRODUCTION OF ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software Implements equations that govern the behavior of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated, or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations. ANSYS is the standard FEA teaching tool within the Mechanical Engineering Department at many colleges. ANSYS is also used in Civil and Electrical Engineering, as well as the Physics and Chemistry departments. ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping. With virtual prototyping techniques, users can iterate various scenarios to optimize the product long before the manufacturing is started. This enables a reduction in the level of risk, and in the cost of ineffective designs. The multifaceted nature of ANSYS also provides a means to ensure that users are able to see the effect of a design on the whole behavior of the product, be it electromagnetic, thermal, mechanical etc.



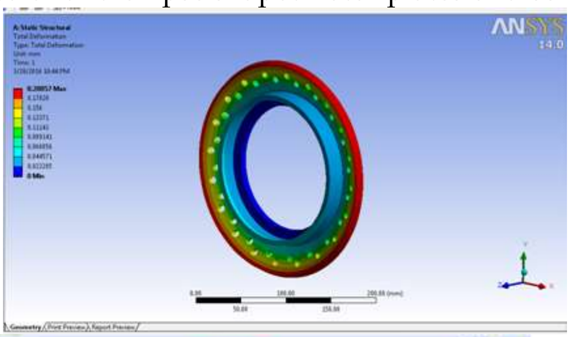

3-D Meshed Model by ANSYS

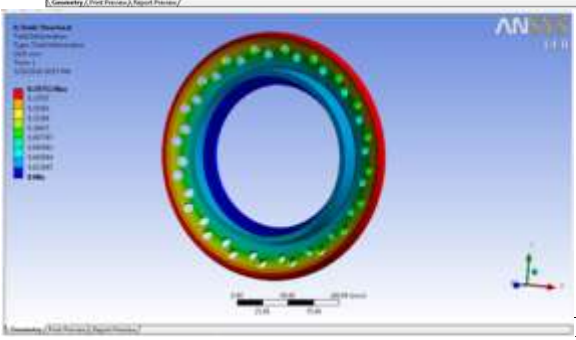
## VII. RESULTS AND DISCUSSIONS

Conducting series of numerical tests with different hole diameters and shape on the disc brake rotor using ANSYS following results are obtained.

**Deformation Profile**

It is observed from the deformation results that the maximum deformation takes place near the edge of the plate in all the considered cases (different diameters of circular hole and ellipse). The maximum deformation zone is represented in red colour in the numerical results as shown in the following diagrams and the deformation gradually decreases towards the center of the rotor of disc brake. This trend is predicted as the center of the rotor is fixed and edge of the rotor plate of disc brake is free end. Due to the development of the torque on the disc brake of rotor plate the free edge undergoes higher level of deformation whereas the inner edge which is fixed is under zero deformation. The deformation is higher in the zone of the rotor plate at the diameter beyond existence of the holes. The higher level of deformation initiates from the edge of the holes for both circular and ellipse shaped rotor plates of disc brake.




Deformation of 10mm Hole dia. of disc brake

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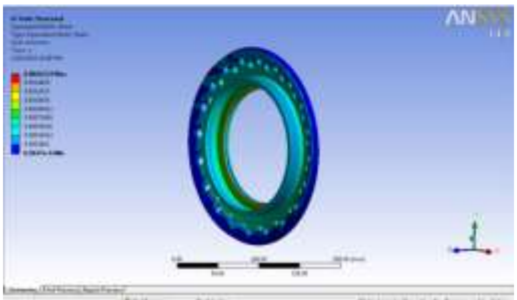
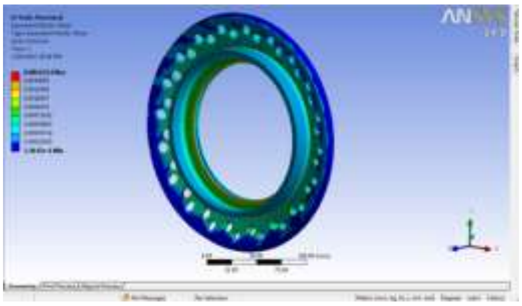
Deformation of 10mm Hole dia. of disc brake

Also it is observed that the deformation decreases with increase of holes diameter. The maximum deformation is found to be 0.2005, 0.199, 0.197 and 0.196 for the rotor plates of disc plate is 8, 9, 10 and 11mm holes diameter respectively. Also the deformation of the rotor having ellipse shaped holes is tested and found the maximum deformation of 0.213mm. This shows that the maximum deformation occurred is almost same (very close) in all the considered cases of 8 to 11mm holes diameter and even for ellipse shaped holes.

**Strain Profile**

It is found that strain in the rotor plates of disc brake is decreasing from the outer edge to the inner edge for all the cases of circular and ellipse shaped holes. The maximum strain occurs at the fibers close to the inner edge. Though the deformation is lower at the inner fibers the strain is higher, due to lower original size of the fibers close to the inner edges. The maximum strain developed in the plates is found to be 0.001459, 0.00162, 0.00192 and 0.00163 mm/mm for the rotor plate of disc brake having circular holes of 8, 9, 10 and 11mm diameter respectively. This shows that the strain increases with increase of holes diameter up to 10mm and decreases again from there. Also the maximum strain obtained in the rotor plate made of ellipse holes is found to be 0.00176mm/mm. The strain in the elliptical holes rotor plate of disc brake is less than the strain developed in the equivalent rotor plate of 10mm circular holes diameter



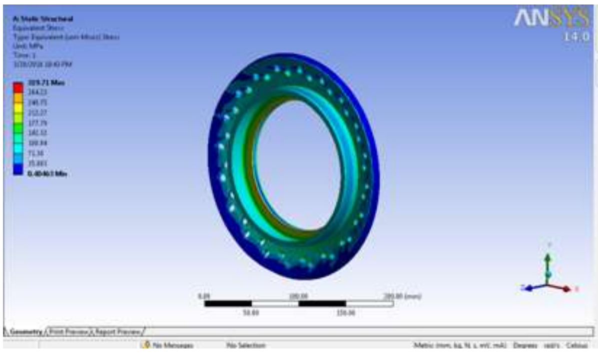


Strain developed on disc brake as 9mm hole dia.    Strain developed on disc brake as 11mm hole dia

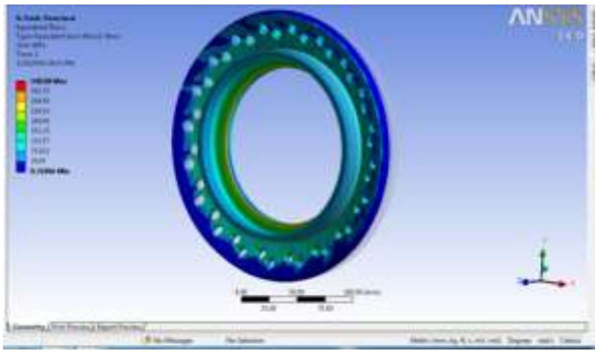
**Stress Profile**

The maximum stress is found to be 319.71, 324.47, 340.08 and 301.08 N/mm$^2$ for the rotor plate of disc brake having 8, 9, 10 and 11mm holes diameter. The maximum stress obtained for the ellipse case is 331.49N/mm$^2$. From the results it is found that the maximum stress increases with increase of holes diameter of rotor plate of disc brake from 8mm to 10mm and decreases again from there. The maximum stress values are found near the edge of the holes in all the cases due to stress concentration due to redistribution of stress lines with sudden change in cross section of the rotor plate.

The increase of stress value for the diameters from 8mm to 10mm is due to redistribution of the stress curves along the circumference of the plate. It means due to increase in size of hole diameter the stress curves has to take turn suddenly which leads to increase of stress concentration in the zones of diversion of stress lines which result in sudden rise in stress. And again decrease of stress beyond 10mm diameter is because the holes in two adjacent rows get closer and thereby the stress lines can rearrange themselves and take deviation to go through the holes from one row to the other row. The stress developed in the rotor plate of disc brake having elliptical holes is less than the stress developed in the equivalent rotor plate of disc brake of 10mm circular diameter.



Stress developed on disc brake as 8mm hole dia.

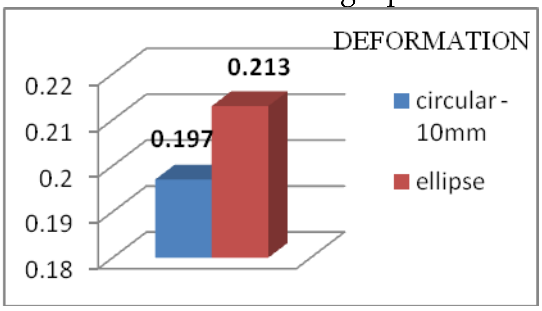


Stress developed on disc brake as 10mm hole dia.

## VIII. EFFECT OF CIRCULAR HOLE

**Effect on Deformation:-**

It is observed that the deformation developed is higher in the rotor plate of disc brake having elliptical holes than that of having circular holes. The deformation in the elliptical holes rotor plate of disc brake is 8.4% higher than that of the rotor having equivalent circular holes.




Comparison of Deformation between ellipse & Circular dia. of 10mm

It is found that strain developed in the rotor plate having circular holes is higher than that of the rotor plate having elliptical holes. The strain developed in the rotor plate of disc brake having elliptical holes is 9.09% less than that of the rotor plate of disc brake having equivalent circular holes.

**Effect of Strain & Stress**

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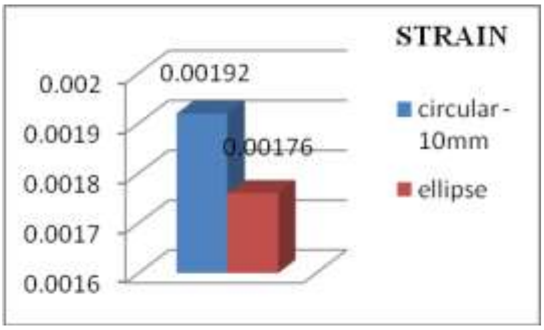


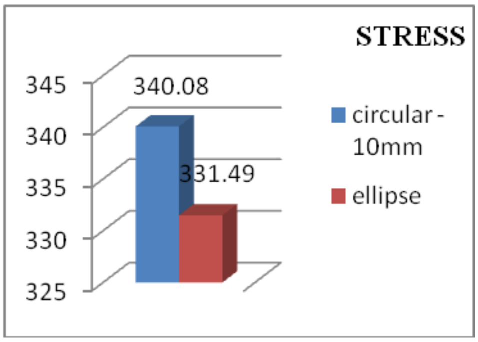


Comparison of strain & stress between ellipse & Circular dia. of 10mm

It is found that the rotor plate of disc brake with elliptical holes is developed with the stress less than that of the stress in the rotor plate with equivalent circular holes. The stress developed in the rotor plate of disc brake with elliptical holes is 2.5% less than that of the stress developed in the rotor plate of disc brake having equivalent circular holes.

## IX. CONCLUSIONS

From the series of numerical tests carried using ANSYS with different circular holes on the rotor plate of disc brake and also by changing the shape of hole taking elliptical shape in place of equivalent circle shape are analyzed and from which the following conclusions are drawn.

- The deformation in the rotor plate of disc brake is found to be decreasing from outer edge to the inner edge for all the considered cases of circular and elliptical shaped holes.
- The deformation of the disc brake rotor plate decreases slightly with increase of circular holes diameter.
- The strain developed in the rotor plate of disc brake increases with increase of circular holes diameter from 8mm to 10mm and decreases from there.
- The maximum stress developed in the rotor plate of disc brake increases with increase of circular holes diameter from 8mm to 10mm and decreases from there.
- The strain developed in the rotor plate of disc brake of elliptical holes is 9.09% lower than that of the rotor plate with equivalent circular holes.
- The maximum stress developed in the rotor plate of disc brake is 2.5% less than that of the stress developed in the rotor plate with equivalent circular holes.
- Considering the circular holes on the rotor plate of disc brake 8mm holes diameter is effective.
- Comparing the elliptical and circular shaped holes on the rotor plate of disc brake, elliptical holes rotor plate disc brake is decided to be effective.

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