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Experimental Investigation of Disc Brake of The Mounting Bicycle By Using Grey Cast Iron

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ABSTRACT

Braking involves converting the kinetic energy of a vehicle into mechanical energy, which is then dissipated as heat. When braking, the friction between the disc pads can generate high temperatures. The tangential stress and sliding speeds at the contact point are crucial factors contributing to this phenomenon. This study aims to analyze the thermal conductivity of a mountain bicycle brake disc using the ANSYS software tool.

The temperature distribution modeling of the disc brake allows for the identification of various factors and parameters involved in the braking process. These include the braking type, disc geometry, and material used for the disc. The simulation results obtained in this study are consistent with those reported in the relevant literature.

Keywords: Disc brake, FEA Analysis, Deflection, Stresses

1.INTRODUCTION

Brake is a system by way of capability of which synthetic frictional resistance is utilized to shifting laptop member, in order to quit the action of a machine. In the system of performing this function, the brakes soak up both kinetic electricity of the transferring member or the conceivable electricity given up through objects being decreased by way of hoists, elevators etc. The power absorbed by way of brakes is dissipated in the structure of warmness to the surrounding.

1.1 Braking Requirements:

1. The brakes should be sturdy ample to cease the automobile with in a minimal distance in case of an emergency.

2. The driver have to have acceptable manipulate over the automobile at some stage in braking and the automobile need to now not skid.

3. The brakes ought to have correct anti-fade traits i.e. their effectiveness need to now not limit with steady extended application.

4. The brakes need to have nicely anti put on properties.

1.2 Disc Brake:

Disc brake consists of a solid iron disc bolted to the wheel hub and a stationary housing referred to as caliper. The caliper is linked to stationary section of the vehicle, usually axle casing or the stub axle and is manufactured with casting in two parts, and with every phase containing a piston. In between every piston and the disc, there is a friction pad held in role with the aid of keeping pins or spring plates. Passages are drilled in the caliper for the fluid to enter or go away the housing which is additionally related to some other one for bleeding. Each cylinder consists of rubber-sealing ring between the cylinder and piston. A schematic sketch of disc brake is as proven under in determine 1.2.1

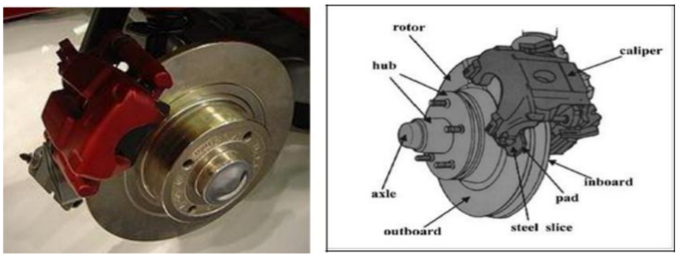

Figure 1.2.1: Disc brake schematic

2. PROBLEM DEFINITION

Disc brakes are most famous in Mountain bicycle. The disc brake performs very vital position in braking. The non-stop structural and thermal hundreds from brake pads due to braking motion lead to failure in the present format of disc.

Disc brake is the most imperative gadget in any vehicle.

Braking leads to the failure of disc.

The failure takes place broadly speaking due to the fact cracking and warping of the disc close to imperative regions.

Figure 2.1: Bent and cracked disc

2.1 Objectives

The failure of the disc can be prevented by using altering the diagram of the disc brake. The alternate layout choice offers the power and stiffness to the disc brake. The greater thing of protection is chosen to limit the probabilities of failure in the disc brake.

• Aim is to graph and boost the disc brake for bicycle which sustains the structural load appearing on brake disc all through motion of braking.

• Compare the energy of two exceptional designs of disc brake with current disc brake.

• The disc brake with greater power of diagram is chosen for the disc brake application.

• Existing sketch of disc brake is modeled in CATIA.

• The structural evaluation is carried out in ANSYS.

2.2 Conclusion Drawn From Literature Review

The researches have been carried out to diagram the viable and fee high quality disc brake structures for the exceptional applications. Some researchers have research the impact of alternate of fabric from forged iron to stainless steel, aluminium and alloys. Recent lookup has been carried out on composite fabric to distribute warmth to surrounding environment. The composite substances are appropriate for thermal and structural performances. The Vibration evaluation is additionally carried out to decide the vibration traits of disc brake system. As per research, the plan enchancment can be the viable choice for the disc brake system.

3.MATERIAL PROPERTIES AND ANALYTICAL CALCULATIONS

3.1 Material Properties

Material property is an intensive, regularly a quantitative property, with a unit that is used as measure of the cost to examine the benefits of one cloth versus every other to resource substances selection.

Material property may additionally be a steady or a feature of one or extra unbiased variables, such as temperature. They regularly range to some degree, in accordance to the path in the cloth in which they are measured; a circumstance referred to as anisotropy.

3.2 Grey Cast Iron

Silicon is integral to make gray forged iron as hostile to white solid iron. The carbide of iron turns into unstable when silicon is alloyed with ferrite and carbon at round 2%. Silicon reasons the carbon unexpectedly to come out of the answer as graphite, leaving a matrix of enormously pure, and tender iron. There will be excessive activation power for increase when vulnerable bonding between planes of graphite lead presents, which end result in skinny and spherical flakes. This shape has quite a few beneficial properties.

Sr. No.	Properties	Grey Cast Iron
1	Modulus of elasticity of material(E)-MPa	2.1e5
2	Material density (p)- (Kg/m3)	7800
3	Poisson's ratio	0.3
4	Thermal Conductivity(k)-(w/m.k)	18
5	Specific Heat Capacity - (KJ/Kg K)	0.46
6	Melting Temp - (K)	1403

Table 3.1.1.1: Properties of Grey Cast Iron

3.3 Analytical Calculations

3.3.1 Disc Brake Standards

Rotor disc dimension = 160 mm = 0.16 m

Rotor disc material = Grey Cast Iron

Pad brake area = 500 mm2 (500 $\times 10^{-6}$ m)

Pad brake material = Asbestos

Coefficient of friction (Wet) = 0.08

Coefficient of friction (Dry) = 0.2

Maximum temperature = 60 ºC

Maximum pressure = 1 MPa (10^6 Pa)

4. FINITE ELEMENT ANALYSIS

Finite Element Method is a numerical process for fixing continuum mechanics of hassle with accuracy proper to engineers. Finite Element Method is a mathematical modelling device involving discretization of a non-stop

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domain? Using building-block entities known as finite factors related to every different by means of nodes for as soon as and second transfer. This technique consists of Finite Element Modeling and Finite Element Analysis

4.1 Temperature distribution in baseline disc-1

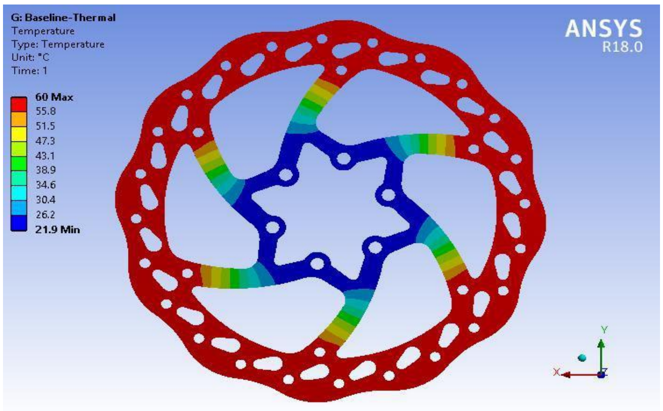


Figure 4.1.1: Temperature distribution in baseline disc-1

The Temperature distribution inside the baseline disc is shown in Figure 4.2.6.1. The output from thermal analysis is provided as input to structural analysis to determine the strength of the disc.

4.2 Post-processing of Structural Analysis

The displacement contour plot is as shown in below Figure 4.3.6.1.

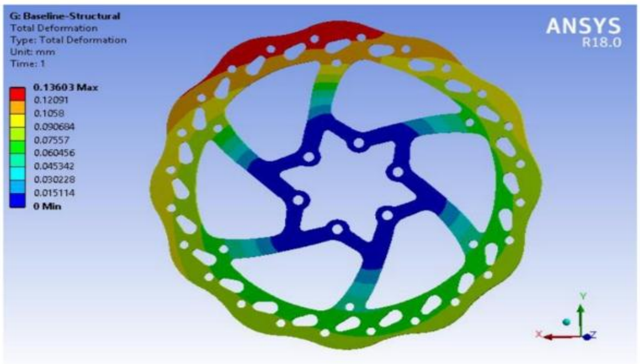


Figure 4.2.1: Total deformation contour plot for baseline disc

The maximum displacement shown by the baseline (disc-1) design is 0.136 mm.

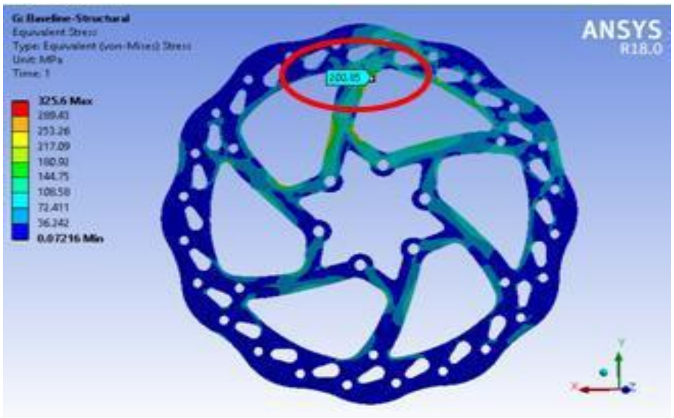


Figure 4.2.2: Von-Mises stress contour plot for baseline disc

The maximum equivalent stress observed in the baseline disc-1 is 200 MPa.

The yield strength of the material is 220 MPa. According to the results, the von-Mises stress 200 MPa is less but nearer to the yield strength of the material. The sudden or impact braking action can cause the failure of the disc at weakest cross sectional area of the disc. The Field failure of the disc is caused due to sudden and dynamic load acting on the disc. The same location of the failure is detected in finite element analysis study which is shown in the Figure 4.3.6.2. The safety factor 1.1 for the baseline model is nearer to the value 1.

4.3 Alternate Design Proposals

After investigation of failure in the baseline disc, two design proposals prepared as shown below in the Figure 4.4.1 and 4.4.2 then performed the thermal and stress analysis.

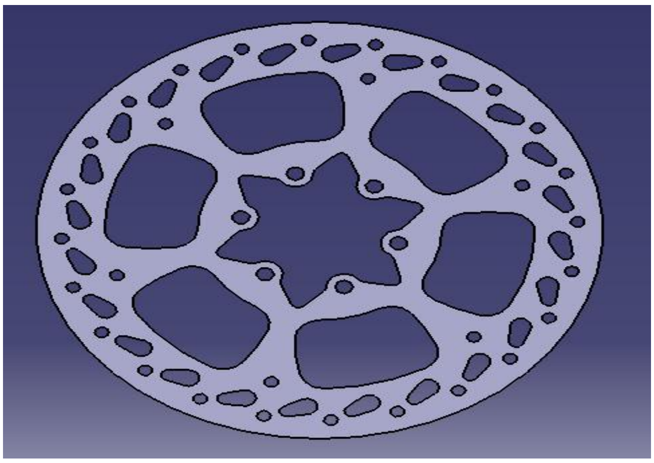


Figure 4.3.1: Alternate design proposal Disc-2

4.3.1 Thermal Analysis of Proposed Design

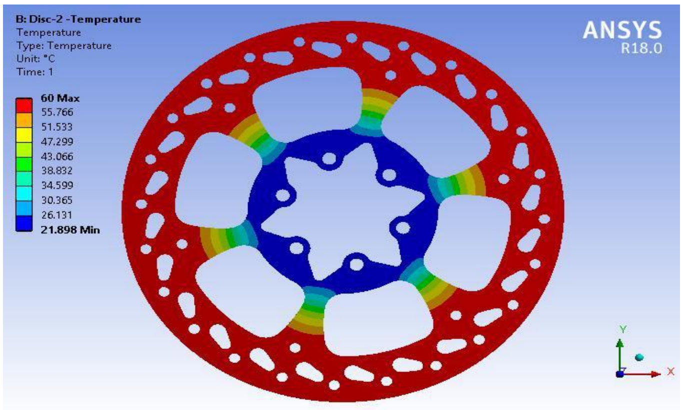


Figure 4.3.1: Temperature Distribution in the Disc-2

The maximum temperature observed in the proposed disc-2 design is 60°C.

4.3.2 Structural Analysis of Proposed Design

The total deformation and stress plots are shown in below Figures 4.4.2.1 to 4.4.2.4 for the proposed disc designs.

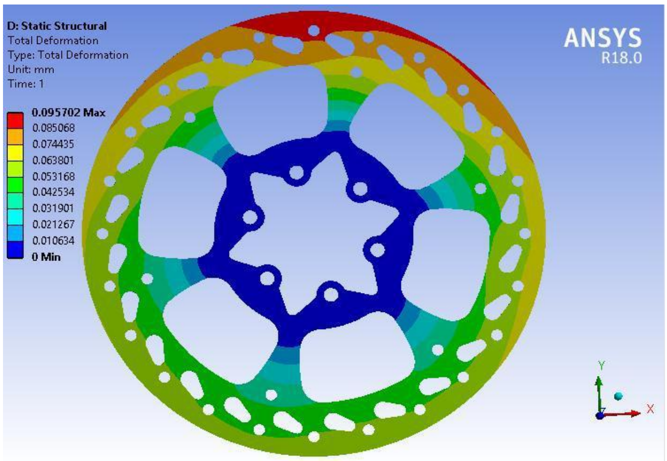


Figure 4.3.2: Total Deformation contour plot of disc-2

The maximum displacement shown by the disc brake for disc-2 is 0.0957 mm.

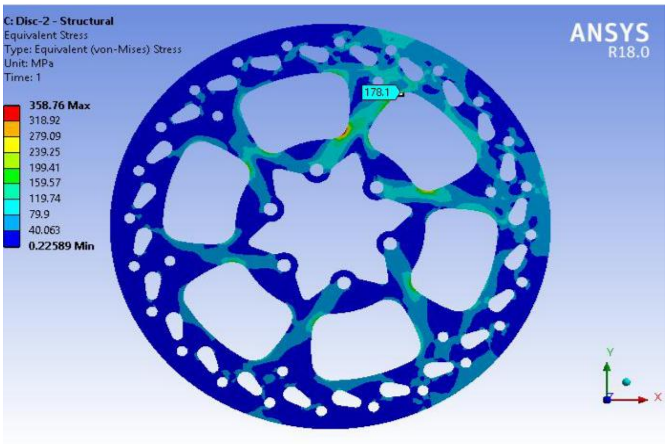


Figure 4.3.3: Von-Mises stress contour plot of disc-2

The von-mises stress of proposed disc-2 observed is 178 MPa.

The maximum equivalent stress observed in the proposed disc 2 is 178 MPa. The yield strength of the material is 220 MPa. According to results, the von-Mises stress 178 MPa is less than yield strength of the material. The safety factor observed is 1.24 for the disc 2 which is higher than the baseline model.

4.4 Summary (From Finite Element Analysis)

It is found from the outcomes that, Maximum stresses are developed in the baseline disc and exactly fits with the area failure. A evaluation of most whole deformation and equal stress values for baseline sketch and subsequent modified designs of the disc are calculated. Following desk indicates assessment between exceptional designs of disc thru FEA.

Table 4.1: FEA Results

Sr. No.	Description	Mass (kg)	Deflection (mm)	Von-Mises stress (MPa)
1	Baseline Disc-1	0.1433	0.136	200
2	Disc-2	0.1658	0.095	178

A stresses in the proposed disc-2 is minimum as compared to the stresses in baseline disc

5. EXPERIMENTAL VALIDATION

A test rig is developed at a Laboratory for the disc brake experimentation. The test rig is used to take a look at the electricity of the manufactured baseline disc and modified disc two graph in the dynamic loading condition.

5.1 Experimental Equipments

Load frame: Two strong supports for the machine

Load cell: Force transducer used for measuring the loads

Output device: Machine have computer interface to for result interpretation and analysis. Older machines have dial and digital displays.

Conditioning: The test rig is placed in normal temperature of 23^{0}C

Test Fixtures: Test rig is inserted into the 20 mm x 20 mm hole prepared in the ground floor.

Strain Gauge: To measure the strain values of the test specimen for applied load.

Figure 5.1.1: Experimental setup of baseline Disc-1

5.2 Experimental Procedure

A take a look at specimen with baseline and optimized fashions are taken for the Experiment.

Baseline specimen positioned internal the fixtures and extensometer.

Applied the stress gauges to report the stress and stress in the specimen.

Rotated the wheel with 20 Km/hr velocity comparable to most pace of mountain Bicycle.

Applied the surprising brakes by way of transferring levers to characterize the dynamic conditions.

The exchange in size of the specimen is recorded via the extensometer.

The braking load vs. deflection curve is additionally recorded.

The stress vs. stress values are recorded via stress gauge meter.

The 2nd specimen i.e. disc two is taken for the experiment. The identical braking load has been utilized on the disc two The stress and stress values are recorded. The load vs. deflection curve is additionally recorded.

Observed the disasters in the specimen if any, and the evaluation between baseline and modified model have been recorded in the desk below.

Figure 5.2.1: Baseline (Disc-1) specimen after experimental test

Failure is observed during experimental test of baseline disc at the same location where the field failure has taken place which is highlighted in the above figure 5.2.1

Figure 5.2.2: Disc-2 specimen after experimental test

There is no failure observed in the proposed disc-2 design during experimental test

5.3 Experimental Results

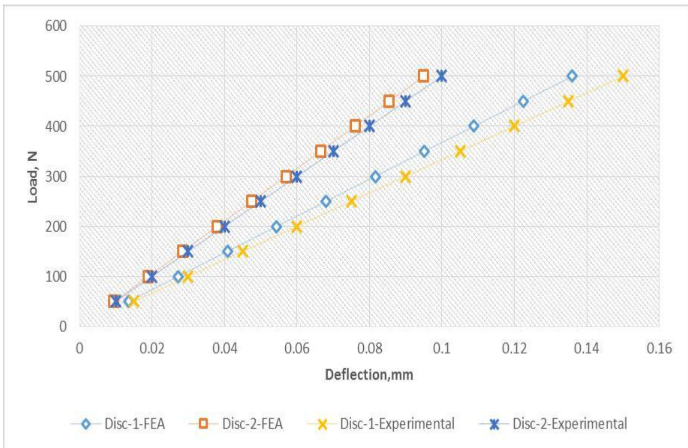
Table 5.3.1: Experimental results

Sr. No.	Description	Deflection (mm)	Von-Mises Stress (MPa)
1	Baseline (Disc-1)	0.15	209
		0.14	
2	Modified Design (Disc-2)	0.1	184
		0.098	

6. RESULTS AND DISCUSSION

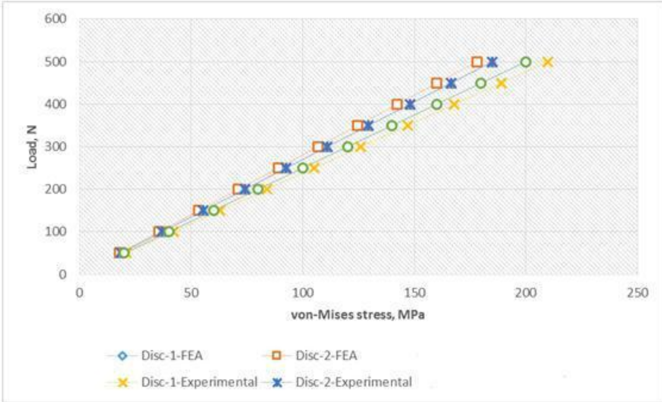
It is observed from the results that, maximum stresses are developed at inner rib of the disc brake. The maximum deformation in baseline disc is observed up to 0.136 mm. The von-Mises stress in the disc for the maximum load is 200 MPa. The total weight of the baseline disc is 0.1433 kg. Therefore, the von-mises stress in the baseline disc 1 is less than yield strength of the material. But, the value is observed near the yield strength limit of material (Yield strength limit = 220MPa). Therefore, there are chances of failure of disc 1 because of impact load/Sudden braking action.

The maximum deformation in disc 2 is observed up to 0.095 mm. The von-Mises stress in the disc for the maximum load of 500 N is 178 MPa. The total weight of the Disc 2 is 0.1658 kg. Therefore, the von-mises stress in the disc 2 is below their yield strength of the material and the value is observed below the yield limit of material (Yield limit = 220MPa). Therefore, the design of disc is safe.



Graph 6.1: Load Vs Deflection (FEA and Experimental comparison)

The deflection values against applied load for FEA and Experimental methods show the correlation between both methods, since there is less than 10% variation observed between FEA and Experimental methods.



Graph 6.2: Load Vs Stress (FEA and Experimental comparison)

7. CONCLUSION

The comparative find out about is carried out with the three one of a kind designs of the disc brake and has reached at the following conclusion:

The deflection in modified format of disc-2 is minimal than that of baseline design.

The von-Mises stress in the disc brake layout two is minimal as in contrast to baseline design.

The mass of the disc sketch two is 10% greater than baseline layout due to expand in the stiffness.

Thus, modified sketch with disc-2 is most appropriate and possible for the contemporary utility from plan and manufacturing perspective.

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