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Experimental Analysis on Finite Element Analysis of a Brake Disc of a Racing Bicycle using CAE Tools

Gaurav Joon[1], Mr. Sanjeev[2]
Department of Mechanical Engineering, CBS Group of Institutions, Jhajjar, Haryana

ABSTRACT

The objective of this paper is to carry out computer aided design and analysis of a ventilated disc brake rotor with actual design considerations and loading conditions. The FE model is capable of predicting structural failure, mode shape & platform for dynamic analysis. The structural and modal linear static analysis has been carried out for a given load to determine the maximum deflection, stress distribution and natural frequency. It is observed that von mises stresses and displacements are within safe limits and structure can withstand the given load. The FEA predictions are validated with experimental data.

Keyword: disc, bicycle, CAE, brake, finite, element.

1. INTRODUCTION

Assignment The disc brake is a device for slowing or stopping the rotation of a wheel while it is in motion. A brake disc is usually made of cast iron, alloy steel but in many cases it is made of composites such as reinforced carbon-carbon or ceramic-matrix composites. The brake is connected to the wheel or the axle. To stop the wheel, friction material in the form of brake pads (mounted on a device called a brake caliper) is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. The friction causes the disc and attached wheel to slow or stop. Brakes (both disc and drum) convert friction to heat, but if the brakes get too hot, they will become less effective because they cannot dissipate enough heat. This condition of failure is known as brake fade. The brake system should have following requirements:

1. The brakes must be strong enough to stop the vehicle with in a minimum distance in an emergency.
2. The driver must have proper control over the vehicle during braking and vehicle must not skid.
3. The brakes must have well anti fade characteristics i.e. their effectiveness should not decrease with constant prolonged application.
4. The brakes should have good anti wear properties.

2. CLASSIFICATION OF BRAKES

The mechanical brakes according to the direction of acting force may be divided into the following two groups:

1. Radial Brake
2. Axial Brake

Radial brakes:

In these brakes the force acting on the brakes drum is in radial direction. The radial Brakes may be subdivided into external brakes and internal brakes.

Axial Brakes:

In these brakes the force acting on the brake drum is only in the axial direction. i.e. Disk brakes, Cone brakes.

DISK BRAKE

A disk brake consists of a cast iron, alloy steel or may be some other materials bolted to the wheel hub and a stationary housing called caliper. The caliper is connected to some stationary part of the vehicle like the axle casing or the stub axle as is cast in two parts each part containing a piston. In between each piston and the disk there is a friction pad held in position by retaining pins, spring plates etc. passages are drilled in the caliper for the fluid to enter or leave each housing. The passages are also connected to another one for bleeding. Each cylinder contains rubber-sealing ring between the cylinder and piston. A schematic diagram is shown in the Fig. 1.

The main components of the disc brake are:
1. The brake pads
2. The calliper which contains the piston
3. The rotor, which is mounted to the hub

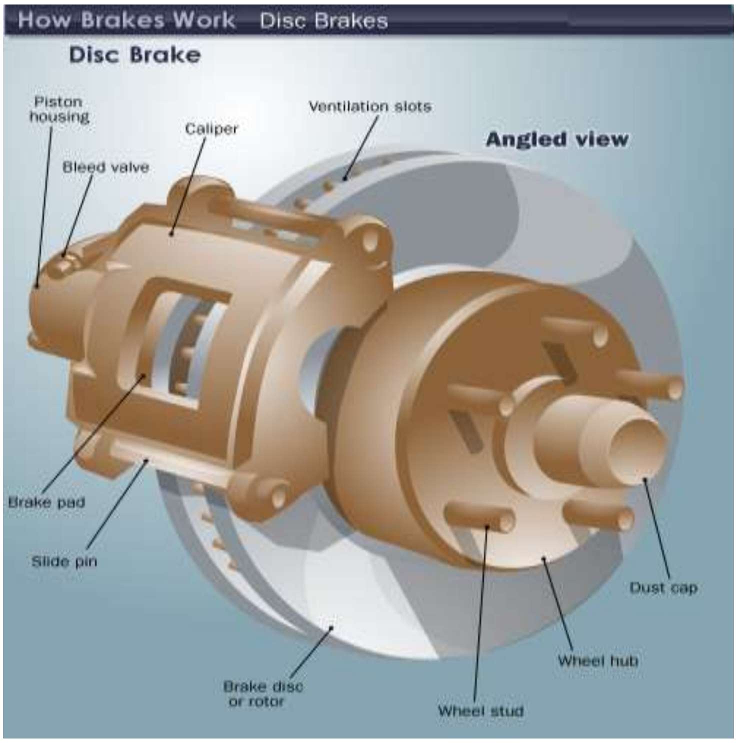

Fig 1: Disk Brake

When the brakes are applied, hydraulically actuated pistons move the friction pads in to contact with the rotating disk, applying equal and opposite forces on the disk. Due to the friction in between disk and pad surfaces, the kinetic energy of the rotating wheel is converted into heat, by which vehicle is to stop after a certain distance. On releasing the brakes the rubber-sealing ring acts as return spring and retract the pistons and the friction pads away from the disc. The disc brake working principle as shown in Fig. 2.

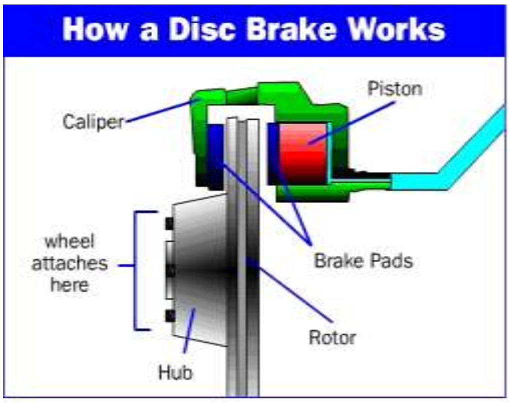

Fig 2: Disk Brake Working Principle

3. CAE AND PROCESS MANAGEMENT

The various activities that make up Computer Aided Engineering are an essential part of the product design cycle to speed up the design cycle, to ensure that the products designed are of higher quality, and to reduce cost of the final product. Broadly, the tasks the designer has to carry out, exists in two categories the first is model creation, while the second covers reporting and interpretation of results.

Regardless of the category, many of the tasks are tedious; requiring a considerable attention to detail one way to improve a model is to use a checklist: element quality checks are an excellent example of checklists. But suppose as a result of oversight or of ignorance, the checklist has not been applied? Even worse, suppose the designer has neglected to report any assumptions in the model and suppose the violation of these assumptions can lead to disaster: Clearly, the potential impact of CAE errors can be very high.

Other Computer Aided Technologies are:

The term **CAD/CAM** (computer-aided design and computer-aided manufacturing) is also often used in the context of a software tool covering a number of engineering functions.

- Computer-aided architectural design **(CAAD)**
- Computer-aided design and drafting **(CADD)**
- Computer-aided drafting **(CAD)**
- Computer-aided electrical and electronic design **(ECAD)**
- Computer-aided industrial design **(CAID)**
- Computer aided engineering **(CAE)**

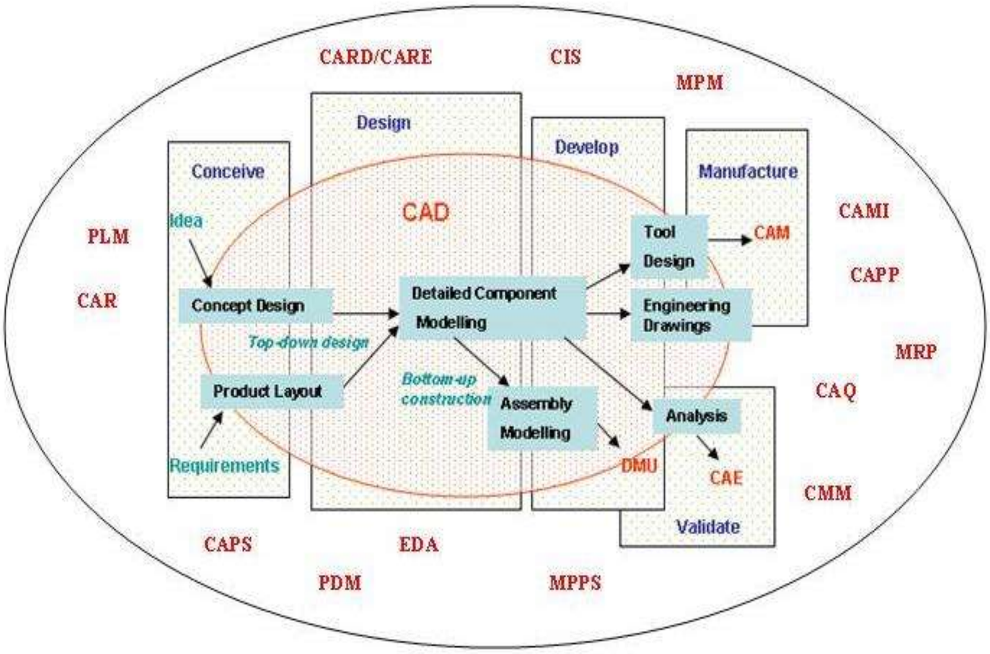

Fig. 3: Various Computer Aided Technologies

4. RESULT AND DISCUSSIONS

The FEA result of the ventilated disc brake have been analyzed and compared with the available experimental results for validation.

The Fig. 4 & 5 shows the vonmises contour of the disc brake for a load of 180 Kg. The maximum stress is found to be (19.066 MPA) near the bolted surface. The value of maximum stress (19.066 MPA) is well below the yield stress (140MPA) for the given material.

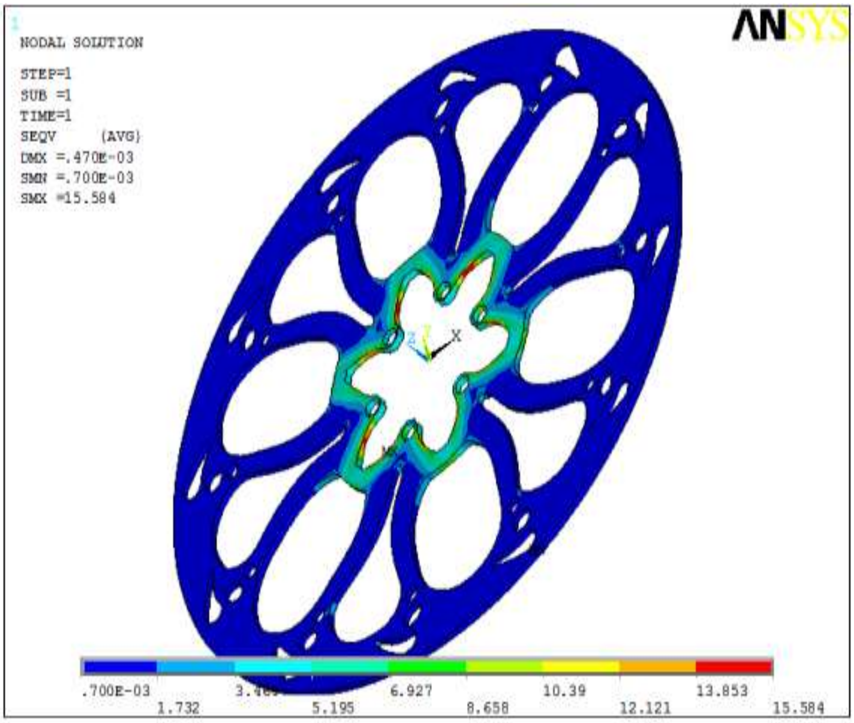

Fig. 4: Vonmises stress for alternative design model

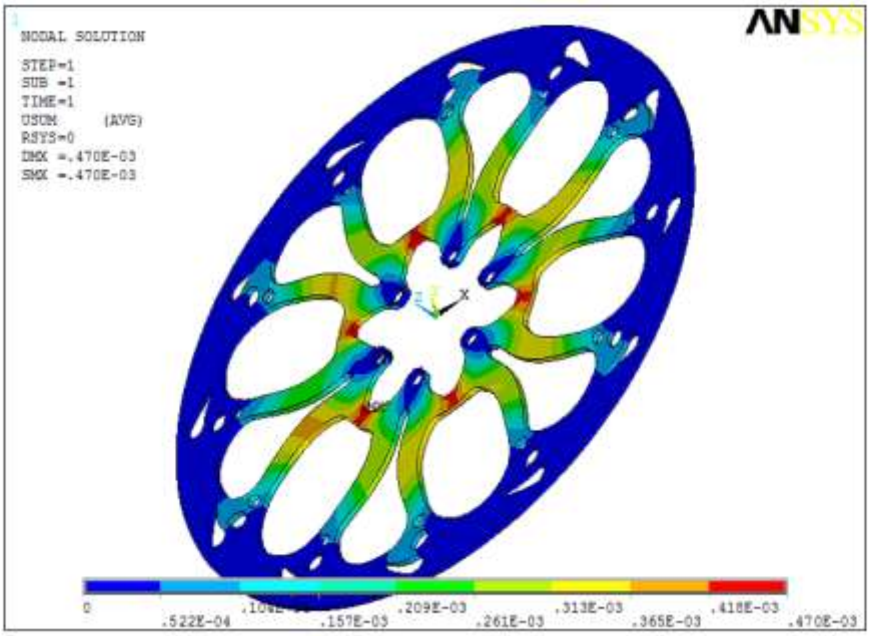

Fig. 5: Displacement Contour of alternative design model

Table 1: Comparison of alternative design model FEA results

Sr. No.	Parameters	Original Model Results	Alternative Design model Results
1	Von Mises Stress	19.066 Mpa	15.584 Mpa
2	Displacement	0.00065mm	0.00047mm

It is observed from table 1 that the alternative design is superior to the previous one. After thoroughly examining the FEA results the Factor of safety of the design model is (7-8) much above the allowable limit (2.5-3). Factor of safety is acceptable and safe for further dynamic simulation.

CONCLUSION

From the results obtained from FE analysis, many discussions have been made and it will be concluded that:

1. The maximum vonmises stress observed in FE analysis of the disc brake rotor is 19.066 MPA for the load of 180 Kg.
2. The maximum deformation is 0.000657mm which is negligible and harmless.
3. The first five natural frequencies are in the range of (5.8-8.2) Hz
4. The results are well in agreement with the similar available experimental results.
5 The maximum Von Mises stress observed in FE Analysis of the alternative design model of disc brake rotor is 15.584 MPA for the similar loading condition.
6. The maximum deformation of the alternative design is 0.00047mm for the similar loading condition.

REFERENCES

[1]. Y. YILDIZ and M. DUZGUN* stress analysis of ventilated brake discs using the finite element method Mechanical Department, Faculty of Technical Education, Gazi University, Ankara 06500, Turkey, Received 9 July 2008; Rrevised 21 January 2009.
[2]. B.-C. SONG1 and K.-H. LEE2* structural optimization of a circumferential friction disk brake with consideration of thermoelastic instability 1)Research Engineer, R&D Center, NEXEN TIRE Corporation, Yangsan-si, Gyeongnam 626-230, Korea 2) Department of Mechanical Engineering, Dong-A University, Busan 604-714, Korea
[3]. JÜRGEN HEILIG and JÖRG WAUER Stability of a Nonlinear Brake System at High Operating Speeds Institut für Technische Mechanik, Universität Karlsruhe, D-76128 Karlsruhe, GermanyReceived: 4 May 2001; accepted: 26 June 2002
[4]. Y.-G. JOE1), B.-G. CHA 2), H.-J. SIM1), H.-J. LEE1) and J.-E. OH3)* analysis of disc brake instability due to friction-induced vibration using a distributed parameter model, Department of Mechanical Engineering, Hanyang University, Seou1 133-791, Korea, November 2007
[5]. Zhengfeng Bai, Yang Zhao, Wenlai Ma, Hao Tian Modal Analysis for Small Satellite System with Finite Element Method Department of Astronautics Engineering Harbin Institute of Technology Harbin, Heilongjiang Province, China
[6]. Xue Jing, Li Yuren and Liu Weiguo Tian Guanglai and Wei Hanbing The Finite Element Model of Transient Temperature Field of Airplane Brake Disks with Rough Surface Profile College of Automation College of Automation Northwestern Polytechnical University Northwestern Polytechnical University Xi'an,Shaanxi Province, China Xi'an,Shaanxi Province, China.
[7]. Daniel Hochlenert Nonlinear stability analysis of a disk brake model Received: 16 July 2008 / Accepted: 1 October 2008 / Published online: 10 January 2009 © Springer Science+Business Media B.V. 2009
[8]. COMNINOU, M. AND DUNDURS, J. On the Barber Boundary Conditions for Thermo elastic Contact, ASME J, vol. 46, page 849-853, (1979).
[9]. Ji-Hoon Choi, In Lee∗ Finite element analysis of transient thermoelastic behaviors in disk brakes Department of Aerospace Engineering, Korea Advanced Institute of Science and Technology, 373-1 Guseong-dong, Yuseong-gu, Taejeon 305-701, South Korea
[10]. M.M. Shahzamanian a,b, B.B. Sahari a,b, M. Bayat b,c,*, F. Mustapha d, Z.N. Ismarrubiea Finite element analysis of thermoelastic contact problem in functionally graded axisymmetric brake disks Mechanical and Manufacturing Engineering Department, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia b Institute of Advance Technology (ITMA), Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia.
[11]. Jaeyoung Kang Squeal analysis of gyroscopic disc brake system based on finite element method Division of Mechanical and Automotive Engineering, College of Engineering, Kongju National University, Cheonan-Si, Republic of Korea.

[12]. J.-J. Sinou * Transient non-linear dynamic analysis of automotive disc brake squeal – On the need to consider both stability and non-linear analysis Laboratoire de Tribologie et Dynamique des Systémes UMR-CNRS 5513, Ecole Centrale de Lyon, 36 Avenue Guy de Collongue, 69134 Ecully Cedex, France

[13]. Guillaume Fritz a,b, Jean-Jacques Sinou b,*, Jean-Marc Duffal a, Louis Je´ze´quel b a Renault SAS, Direction de la Recherche, Effects of damping on brake squeal coalescence patterns – application on a finite element model Groupe Acoustique, October 2006.