Static Structural and Thermal Analysis of Brake Pads Design

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Abstract— In ensuring excellent brake performance, brake pad and disc design are essential factors. But environmental particles can easily reach and disrupt the braking process and decrease braking efficiency. Friction depends on the pad and the disc's geometry and surface properties. Passenger car disc brakes are safety-critical components whose output at the pad-to-rotor interface depends heavily on the contact conditions. It is possible to describe the pad-to-rotor interface as a conformal dry sliding contact. This thesis aims to present a study of automotive disc brake thermo-mechanical behaviour of brake pad of different design during the braking process using finite elemental disc and pad model analysis in Static Structural and Transient Thermal Analysis for a system of vehicle disc brake pads. Static and thermal analysis was carried out on solid discs and brake pad of different design using ANSYS 18 in this work.

Index Terms— Ansys, Brake Pad, Brake Pad Design, Catia, Friction Material, Non-Asbestos Material, Thermal Analysis.

1 INTRODUCTION

In order to be able to transport passengers and goods at higher speeds and higher capacity to achieve the required high performance, vehicles used in the transport industry are being built. This needs the absorption of more kinetic energy when vehicles are stopped or slowed down. Therefore, in a car, a brake system is required to stop and change a speed when changing street conditions and rush-hour traffic conditions. In order to slow down or break the motion of a vehicle, a brake is controlled with the aid of a caliper by which frictional resistance exists on a moving machine. For example, it is converted into heat energy & energy in abrasion breaking. It is renewed into electric energy or flattened air in regenerative breakage. Not all the kinetic energy is modified in to the appropriate method when doing a braking operation, for example in a friction break some energy force is vanished in a vibration procedure. There are two kinds of friction braking, namely disc brakes and drum brakes. Compared to drum brake, disc brake cools sooner due to wider cleared range & comparatively high air stream acquaintance & also displays self-cleaning ability due to centrifugal force. A brake pad consists of a back plate and a friction material that is firmly bound together by a certain bonding material. The friction material and the back plate are often referred to as a brake pad. The brake pad is the location where heat flux through friction material to the brake

disc is produced. The push rod that is attached to the lever or pedal and to the master cylinder piston pushes the master cylinder piston when a brake lever or pedal is pressed. This movement makes it possible for the master cylinder piston to slip and drive the return spring within the master cylinder bore, which creates reservoir tank pressure. A primary seal at this time enables the reservoir tank brake fluid to flow through the brake hosepipes over it. A secondary seal guarantees that no other side of the brake fluid is transferred. Then, through brake hosepipes, the fluid reaches the cylinder bore of the caliper assembly and moves the caliper piston or pistons. The piston ring shifts at this moment with the piston in rolling form. Then the brake pad is pressed by the caliper piston. This motion allows the brake pads to stick to the brake disk, which produces friction and prevents the rotation of the brake disc/rotor. The disk brake system prevents or slows down the vehicle in this way.

2 METHODOLOGY

In a disc brake, the brake absorbs the vehicle's kinetic energy as a pad is pressurized against a disc and it is transformed into heat that is mostly absorbed by the disc and brake pad. This heat is distributed into the atmosphere. There is a rise in temperature due to a change in frictional heat on the plate & pad interface. At a point when this temperature exceeds a basic estimate of a given material, it causes catastrophic occasions, such as brake failure, premature wear, thermal crack. In addition, global deformation occurs in the disk & pad due to heat at the interface of the disc pad. Coning & buckling are some standard distortions.

The key research approach used in this project is finite element model-

ling. The finite element models will be rendered on a step-by-step basis, beginning with the fundamental analysis of basic assumptions and model simplification. In the meantime, the model is prepared on the basis of the assumptions posed in the literature survey in the CATIA3.0 program. Because in this project there are eight key research goals, the research goals are met by different methods, including the fundamental analysis, the 2D and the 3D model. The model is then implemented in ANSYS for analysis software, where it is introduced with simple structural and thermo-mechanical analysis theories. In thermo-mechanical analysis, simple equations such as heat transfer equations, frictional heat flux and convection have been introduced. Including material selection, contact surface specification, meshing strategies, loading, boundary conditions, analysis settings and required solutions, the basic settings of the models have also been implemented. There are final outcomes and debates, along with assumptions and prospective scope.

Following point briefly explain the methodology approach:

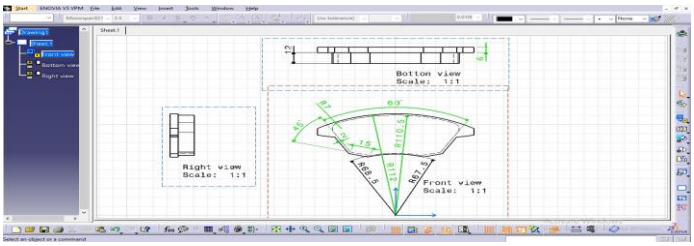
1. Literature Review
2. Modelling of disc brake arrangement
3. Static structural & transient thermal analysis in ANSYS workbench
4. Result and discussion

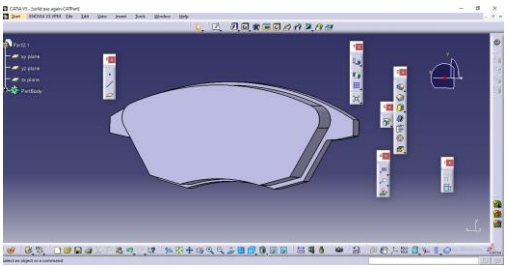
3 Design and Modelling of Brake Pad

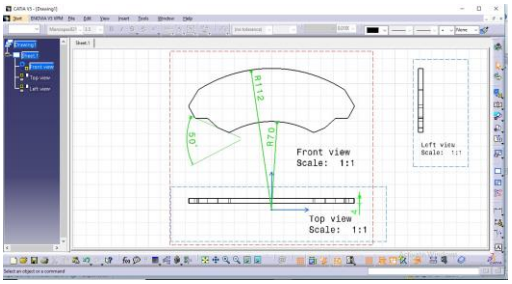
With the advent of new technologies in the automotive industry, cars have turned out to be increasingly successful. As a significant protection device, the brake constantly excites engineers with exceptional enthusiasm. In addition, competition in the automotive industry is growing steadily, placing weight on the efficiency, quality and cost development time of each single vehicle framework. For a designer, the goal is to find the best combination of security, creativity and financial requirements. In conducting warm investigation on a brake lining, the finite element (FE) technique has become a preferred strategy that usually uses a finite component technique to perform thermal analysis. A finite component technique demonstrated is both savvy & efficient, making it appropriate for thermal investigation particularly affectability on disc brakes as this strategy shows clear outcomes on impact of various mechanical properties at a disc & rubbing pad surfaces.

3.1 Part design of brake pads

In the present study, we studied various geometries on the basis of different combinations of strong & ventilated or cross-drilled disc brake pads. So the following are the various geometries of brake pads based on our research.







The purpose of the back plate is to keep inside it a friction material. When one pushes a stop, the Back Plate often acts as a position where the pressure intensity of fluid oil is taken. Steel is usually a material for aback plate. The thickness of 4 mm is used for the back plate in this research paper. A 2 mm fillet is supplied at the edges of a chamfer.

4 Ansys

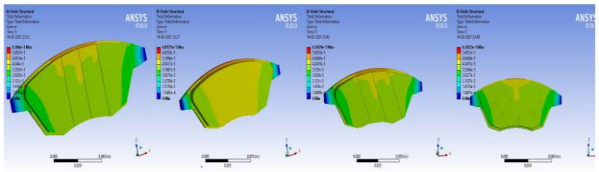
The ANSYS programming group is all about useful finite element evaluation (FEA). ANSYS 15 is used entirely in brake applications to recreate assistant deformation, temperature, stress and pressure distribution. The brand knows situations that handle a direct part of these parts and understands them all; offering a complete description of how a system normally goes about. These findings are seen in the ordered structure. ANSYS 15 is used to evaluate this work.

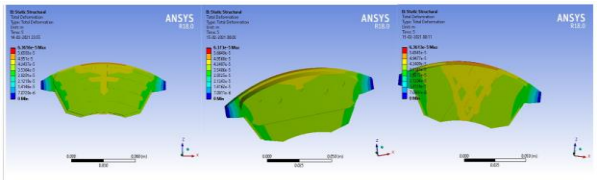
Analysis in ANSYS workbench follows three steps as:

- Pre-Processing.
- Solution.
- Post-Processing

Due to the sliding frictional contact between the disc pad models, ANSYS allows the determination and conception of structural deformation and von mise stresses. The results of the contact calculations described in this section are related to the total deformations during loading, the stress generated by Elastic Strain on the disc and the equivalent stress

generated on the pad.

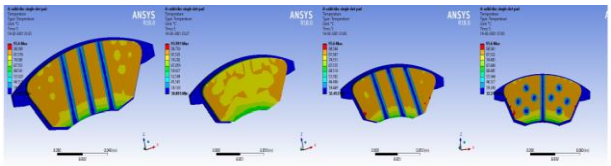


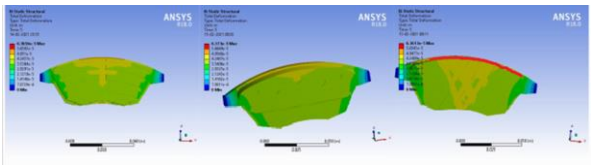


PAD	TOTAL DEFOR-MATION(µm)
1	63.66
2	68.12
3	63.62
4	63.62
5	63.65
6	63.73
7	63.61

4.1 DISC PAD MODEL WITH THERMAL EFFECTS

When we couple both static and transient analysis, the current section deals with the disc brake model. Basically, when stresses are placed and up to what temperature it gains and how the temperature distribution occurs along the profile, we get model behaviour information.





PAD	Max. temperature(c)	Min. temperature(c)
1	95.6	32.49
2	95.99	30.895
3	95.6	32.453
4	95.6	32.2
5	98.271	18.3
6	95.682	10.05
7	111.89	21.673

5 CONCLUSION

Studies in static structural and transient thermal analysis of the disc brake pad model using mechanical and thermo-mechanical approaches were attempted in the thesis work. In order to increase the braking performance and to provide good stability to the vehicle in the design stage, deformation, elastic strain and temperature distribution of the brake pads model have been carried out. In current research, two techniques, namely mechanical and thermo-mechanical analysis, have been used to analyze a brake pad model.

From the results it can deducted that:

- Max. deformation occurs on the brake pad-2
- Max. elastic strain occurs on the brake pad-2
- Max. temperature occurs on the brake pad-7 and min. temperature occurs on the brake pad-6
- Max. temperature distribution occurs at the outer radius of brake pad-7

6. REFERENCES

1. A. Rashid, **Overview of Disc Brakes and Related Phenomenon** – a review, *International Journal of Vehicle Noise and Vibration*, 2014,10(4).

2. K. Lee**, Numerical Prediction of Brake Fluid Temperature Rise During Braking and Heat Soaking**, *The Society of Automotive Engineer Technical Paper*, 1999.

3. A. Belhocine, M. Bouchetara, N.M. Ghazali, O.I. Abdullah, **Structural and Contact Analysis of a 3-Dimensional Disc-Pad Model With and Without Thermal Effects,** *Turkish Journal of Engineering, Science and Technology*,2014,(04).

4. K.N. Kumar, B.N. Raju, M.R. Roy, **Static and Thermal Analysis of Disc Brake With Pad** , *International Journal of Engineering Trends and Technology,2015, 23(8).*

5. V. Parab, K. Naik, A.D. Dhale, **Structural and Thermal**

Analysis of Brake Disc,

International Journal of Engineering Development and Re

search,2014,2(2).

6. V.C. Reddy, M.G. Reddy, G.H. Gowd, **Modelling and Analysis of FSAE Car Disc Brake Using FEM**, *International Journal of Emerging Technology and Advanced Engineering*,2013,3(9).

7. R. Jaiswal, A.R. Jha, A. Karki, D. Das, P. Jaiswal, S. Rajgadia, **Structural and Thermal Analysis of Disc Brake Using Solidworks and Ansys,** International Journal of Mechanical Engineering and Technology,2016,7(1).

8. A. Belhocine, M. Bouchetara, **Simulation of Fully Coupled Thermomechanical Analysis of Automotive Brake Discs**, *Transactions of the Society for Modelling and Simulation International*,2014,88(8).

9. M. Patel, J. Raval, J. Patel, **Design of Disc Brake's Rotor,** *International Journal of Engineering Development and Research*,2.16,4(4).

10. F. Talati and S. Jalalifer, **Analysis of Heat Conduction in a Disc Brake System**, *Springer*, 2009,45(12).