

Comparative Study of Conventional and Modified Disc Brake on the basis of Steady State Thermal Analysis

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Abstract

An automotive disc brake is a device which creates resistance to the motion of wheel under running conditions. The basic function of disc brake is to stop or slow down the motion of wheel by applying frictional force through caliper assembly. During this process kinetic energy converts in heat energy and dissipate into surrounding atmosphere. The conversion of energy results in speed retardation, and brings the vehicle in steady state. The heat dissipation properties during actuation have significant impact on the brake performance. During operation the high stresses are built up, results in wear and fading. The performance parameters can be improved by considering thermal characteristics of disc brake materials. The objective of this study is to investigate, under extreme working conditions, the thermo chemical behavior of different brake rotors in order to evaluate their efficiency and stability, also to identify any compromising weakness on them. In this paper the investigation is done by considering different material used for brake disc manufacturing and the thermal behavior of the same in loading condition analysis of different shapes with different material of disc rotor.

Keywords: Analysis, brake, disc, heat, thermal

INTRODUCTION

Disc brake is one of the types of brake which uses calipers to push the stationary

pads to hold the rotating disc produce a friction. The retardation of the vehicle is obtained by applying the pressure on the

disc & caliper assembly which is attached to the wheel or axle. There is conversion of the kinetic energy of the vehicle to the heat energy which is then dissipated to the surrounding in the form of heat. [1]. A brake is a contact mechanical device for changing over the momentum or kinetic energy of the moving vehicle into heat by method for rubbing. It is obliged to stop or ease off the vehicle in the briefest conceivable separation when needed to do so. [2] When hydraulic pressure is applied to the caliper piston, the pressure tends to exert a force on the caliper which results in squeezing the disc between two friction surfaces of the disc. Since disc brakes do not use friction between the lining and rotor to increase braking power as drum brakes do, they are less likely to cause a pull. As most of the portion of the disc brake is exposed to the surrounding, there is best heat dissipation rate which gives faster cooling of the disc brake disc. This phenomenon plays an important role in minimizing the brake fade. It also allows for self-cleaning as dust and water is thrown off, reducing friction difference. [3]

LITERATURE REVIEW

According to Praveena S Lavakumar, cast iron is suggested as the best material for the brake disc as it has low thermal

conductivity.[4] Venkatkumar R gurubaran in their “design and analysis of disc brake rotor stated that copper liners can be also used for making the brake disc rotor as it gives moderate cooling at low temperatures.[5] Ganesh P and Naresh C in “Finite element analysis of normal and vented disc rotor” stated that “Aluminum metal matrix is more beneficial for use as it is lighter in weight, better wear resistant and thermal conductivity”. They also come to conclusion that “Aluminum utilization for brake disc manufacturing can contribute to increase in acceleration and reduction in braking distance”. [6] Fig -1: Disc brake assembly mounted on front wheel. Hemraj nimhal et al. in their “Thermal analysis of disc brake using ANSYS software” stated that “use of non vented disc made up of ceramic material can be prove as best material for future because of its Mechanical and material properties.[7] Bhaskarasetupathi et al.in their “Numerical analysis of rotor disc for optimization of disc material” stated that Aluminum metal matrix is suitable for the manufacturing of the disc brake in mechanical strength and thermal strength with the condition that the tribological characteristics should be suitable .[8] Subhasissarkar and Dr.PravinRathod in “modeling and simulation of disc brake to analyze the temperature distribution using

FEA” stated that “Increase in vehicle speed, the temperature increases but the rate of heat generation with speed is less for AMMC as compared with Grey Cast iron. They also come to conclusion that “disc brake design plays an important role in heat transfer like vent hole size, vane thickness etc. [9] A. Belhocineet al. in “Thermal analysis of both ventilated and full brake disc rotors with frictional heat generation” concluded that the radial ventilation plays a vital important role in the cooling of the disc during the braking phase.

CALCULATION FOR HEAT FLUX

In the experimental investigation conducted on the disc brake, we have prepared 3 different profiles and the profiles were made up of three different materials namely stainless steel 410, Cast iron and aluminum. The boundary condition is that the vehicle has a loaded weight of 300kg and it runs with a maximum speed of 100 Kmph.

- Mass of the vehicle: 100kg.
- Maximum speed of vehicle: 100kmph.
- Kinetic energy of the vehicle: $0.5mv^2$
- Rotor disc diameter in meter: 0.241m
- Permissible temperature in Celsius: 2500 C.
- Pressure applied on the brake pads: 1Mpa.
- Tangential force acting on the disc: 2835.20 N.
- Stopping distance for the vehicle: 40.823 meters.
- Generated heat flux for above condition for stainless steel 410: 23148.14 watt/m².
- Heat flux for disc profile made up of cast iron: 16724 watt/m².
- Heat flux for profile III: 11342 watt/m².
- The calculation for the heat flux is done by the relations given in the brake design and safety by Rudolf Limpert. All the heat flux values are applied to the models in ANSYS 15.0. The models are created in Creo parametric and the analysis is performed in ANSYS.

COMPARISON

Steady State Thermal Analysis

To express the heat transfer in the disc brake model, thermal boundary conditions and initial condition have to be defined. As shown in Figure, at the interface between the disc and brake pads, heat is generated due to sliding friction, which is shown as dashed lines. In the exposed region of the disc and brake pads, it is assumed that heat

is exchanged with the environment through convection. Therefore; the convection surface boundary condition is applied there. On the surface of the back plate, adiabatic or insulated surface boundary condition is used as presented in Figure. The vehicle speed decreases linearly with respect to time where the variation of heat flux during the simulation is represented in Fig.

1. Thermal Boundary Conditions

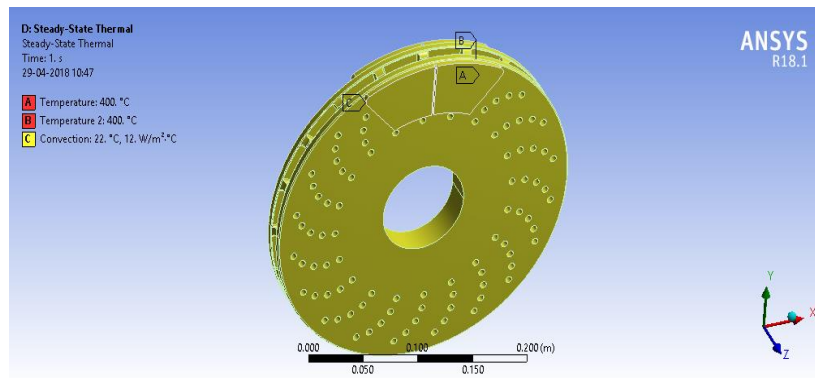


Fig1: Boundaries Conditions for conventional disk break

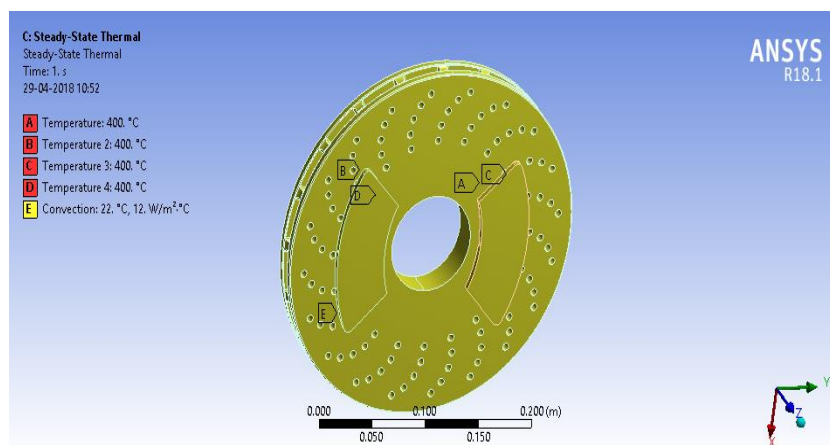


Fig 2: Boundaries Conditions for Modify disk break

Result: Temperature and Heat Flux

Temperature distribution over disk break:-

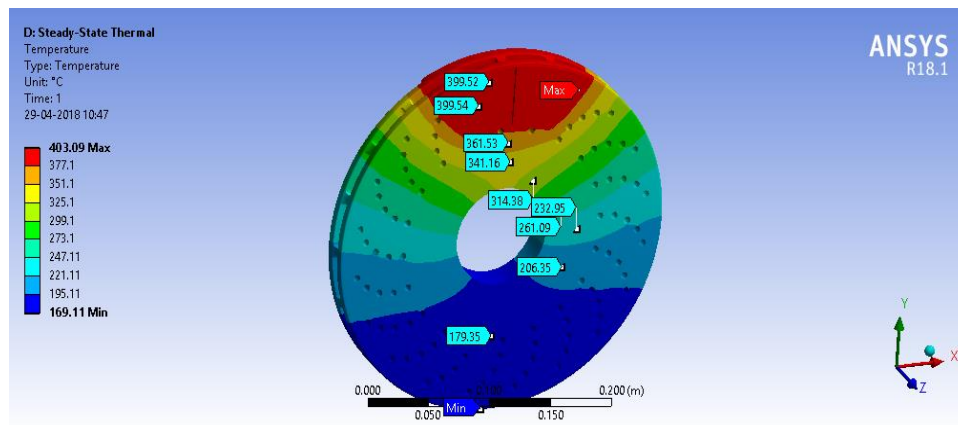


Fig:3 Temperature distribution on Conventional disk break

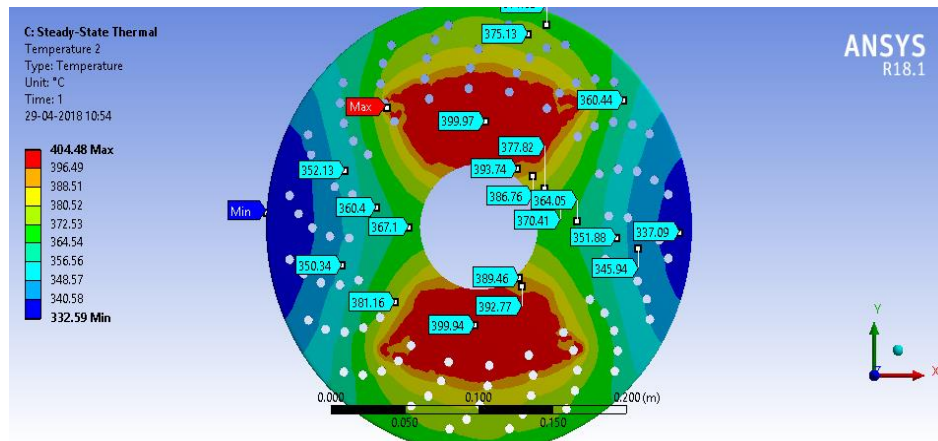


Fig: 4 Temperature distributions on Modify disk break

Heat Flux on Disk break

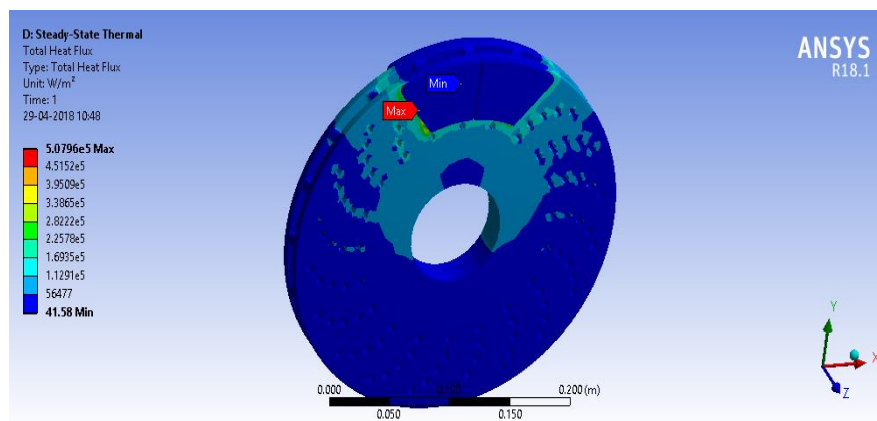


Fig:5 Heat Flux on Conventional Disk Break

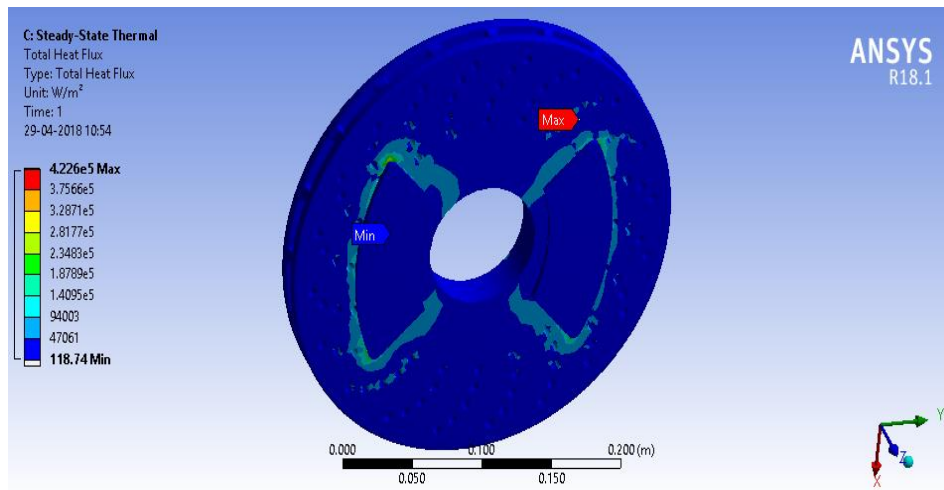


Fig: 6 Heat Flux on Modify Disk Break

Comparison table for Thermal Analysis

Disk break Type	Temperature (Degree Cel.)	Heat Flux (W/m ²)
Convectional Disk Break	169.11	5.07 e +07
Modifying Disk break	332.59	4.2 e +05

Boundary Condition for both Disk break:-

Temperature at frictional surface: - 400 Degree Cel.

Convection: - 22 Degree, 12 W/m². C

CONCLUSION

In this work, a disc-pad model has been analyzed using two approaches, namely mechanical and thermo mechanical analysis. In addition to this, three pad designs are also simulated to identify its influence on the stress distribution. From the prediction results it can be deduced that

- Large deformations are occurred at the outer radius of the disc.
- The presence of grooves in the pads influences
- Unfavorably the mechanical behavior of a brake.

- More uniform stress distribution is noticed for the pad without groove and with a double-piston loading
- Temperature has a significant effect on the structure and contact behavior of the disc brake assembly.
- Large deformation and high contact pressure is found in the disc-pad model with the thermal effect.
- The smoothness of the mesh increases the precision of the solution. The results obtained for the numerical calculation are comparable with those which one finds in the specialized literature.

REFERENCES

- I. Swapnil R. Abhang, D.P Bhaskar, International journal of engineering trends and technology (IJETT), "Design analysis of disc brake", Volume 8 Number 4-Feb 2014.
- II. Telang AK*1, Rehman A2, Dixit G3, Das S4, Journal Of Engineering Research and Studies, "Alternate material in automobile brake disc application with emphasis on all composites" JERS/Vol. I/Issue I/July-Sept. 2010/35-46.
- III. Rakesh Jaiswal, Anupam Raj Jha, Anush Karki, Debayan Das, Pawan Jaiswal, Saurav Rajgadga, and Ankit Basnet, International Journal Of Mechanical Engineering and Technology (IJMET), "Structural and thermal analysis of disc brake using Solidworks and ANSYS", Volume 7, Issue 1 Jan-Feb 2016, pp. 67-77, Article ID: IJMET_07_01_008.
- IV. C. Baron, T. Ingrassia, V. Nigrelli, V. Ricotta, Università degli Studi di Palermo, Dipartimento di Ingegneria Chimica, Gestionale, Informatica, Meccanica – 90128 Palermo, Italy "Thermal stress analysis of different full and ventilated disc brake", 34 (2015) 608-621; DOI: 10.3221/IGF-ESIS.34.67.
- V. Benjamin Paulik, Krauss GmbH Haugweg 24 D-71711 Murr, "Temperature measurement applied in Krauss friction tester and Dynos", 07.07.2015.

- VI. M.A Maleque¹, S. Dyuti² and
M.M Rahman (Member, IAENG)³,
Proceedings of the World Congress
on Engineering , “Material
selection method in design of
automotive brake disc”, 2010 Vol
III WCE 2010, June 30 - July 2,
2010, London, U.K.

- VII. Aleksander Grkic, Davorin Mikluc,
Slavko Muzdeka, Zivan Arsenic,
Cedomir Duboka, “A model for
the estimation of disc brake
interface”,.

- VIII. Mr. Pravin N. Jawariker, Dr.
Subhim N. Khan, Mr. Balaji D.
Kshirsagar, International Journal of
Innovative Research in Science and
Engineering, “Structural
optimization, thermal and vibration
analysis of two wheeler disc brake
rotor”, Vol. No.2, Issue 08, August
2016.

- IX. P. S. Ghoshdastidar, second edition
(Professor Department of
Mechanical Engineering, IIT
Kanpur), Oxford University press
2012.