Comparative study and performance analysis of automotive braking system

A Nagarajan
Research Scholar, Department of Mechanical Engineering,
Maharishi University of Information technology Lucknow, India
Dr Aditya chauhan
Department of Machanical Engineering
Maharishi University of Information technology
Lucknow, India

Abstract - The current breaking system of automobile is analyzed in this paper. In the automobile field braking system is one of the most important think. The braking system needs good functioning and maintenance. In order to increase the efficiency, the disk brake is alternate for the drum brake. In this analysis various materials are used for both drum and disk brake. A hydraulic line to the caliper is used by brake fluid. In the Brake rotor brake pads are fitted. The axial of the vehicle had rim with tyre setup for brake attachment. The brake rotor material is efficiency and corrosion varies. The disk rotor is analyzed by new materials and the results are compared with existing material.

Keywords - Braking system, disk rotor, Material optimization, drum brake, Brake pads.

1. Introduction

A disc brake in the braking system is required to reduces rotation of the wheel by pushing the pad against the rotor. The brake disc 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 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. Friction causes the disc and attached wheel to slow or stop. Brakes convert motion to heat, and if the brakes get too hot, they become less effective, a phenomenon known as brake fade.

Disc brakes are widely used on cars because of their better heat dissipation ability; a direct result of the exposed friction surface. The friction surface of a drum brake is inside and heat dissipation relies upon heat being conducted through the drum so car

manufacturers fit drum brakes only on the rear axle of "low" performance cars.

Additionally a drum brake provides a very effective parking brake. In commercial vehicles, drum brakes are still widely used across the world, being robust, durable and easy to maintain but in Europe most heavy goods vehicles now use disc brakes. Furthermore, the performance requirement is not just for one isolated brake application, but for a series of high deceleration brake applications which form the part of the performance assessment known as the „fade" test.

So, the front brakes of a typical passenger car have to be designed to provide large amounts of braking torque, and withstand large amounts of heat generated, heat transfer, high temperatures and thermal loading. Ameer FareedBasha [1] et al, studied about the model of a disc brake used in Honda Civic. Coupled field analysis (Structural+Thermal) is done on the disc brake. The materials used are Cast Iron. Analysis is also done by changing the design of disc brake. Actual disc brake has no holes; design is changed by giving holes in the disc brake for more heat dissipation.fluid through the hoses and into the caliper where the pads are pushed onto the rotor, stopping the bike.

2. Present Theories and Practices

Following are the researchers who have worked in the area of a Disc Brake. Y. Yildiz and M. Duzgun [1] have studied on a stress analysis of ventilated brake discs using the finite Element method. In this study, three different ventilated brake discs, the cross drilled disc, the cross-slotted disc, and the cross-slotted with a side groove disc, were manufactured, and their braking force performances were investigated experimentally together with a solid disc. Stress analyses were subsequently performed by the finite element method. Analyses results showed that the maximum stress generations were formed on the ventilated discs in comparison to the solid disc.

However, these comparisons indicate that the application of varying force distributions along brake pads reduces the stresses on ventilated discs by 8.8% to 19.1%. MesutDuzgun [2] has studied Investigation of thermo-structural behaviors of different

ventilation applications on brake discs.

In this study, the thermal behaviors of ventilated brake discs using three different configurations were investigated at continuous brake conditions in terms of heat generation and thermal stresses with finite element analysis. The results were compared with a solid disc. Heat generation on solid brake discs reduced to a maximum of 24% with ventilation applications. The experimental study indicated finite element temperature analysis results in the range between 1.13% and 10.87%. However, thermal stress formations were higher with ventilated brake discs in comparison to those with solid discs.

M. Pevec et al [3] have studied prediction of the cooling factors of a vehicle brake Disc and its influence on the results of a thermal numerical simulation. In this study the common method that is used for predicting the temperatures in the brake disc during braking is numerical simulation analysis. With the help of Computational Fluid Dynamics, the flow through a vehicle ventilated brake disc of known geometry was determined, and the wall heat transfer coefficients for all vehicle speeds and brake disc temperatures were calculated. The results were then imported into a thermal numerical simulation of a sequential braking vehicle test.

The results showed Shivaji et al., International Journal of Advanced Engineering Research and Studies E- ISSN2249–8974 Int. J. Adv. Engg. Res. Studies/III/III/April-June,2014/25-27 that the consideration of cooling factors has a significant impact on temperature courses. Sung Pil Jung et al [4] have studied Thermal Characteristic Analysis and Shape Optimization of a Ventilated Disc. In this study, an analysis technique that can estimate the temperature rise and thermal deformation of the ventilated disc considering vehicle information, braking condition and properties of the disc and pad is developed.

The analytical process of the braking power generation during braking is mathematically derived. The thermal energy that is applied to the surface of a disc as heat flux is calculated when a vehicle is decelerating from 130 km/h to 0 km/h with deceleration of 0.4 g.

Then, the temperature rise and thermal deformation of a disc are calculated. The shape of the cross section of the disc is optimized according to the response surface analysis method in order to minimize the temperature rise and thermal deformation.

Pyung Hwang and XuanWu [5] have studied Investigation of temperature and thermal stress in ventilated disc brake based on 3D thermo-mechanical coupling model. In this study, object of the present study is to investigate the temperature and thermal stress in the ventilated disc-pad brake during single brake. The brake disc is decelerated at the initial speed with constant acceleration, until the disc comes to a stop.

The ventilated pad-disc brake assembly is built by a 3D model with a thermo-mechanical coupling boundary condition and multi-body model technique. Ali Belhocine and MostefaBouchetara [6] have studied Thermal analysis of a solid brake disc. The objective of this study is to analyze the thermal behavior of the full and ventilated brake discs of the vehicles using computing code ANSYS. The modeling of the temperature distribution in the disc brake is used to identify all the factors and the entering parameters concerned at the time of the braking operation such as the type of braking, the geometric design of the disc and the used material.

The results obtained by the simulation are satisfactory compared with those of the specialized literature. Jaeyoung Kang [7] has studied Squeal analysis of gyroscopic disc brake system based on finite element method. In this paper, the dynamic instability of a car brake system with a rotating disc in contact with two stationary pads is studied. For actual geometric approximation, the disc is modeled as a hat-disc shape structure by the finite element method.

From a coordinate transformation between the reference and moving coordinate systems, the contact kinematics between the disc and pads is described. The corresponding gyroscopic matrix of the disc is constructed by introducing the uniform planar-mesh method. The dynamic instability of a gyroscopic nonconservative brake system is numerically predicted with respect to system parameters.

The results show that the squeal propensity for rotation speed depends on the vibration modes participating in squeal modes. Moreover, it is highlighted that the negative slope of friction coefficient takes an important role in generating squeal in the in-plane torsion mode of the disc. Sung Pil Jung et al. [8] have studied ThermoMechanical Finite Element Analysis of Hot Judder Phenomenon of a Ventilated Disc Brake System. In this paper hot judder characteristics of a ventilated disc brake system are discussed. Three dimensional finite element models of the ventilated disc, pads and pistons are created, and a fully coupled thermomechanical analysis of the hot judder phenomenon of the disc brake system is performed using SAMCEF.

The brake dynamo test is carried out according to the high speed judder test mode. The evolution of the temperature distribution on the disc surface is described, and the hot spot generation process is investigated. The simulation results such as the maximum disc temperature, BTV are compared to the data from the dynamo test, and the reliabilities of the analysis technique and simulation model presented in this paper are verified. Sung-Soo Kang, and Seong-Keun Cho [9] have studied Thermal deformation and stress analysis of disk brakes by finite element method.

In this paper order to analyze the thermal characteristics of disk brakes, thermal deformation analysis and thermal stress analysis due to heat transfer was carried out through the finite element analysis for ventilated disk and solid disk. By comparing the maximum temperature in the braking process, the ventilated disk showed a lower temperature than the solid disk and effect of temperature increase and decrease, depending on the vent area generated in the flange part of the disk.

The thermal deformation in ventilated disk type occurs in all directions by 0.1162 mm, thermal distribution in the circumferential direction showed large deviation, about 0.017 mm due to the vents. Byeong- choon Goo and Choong-hwan Lim [10] have studied Thermal fatigue of cast iron brake disk materials. In this paper to develop cast-iron brake disks with high heat resistance to thermal shock loading, three candidate materials

were developed.

The main components were Fe, C, Si, Mn, Ni, Cr, Mo, Cu and Al. The mechanical and thermal properties of the candidates were measured. After doing the above literature survey it is decided that dissertation work is to develop for weight optimization of disc and to increase cooling effect with compared to the existing disc. For that it is necessary to carry analysis of the existing disc and make the modifications or select the new design for further weight reduction and increased cooling effect.

3. Properties of Existing Material

Material	Cast iron
Density	7100
Young modulus	125
Poison ratio	0.25
Thermal conductivity	54.5W/M-K
Specific heat	586 J/Kg-K

4. Objectives

At the present time, the disc brake used in most of the vehicles is made up of cast iron. The various methods of optimization of other material and their properties analysis is survived clearly,the efficiency of normal cast iron with material optimized is studied and proposed.

5. Specifications Of Standard Disc BrakeRotor:

In this project study standard Disk rotor

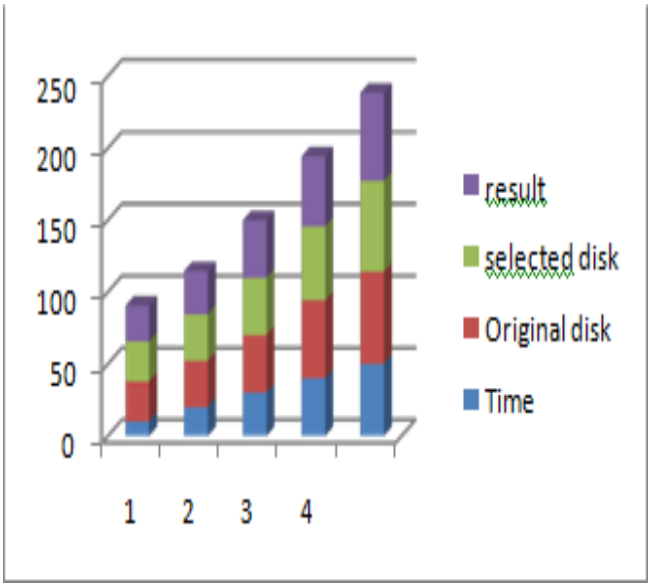
Rotor disc dimension	240 mm
Rotor disc material	Gray cast iron
Rotor thickness	10 mm
Pad brake area	2000 mm2
Pad brake material	Asbestos
Coefficient of friction	0.08-0.12
Coefficient of friction	0.2-0.5
Maximum temperature	250 ºC

6. Physical Fabrication:

Inputs for temperature would be derived through experimentation. Thermocouples would be used at the prescribed location/s for recording the temperature (T1). The experiment would be conducted as per the operating condition of the application. (predetermined speed of the vehicle). The setup for experiment could be developed in a Lab or could be attempted over the actual application (concerned vehicle).the temperature could be recorded directly over the application or over the representative Test Setup developed for this exercise.Upon recommendation by alternative methodology (F.E.Modeling), the revised disk geometry to be tested for verification of the results. This temperature (T2) achieved should be lesser than the benchmark (existing) application i.e. T2 < T1.

Thermal Analysis Study

s.no	Time in min	Temp (max) [°C] ANSYS result Original	Temp (max) [°C] ANSYS result Selected	Temp (max) [°C] Experimental Result Selected Disc
1	10	27.908	27.585	25.02
2	20	32.26	32.15	30.25
3	30	40.154	39.537	40.21
4	40	54.257	51.024	48.84
5	50	64.124	62.968	61.37



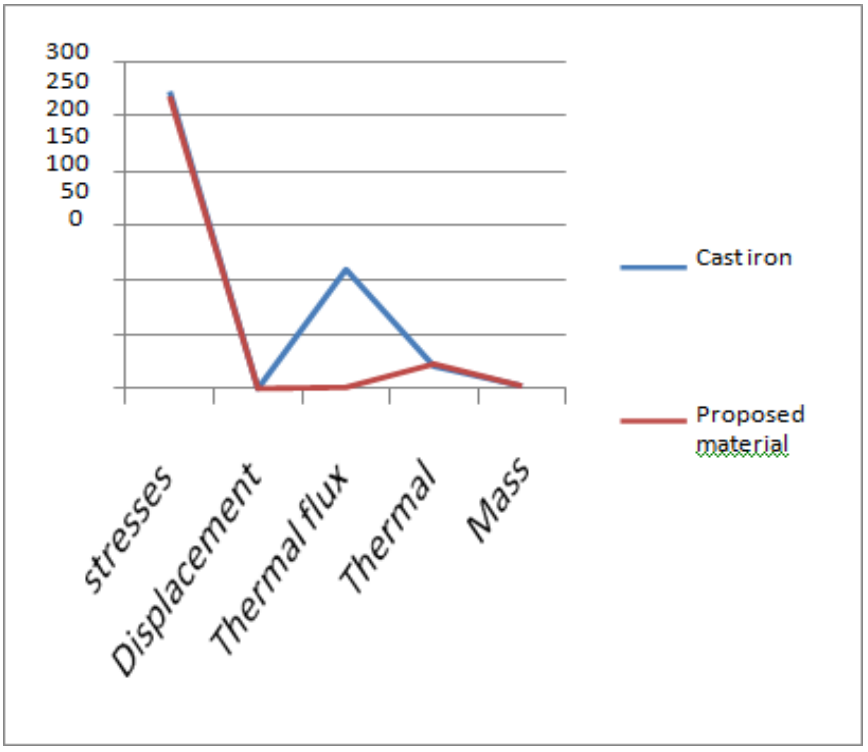
7. Scope of Work:

The scope of this work would be the study of the following areas:

- Determining (using Testing), the „Thermal dissipation" of the existing disk break application.
- Using the inputs from experiment, to develop 3d .Model for the application
- Suggest Design alternative for heat dissipation.

8. Results Comparison

Parameter	Existing model	Proposed model
Von misses stresses	273.223	268.25
Displacement vector sum	0.26429	0.158
Thermal flux vector sum	109.403	110.251
Thermal	20.739	22.54
Mass	2.7904kg	2.587



9. Conclusion

The disk rotor is analyzed by new materials and the results are compared with existing material by using ANSYS software. The existing material has von misses stress 273.223 N/m2, mass 2.7904 kg, but present material has more than the existing material. The existing material has Displacement vector sum 0.26429 m and thermal 20.739 but the present material has lower than the existing material. So the new proposed material is more suitable than the existing material.

The study and analysis of overcome disk brake is ploted.The modelling and analysis of coir fibre composite with comparison of existing material, fabrication of composite disk brake and Testing of material eill be reported as future work.

References

1. Daniel Das. A, Preethy.S, " Structural and Thermal Analysis of Disc Brake in Automobiles ", International Journal of Latest Trends in Engineering and Technology (IJLTET)- Vol. 2 Issue 3 May 2013.

2. Guru Murthy Nathi, T N Charyulu, K.Gowtham, P Satish Reddy, " Coupled Structual / Thermal Analysis Of Disc Brake",2012

3. N. Balasubramanyam, Smt. G. Prasanthi, "Design and Analysis of Disc Brake Rotor for a Two Wheeler", International Journal of Mechanical and Industrial Technology (IJMIT)- Vol. 1, Issue 1, pp: (7-12), Month: October 2013-March 2014.

4. Amit Telang, AmeenurRehman, Gajendra Dixit &Satyabrata Das, " Effect of reinforcement and heat treatment on the friction performance of Al Si alloy and brake pad pair ", Research paper- 2010 5. Zhang Jian Xia Changgao Research of the "Transient Temperature Field and Friction Properties on Disc Brakes" Y.Yildiz and

M.Duzgun,"Stress analysis of ventilated brake discs using the finite Element method", International Journal of Automotive Technology,Vol.11, No.1, (2010) pp.133−138.

5. MesutDuzgun,"Investigation of thermo-structural behaviors of different ventilation applications on brake discs", Journal of Mechanical Science and Technology,Vol.26 (1) (2012) pp.235-240.

6. M. Pevec, I. Potrc, G. Bombek and D. Vranesevic,"Prediction of the cooling factors of a vehicle brake Disc and its influence on the results Of a thermal numerical simulation", International Journal of Automotive Technology,Vol.13,No.5,(2012) pp.725−733.

7. Sung Pil Jung, Young Guk Kim and Tae Won Park,"A Study on Thermal Characteristic Analysis and Shape Optimization of a Ventilated Disc", International Journal Of Precision Engineering And Manufacturing,Vol.13, No.1(2012),pp.57-63.

8. Pyung Hwang and XuanWu,"Investigation of temperature and thermal stress in ventilated disc brake based on 3D thermo-mechanical coupling model", Journal of Mechanical Science and Technology,Vol.24 (2010) pp.81-84.

9. Ali Belhocine, MostefaBouchetara,"Thermal analysis of a solid brake disc", Journal of Applied Thermal Engineering, Vol.32 (2012),pp.59-67.

10. JaeyoungKang,"Squeal analysis of gyroscopic disc brake system based on finite element method", International Journal of Mechanical Sciences,Vol.51,No.7, (2009) pp.284-94.

11. Sung Pil Jung, Tae Won Park, Jang Bom Chai and Won Sun Chung,"Thermo-Mechanical Finite Element Analysis of Hot Judder Phenomenon of a Ventilated Disc Brake System", International Journal of Precision Engineering and Manufacturing, Vol.12, No.5,(2011) pp.821-828.

12. Sung-Soo Kang, and Seong-KeunCho,"Thermal deformation and stress analysis of disk brakes by finite element method",Journal of Mechanical Sciences and Technology, Vol.26(7),(2012) pp.2133-2137.

13. Byeongchoon Goo and Choong-hwanLim,"Thermal fatigue of cast iron brake disk materials", Journal of Mechanical Sciences and Technology, Vol.26(6),(2012) pp.1719-1724.