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FINITE ELEMENT ANALYSIS OF DISC BRAKES OF STEEL AND GARY CAST IRON FOR THERMAL EFFECTS

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Abstract

Brakes are used to stop or slow down the rotation of wheel. In this paper there is discussion regarding heat distribution on the disc brake during the phenomena of braking. Due to change from kinetic energy to mechanical energy heat is been distributed on the disc brake. The reason of Energy change during braking process is friction process due to the contact between the two surfaces that is the disc and disc plate. As a result of friction the temperature rises extremely high. The aim of this study is to perform finite element analysis of disc brake and analyze the thermal effect by inspecting heat flowing rate over the disc brake using 3-dimensional model. After the analysis it has been obtained that due to friction between disc pad and disc rotor the temperature rises. Obtained results are used for pinpointing the effect of heat flowing over the disc pad during braking process.

1. Introduction

The wheel brake due to friction reduces rotation which is caused by applying brake pads against disc of brake with help of calipers. Main composition of disc brake is structural wheel, but also in some cases its composition includes reinforced carbon-carbon or ceramic matrix composition. Brake caliper is a frictional material mounted on a device basically used to stop the wheel that is forced hydraulically, pneumatically or mechanically against sides of disc [1-3].

Disc brake is bolted to the wheel point and a static housing which is known as caliper. Further caliper is coupled to another static part of the

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vehicle similar to axle casing or stub axle which is cast into two different parts where each part contains a piston. Retainment pins and spring plates helps to hold frictional pad in position which is further held between each piston and the disc. For bleeding different passages are connected to each other. In between cylinder and pistons each cylinder consist of rubber sealing ring [4-5]. The main objective of paper is to perform comparison between the thermal effect of solid disc and ventilated brake by Finite Element Analysis.

2. Methodology

In the analysis the material of rotor disc is grey cast iron and stainless steel. In generally car accidental cases braking play a vital role in the critical issue. During Analysis heat flux or total heat rate examine for car which is moving with the velocity of 33.33m/s (120 km/ph) and the following is the calculation procedure :

- Mass of the vehicle : 610kg
- Initial Velocity (u) : 30.33m/s (120 km/hr)
- After applying brake to the vehicle speed (v) : 0m/s
- Rotor brake diameter : 215mm
- Axle weight distribution of 30% on each side (ϒ) = 0.3
- Amount of kinetic energy absorbed while braking in percent approximately (90%) $k = 0.9$
- Acceleration due to gravity = 9.81 m/s2
- Coefficient of friction for dry pavement $(\mu) = 0.7$

Disc brake generates heat due to friction between surface area contacts of brake pad. Law of conservation of energy and finite element methods are two methods which are used for calculation of heat theoretically and numerically.

For calculating the both side of the rubbing area for regular heat supplied Law of conservation of Energy is used where kinetic energy of vehicle during motion is equal to loss of heat after the vehicle stop. Finite Element method is used for solving numerical solution.

The material parameters and properties used in the calculation are shown in Table 1.

Table 1. Material Properties.

Material	grey cast iron	stainless steel
1. Mass type	7400(w/mk)	7200
2. Thermal conductivity	56	60
3. Specific heat (cv)	447(j/kg)	320
4. Thermal expansion	0.18	0.14
5. Modulus of elasticity	110(Gpa)	210
6. Coefficient of friction μ	0.5	0.5
7. Heat transfer coefficient	150	180
8. Angular velocity	80	80
9. Hydraulic press (Mpa)	1	1

3. Fem Model

In this paper the model of disc brake is developed for two types which are solid disc brake and ventilated disc brake. The material used is grey cast iron and the thickness of the edge of disc is varied to 60, 225 and 35mm. Figure 1 shows the two types of disc brake of thickness 225mm.

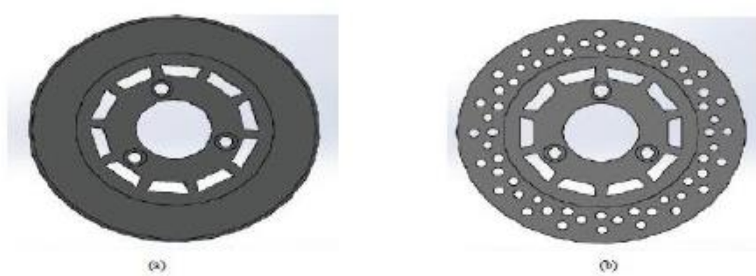


Figure 1. Finite element model for (a) the solid disc brake (b) ventilated disc brake.

For providing robust auto meshing is being done and. the model is divided into several different parts *A* meshed model is shown in figure 2. Tetrahedral 3-D elements with 8 nodes were used for the mesh of the model.

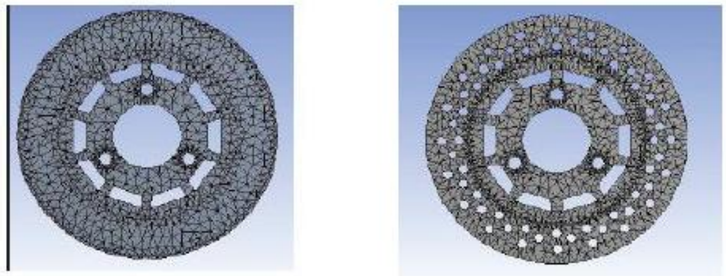


Figure 2. Meshed model for (a) the solid disc brake (b) ventilated disc brake.

Thermal Boundary Conditions

After selecting Simulation mode and physical features, initial condition of simulation of the material boundary conditions are applied. To investigate the temperature variation of temperature transient thermal analysis is conducted by applying the heat flux 0f 37.632 kW/m^2 for repeated braking. With the proof of thermal analysis included to convective heat transfer coefficient structural analysis is performed to the surface of ventilated disc shown in Figure 3.

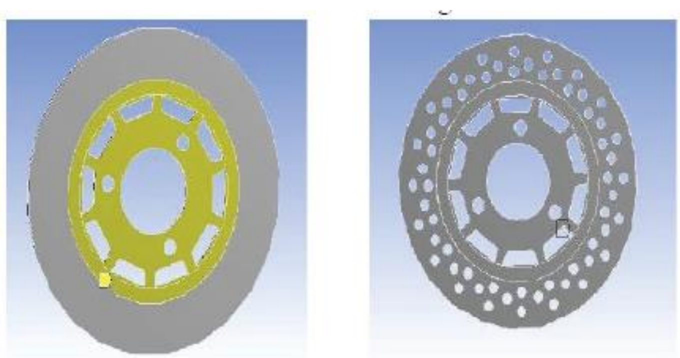


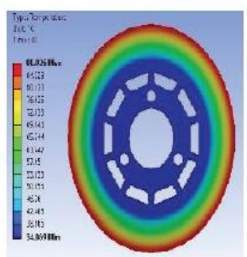
Figure 3. Thermal boundary condition for both type of brake (solid and ventilated).

4. Results and Discussion

Present model is validated by performing the behavior of transient thermal analysis of the disc brake on working condition with constant fluid pressure P =1 MPa and ω (angular velocity) = 50 Radian/sec. for time = 10sec. FEM simulations can be obtained in 6 repetitive brake applications. Each independent cycle is composed of 4 second braking time and constant speed driving. For computations time step of 0.001 sec was used. Heat flux is distributed in each process on frictional surface after interval of 6 seconds before it reaches rest position. The pressure of fluid was supposed to be reduces directly in one direction only and after 6 seconds it becomes zero. This observation was obtained from FEM solutions for transient thermal of model. On basis of performance of disc brake, analysis of ventilated radial vanes was carried out for cast iron material for the 6 braking conditions.

Temperature on the surface of brake disc made up of grey cast iron material rises. After applying brake temperature will rise from 34.8690C to 88.0260C. Also for the second type of brake that is ventilated type application temperature goes to 73.9590C. in the diagram as shown below the highest degree of temperature shown by red color. Increase in average temperature is shown in green color over the periphery of the disc as shown in Figure 4 and 5.

In Disc brakes which are made up of stainless steel, temperature start increases and varies 34.5290C to 293.100C. But for the ventilated disc brakes temperature reaches to 1690C. Representation of maximum increase in temperature and the average increase in temperature is in red and green color respectively on the surface of friction is shown in Figure 6 and 7.



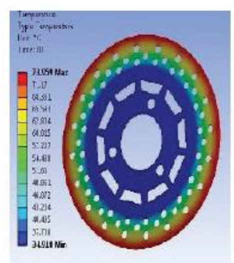


Figure 4. Temperatures of Solid Disc Brakes **Figure 5.** Temperatures of Vent Disc Brakes.

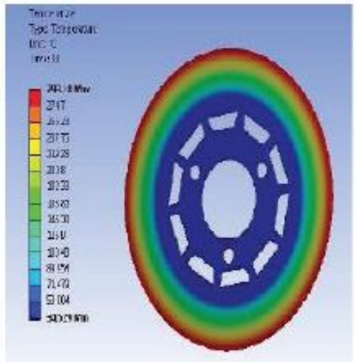
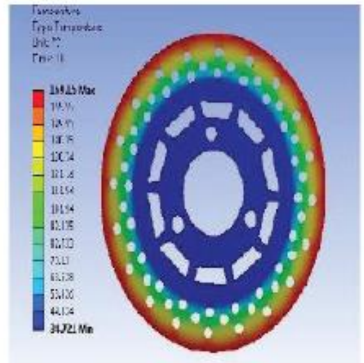
 

Figure 6. Temperatures variations in type 1. **Figure 7.** Temperatures variation in type 2.

Type 1 disc brake

Type 2 venti disc brake

5. Conclusion

Analysis Result shows that high temperature is generated grey cast iron and stainless steel solid disc brake that is 88.00C and 293.100C. But in case of ventilated disc brake the temperature generated in both of gray cast iron or stainless steel are as compare less i.e 73.90C and 1690C.from the above discussion and data analysis we should conclude that the gray iron material ventilated disc brake best the brake application.

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