

# Modeling and Analysis of a Disc Brake

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**Abstract:** *The disc brake is a device for slowing or stopping the rotation of a wheel. Disc brakes are exposed to large thermal stresses during routine braking and extraordinary thermal stresses during hard braking. The aim of the paper is to model a disc brake used in Honda Civic. Structural and Thermal analysis is done on the disc brake with three different materials. The materials used are Stainless Steel, Cast Iron and Aluminum Alloy. 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 to avoid brake fade. Modeling is done in Pro/Engineer and analysis is done in ANSYS.*

**Keywords:** Disc Brake, Pro/Engineer, ANSYS

## 1. Introduction

A brake is a device which inhibits motion. A brake disc, usually made of cast iron or ceramic is connected to the wheel or the axle. To stop the wheel, friction material in the form of brake pads is forced against both sides of the disc. Friction causes the disc and attached wheel to slow or stop. Brakes convert friction to heat, but if the brakes get too hot, they will cease to work because they cannot dissipate enough heat. This condition of failure is known as brake fade.

Brakes are generally applied to rotating axles or wheels, but may also take other forms such as the surface of a moving fluid (flaps deployed into water or air). Some vehicles use a combination of braking mechanisms, such as drag racing cars with both wheel brakes and a parachute, or airplanes with both wheel brakes and drag flaps raised into the air during landing.

Friction brakes on automobiles store braking heat in the drum brake or disc brake while braking then conduct it to the air gradually. When traveling downhill some vehicles can use their engines to brake. When the brake pedal is pushed the caliper containing piston pushes the pad towards the brake disc which slows the wheel down. On the brake drum it is similar as the cylinder pushes the brake shoes towards the drum which also slows the wheel down.

M.A. Maleque[1] have studied about the brake rotor material selection method and selected the optimum material for the application of brake disc system emphasizing on the substitution of this cast iron by any other lightweight material. The analysis led to AMC material and identified as an optimum material among the candidate materials for brake disc. This could be justifiable in this case as higher friction coefficient and lower density are advantageous from the technical and economical point of view for this type of application.

A. Belhocine, M. Bouchetara [2], analyzed the thermo mechanical behavior of the dry contact between the brake disc and pads during the braking phase. The simulation strategy is done in ANSYS11. The modeling of transient temperature in the disc is actually used to identify the factor

of geometric design of the disc to install the ventilation system in vehicles. The thermo-structural analysis is then used with coupling to determine the deformation established and the Von Mises stresses in the disc, the contact pressure distribution in pads.

K.Sowjanya, S.Suresh[3], dealt with the analysis of Disc Brake. Cast iron and Aluminum Metal Matrix Composite materials are selected and analyzed. Structural Analysis is done to determine the Deflection, Normal Stress, Vonmises stress

Guru Murthy Nathi et al. [4]. did work on Coupled Structural / Thermal Analysis of Disc Brake is to study and evaluate the performance under severe braking conditions and there by assist in disc rotor design and analysis. A transient thermal analysis has been carried out to investigate the temperature variation across the disc using axisymmetric elements. Further structural analysis is also carried out by coupling thermal analysis.

Hartsock[5] studied thermo-elastic phenomenon of disc brake rotor & pad occurring while braking and found thermo-elastic instability occurs due to torque variation during initial rotor run out because differences in rotor thickness or coefficient of friction. These pulsation brakes in sinusoidal components which show localized hot spot which are usually asymmetric. thermo-elastic instability will not occur below critical speed. It depends on rotor material, properties, thickness and coefficient of friction.

L. Segal [6] researched on considerable effect of temperature on brakes. In braking process brake rotor disc, brake shoe friction liner & support system heat considerably and found braking should not last longer than 10-15 seconds on test because brake element heats up to 80°C. At this higher temperature braking system & properties of brake material become worse.

Xiaojing Z [7] experimented on braking process. For test of braking system, stationary brake tester are used. The braking stand classified according to their sizes, braking force & other parameters. The result of test affects by friction coefficient, duration between repetitively application of brake while running & structure of stand also.

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**Modelling and Analysis of Disc Rotor without Cross Holes**

The material properties of Stainless steel, Cast Iron and Aluminum is shown in Table.1.

**Table 1: Material Properties**

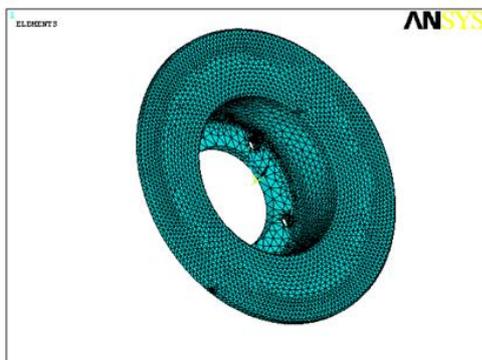
Material	Young's Modulus N/mm <sup>2</sup>	Poisson's Ratio	Density Kg/mm <sup>3</sup>	Thermal Conductivity W/mm/K	Specific Heat J/Kg/K
Stainless steel	200000	0.28	0.000007612	25	460.5
Cast Iron	103000	0.211	0.0000071	50	540
Aluminum	70000	0.33	0.0000028	113	963

Pro/E Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. The model of the disc brake is created in Pro/E as per the required dimensions without cross holes is as shown in the fig.1.



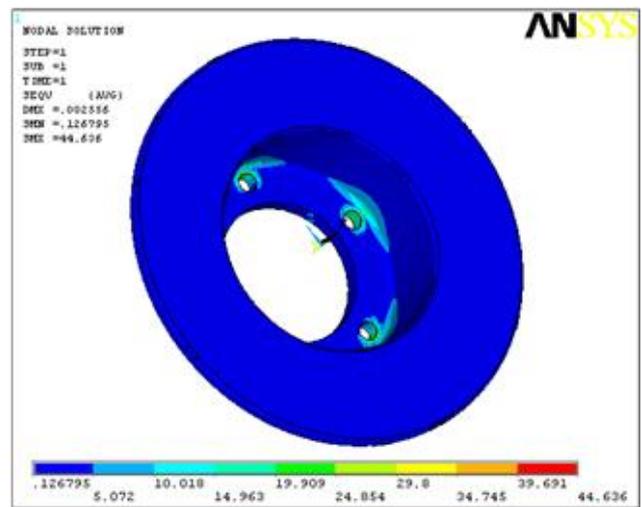
**Figure 1: Model of Disc Brake with Out Holes**

The model is imported in ANSYS . First stainless steel material properties is given. Element Solid186 element is selected for meshing. SOLID186 is a higher order 3-D 20-node solid element that exhibits quadratic displacement behavior. The element is defined by 20 nodes having three degrees of freedom per node: translations in the nodal x, y, and z directions. The element supports plasticity, hyperelasticity, creep, stress stiffening, large deflection, and large strain capabilities. The meshed model is as shown in the fig.2.



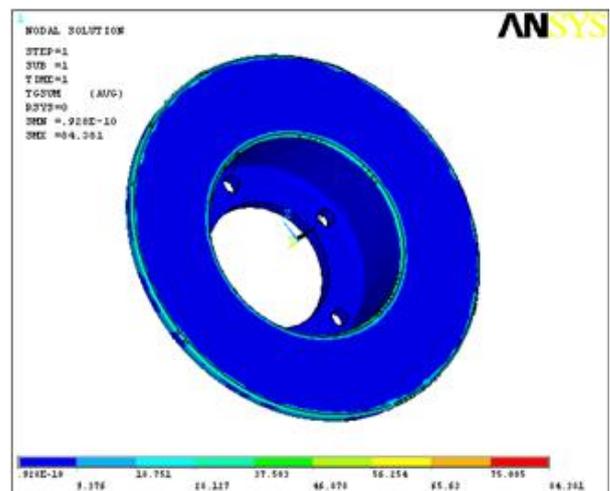
**Figure 2: Meshed model of Disc Brake With Out Holes**

Then static analysis is done by applying pressure of 1.2MPa. The von-mises stress induced in the material is found as 44.636 MPa as is shown in fig.3.



**Figure 3: Structural Analysis**

Then thermal analysis is done with boundary conditions heat flow 2KJ/s, with thermal convection on areas with bulk temperature 293K and heat coefficient 222W/mm<sup>2</sup>K. The thermal gradient is found as 84.381 K/mm is as shown in fig.4.



**Figure 4: Thermal Gradient Analysis**

The similar analysis is done for both cast iron and aluminum the results areas shown in the table.2

**Table 2: Von-mises stress and thermal gradient for three materials without cross holes**

	Von Mises Stress (N/mm <sup>2</sup> )	Thermal Gradient (K/mm)
Stainless Steel	44.636	84.381
Cast iron	46.254	98.891
Aluminum Alloy	43.338	118.733

**Modelling and Analysis of Disc Rotor with Cross Holes**

The model of the disc brake is created in Pro/E as per the required dimensions with cross holes is as shown in the fig.5.

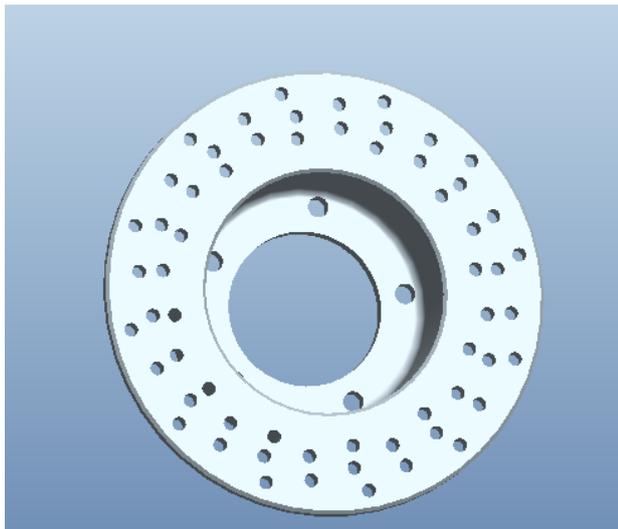


Figure 5: Model Of Disc Brake With Holes

The model is imported in ANSYS . First stainless steel material properties is given. Element Solid186 is selected for meshing. The meshed model is as shown in the fig.6.

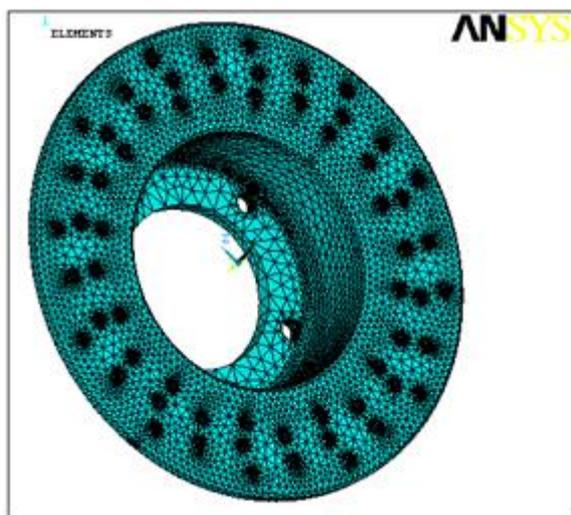


Figure 6: Meshed model of Disc Brake with Holes

Then static analysis is done by applying pressure of 1.2MPa. The von-mises stress induced in the material is found as 70.022 MPa.

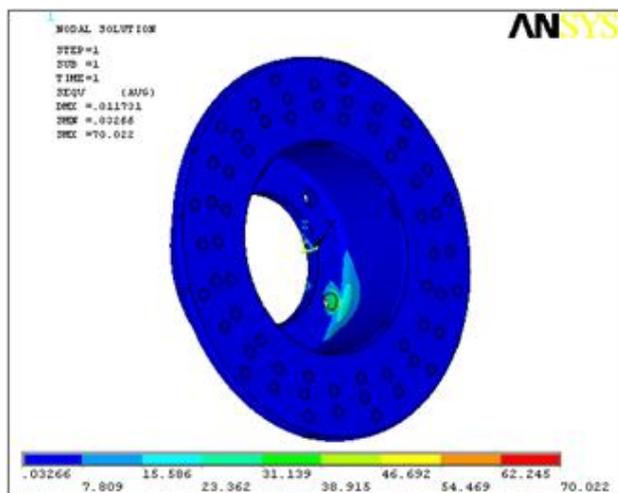


Figure 8: Von-mises stress of Disc Brake with Holes

Then thermal analysis is done with boundary conditions heat flow 2KJ/s, with thermal convection on areas with bulk temperature 293K and with film-coefficient 222W/mm<sup>2</sup>K. For stainless steel the thermal gradient is found as 99.803 K/mm is as shown in fig.9.

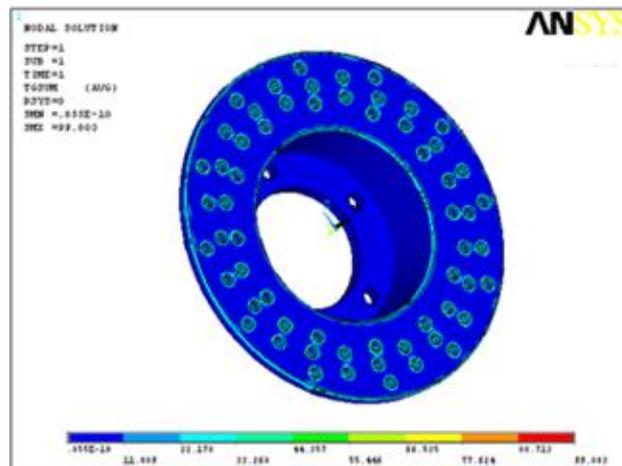


Figure 9: Thermal Analysis

The similar analysis is done for both cast iron and aluminum the results areas shown in the table.3.

Table 3: Von-mises stress and thermal gradient for three materials without cross holes

	Von Mises Stress (N/mm <sup>2</sup> )	Thermal Gradient (K/mm)
Stainless Steel	70.022	99.803
Cast iron	45.174	200.49
Aluminum Alloy	41.621	220.033

## 2. Conclusion

Structural and thermal analysis have been done on the disc brake with three materials stainless steel, cast iron and Aluminum alloy. It is observed during structural analysis that stress values of Aluminum alloy is less compared to Stainless steel and Cast iron. Thermal analysis depict that thermal gradient is more for Aluminum alloy. When the design of disc brake have been changed by adding holes, thermal gradient increased.

## References

- [1] M.A. Maleque, S. Dyuti and M.M. Rahman, ‘Material Selection Method in Design of Automotive Brake Disc’, Proceedings of the World Congress on Engineering 2010 Vol III, WCE 2010, June 30 - July 2, 2010, London
- [2] A.Belhocine, M.Bouchetara “Temperature and Thermal Stresses of Vehicles Gray Cast Brake” , Department of Mechanical Engineering, University of Sciences and Technology of Oran 2016.
- [3] K. Sowjanya, S. Suresh “Structural Analysis of Disc Brake Rotor” , International Journal of Computer Trends and Technology (IJCTT) – volume 4 Issue 7–July 2013.
- [4] Guru Murthy Nathi, T N Charyulu, K.Gowtham, P Satish Reddy “Coupled Structural Thermal Analysis of Disc Brake”, International Journal of Research in Engineering and Technology.

- [5] Hartsock, D.L. &Fash, J.W. (1999), —Effect of pad / caliper stiffness, rotor thickness on thermo-elastic instability in disc brakes, Journal of Tribology, Vol. 129, No 1, 513–517. International Engineering Research Journal Page No 288-300
- [6] L. Segal(1999), —Diagnostic method for vehicle brakes, Journal of NDT&E, International 32, Israel Institute of Technology, pp.369-373.
- [7] Xiaojing, Z., Dongsheng, W. (2011),The Theoretical Analysis of Test Results Error for roller type automobile Brake Tester,International Federation for Information Processing, Nanchang, China, Vol. No. 3, pp. 382 – 389. 891150, pp. 1138–1146.