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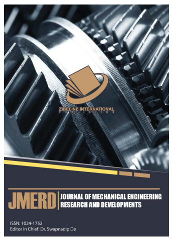

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MODELING AND ANALYSIS OF DISC BRAKE IN AUTOMOBILES

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ABSTRACT

Brake system is the one of the most significant components in modern automobiles. Its duty is reducing the speed of the vehicle and stops it. Disc brake changes the kinetic energy of rotating parts (wheels) to the heat and dissipated it to air. In this paper the disc brake is modeled and simulated with specific dimensions and analysis it with Finite Elements software (ANSYS R16.1). Two materials were chosen for the disc brake, the Grey Cast Iron and Carbon-Ceramic. Comparison can be done with temperature distribution, deformation and stress and choose the best material. The results showed the Carbon-Ceramic can withstand the thermal stress and approximately there is no deformation for it. Carbon-Ceramic is preferred for disc brake to achieve better performance.

KEYWORDS

Disc Brake, Grey Cast Iron, Carbon-Ceramic, ANSYS R16.1.

1. INTRODUCTION

Brake system is responsible of passengers' safety and it is the most important control system in modern cars. Brake system is required to halt the automobile within the smallest possible distance to avoid accidents. The brake system converts the kinetic energy into heat and this is carried out by using friction force. Friction force leads to increase the temperature of disc which is in contact with pad. When very hard braking is applied, the temperature of disc can reach to high value. The unexpected increasing in temperature causes thermal shock and thermal stress within the disc [1]. Usually brake system contains a cast iron disc bolted to wheel hub and fixed housing named caliper. The caliper is connected to fixed part of automobile such as the axle [2]. A group of researcher analyzed the disc brake with four different materials HSS M42, HSS M2 Aluminum and grey cast iron to obtain the stress analysis for the materials, the brake is simulated with CATIA and analysis with finite elements software ANSYS [3]. Some researchers modeled the disc brake with finite element software ANSYS, the main purpose was investigated the thermo-mechanical behavior. Von-Mises stress and deformation were obtained for two different materials cast iron and stainless steel [4]. A studied the disc brake with three materials carbon composite, stainless steel and cast iron. Disc brake was simulated with CATIA and analyzed with finite elements ANSYS. Deformation and stress were gotten, and it observed that stainless steel is better than cast iron as a material for disc brake [5]. Another group researchers offered enhanced design of disc brake with finite elements analysis. Stainless steel and cast Iron were used as materials. It has been investigated the deformation, temperature effect and stress with various braking conditions [6]. A group researchers evaluated the temperature of the disc and determined structural deformation, stress concentration and the pressure between the pad and disc with ANSYS [7]. Other researchers in their paper found that temperature could effect on the level of vibration in the assembly of disc brake [8]. A study presented the natural frequency of disc brake. The brake is modeled with CATIA V5 with many different thickness of disc. It can be observed from the results that the highest reduction in mass produces the lowest value of frequency and the highest value in massproduces the higher value of the frequency [9]. Some researchers calculated the temperature on the surface of disc brake by using the uniform heat flux assumption. It was observed that the temperature which was measured on the exit of pad was higher than the temperature which was evaluated from heat flux assumption [10].

1.1 Brake Requirements

1- The brake must be strong enough to stop the vehicle in emergency circumstances within minimum distance. The driver must be able to avoid skidding and control the automobile in braking.
2- The brake should have a good anti-wear properties.
3- The brake effectiveness should not decline with time.

Classification of Brake:

1- Mechanical Brake.
2- Electric Brake.
3- Hydraulic Brake.

1.2 Modelling Disc Brake

The modelling of disc brake was carried out by using Finite Elements Analyzer (ANSYS R16.1). The disc brake with diameter 0.3 m was simulated as shown in figure.1 below.

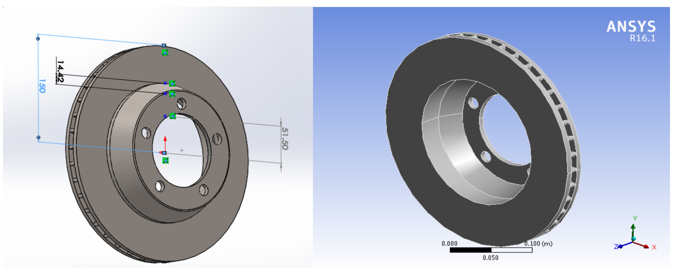

Figure 1: Front and back view of disc brake.

Two materials are chosen for simulating the disc brake, Grey Cast Iron and ceramic carbon to choose the better material that can withstand deformation. The mechanical properties for both materials listed in table (1).

Table 1: Mechanical properties of materials

Properties	Grey Cast Iron	Carbon Ceramic
Density (Kg/m^3)	7200	1800
Young modulus (pa)	1.1e+11	9.5e+10
Poisson's ratio	0.28	0.31
Thermal conductivity (w/m.c)	52	40
Specific Heat (J/ Kg.C)	447	800

The mass of disc brake which is made of Grey Cast Iron is 7.5 Kg while the mass of disc brake with ceramic carbon is 1.8 kg because the carbon ceramic is lighter than grey cast iron. The atmosphere temperature is 22 oc and the disc brake subjected to 90oc caused by frictional force during hard braking.

2. MESH GENERATION

The main objective of the finite element analysis is to analyze the structure, which is a collection of separate pieces named elements, which are connected to each other at a finite number of points named Nodes. The boundary conditions are then applied to these elements and nodes [11]. The mesh process was carried for Grey cast Iron as shown in figure.2 with number of nodes 1404836 and number of elements 934867.

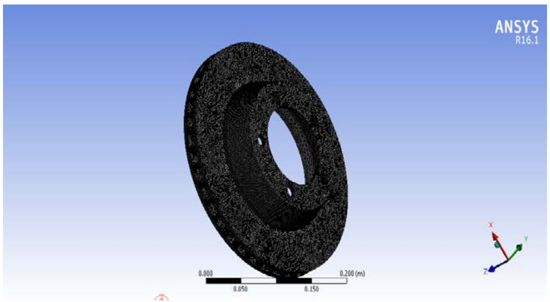

Figure 2: The mesh generation for Grey Cast Iron disc brake.

The mesh process was carried for Carbon-Ceramic as shown in figure 3 with number of nodes 1404836 and number of elements 934867.

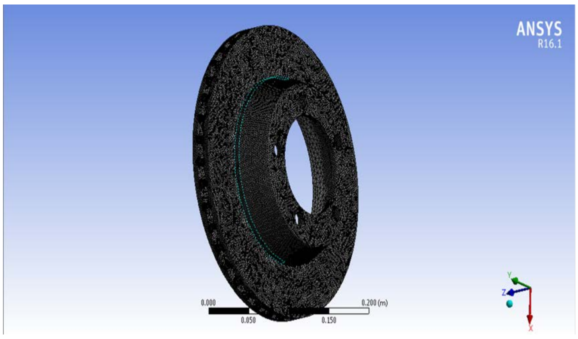

Figure 3: The mesh generation for Carbon-Ceramic disc brake.

3. RESULTS AND DISCUSSION

The temperature distribution, deformation and stress for two materials were obtained in order to compare between them to choose the better material. The results for two materials as below:

3.1 Grey Cast Iron

The temperature distribution as shown in figure.4, when the surrounding atmosphere temperature is 22o c and the disc subjected to 90oc because of the applied friction force.

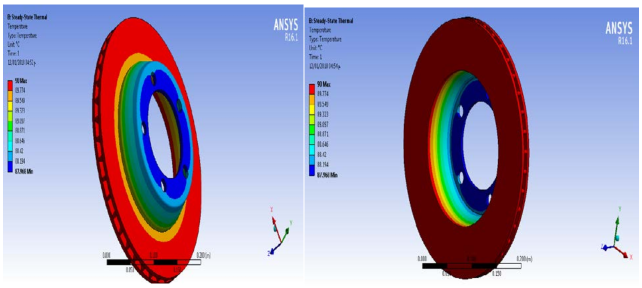

Figure 4: Temperature distribution for Grey Cast Iron disc brake. The maximum deformation for Grey Cast Iron is 0.1173 mm as shown in figure.5 below

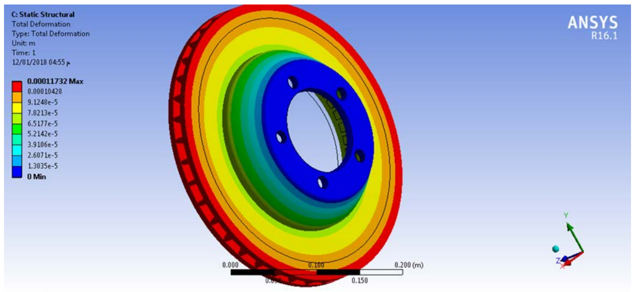

Figure 5: Total Deformation for Grey Cast Iron disc brake.

The maximum stress according to von-mises theory is 2.4758 (pa) as shown in figure.6 below

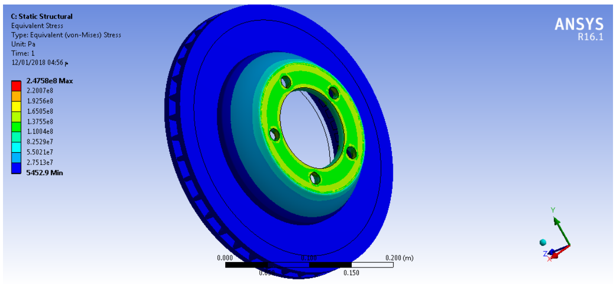

Figure 6: The total stress for Grey Cast Iron disc brake.

3.2 Carbon-Ceramic

The temperature distribution for carbon-ceramic as shown in figure 7, when the surrounding atmosphere temperature is 22°c and the disc subjected to 90°c.

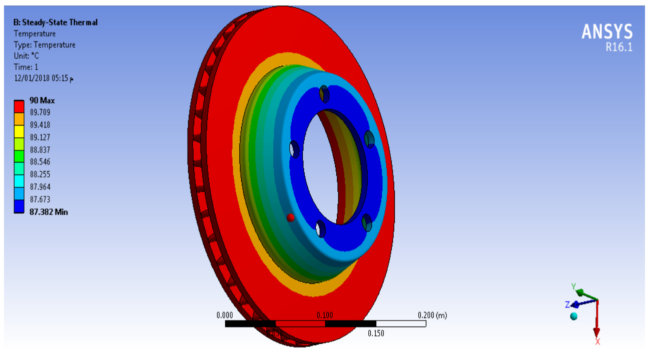

Figure 7: The Temperature distribution for Carbon-Ceramic disc brake.

The maximum deformation for Carbon- Ceramic is 0.0025 mm as shown in figure.8 which is very small value and this is because the carbon- ceramic can withstand high temperature and forces and therefore it is used for high speed and race cars.

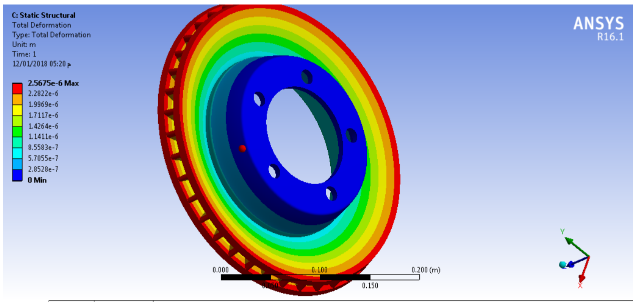

Figure 8: Total Deformation for Carbon-Ceramic disc brake.

The maximum stress according to von-mises theory is 1.9524 (pa) as shown in figure 9 below

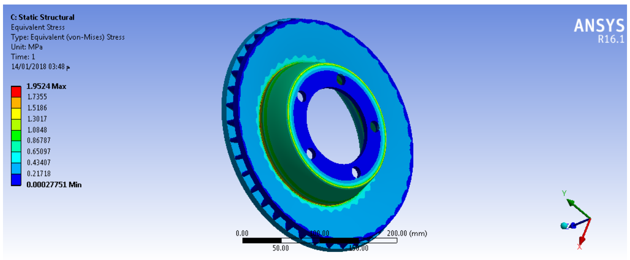

Figure 9: The total stress for Carbon- Ceramic disc brake.

The results can be summarized in table (2) below:

Table 2: Results of Different Materials

Results	Grey Cast Iron		Carbon Ceramic	
	Min.	Max.	**Min.**	**Max.**
Total Deformation (mm)	0	0.117	0	0.0025
Stress (pa)	5452.9	2.4758e +008	0.0002775	1.9524
Temperature Distribution (C)	87.968	90	87.382	90

4. CONCLUSIONS AND RECOMMENDATIONS

The disc brake was simulated and analyzed by using finite elements analyzer (ANSYS R16.1). Grey Cast Iron and Carbon –Ceramic were selected as materials for disc brake. Temperature distribution, total deformation and stress were obtained for both materials. It can be observed from the results the minimum deformation and stress occurred in carbon-ceramic and it can well withstand the high temperature, so it is preferred for manufacturing disc brake to get better performance. For future works, it is recommended to simulate the disc brake with different materials and various temperatures and study the effect of presence holes or cracks on the performance of disc brake.

REFRENCES

[1] Aziz, A., Tao, J. 2012. Simulation of Thermal Stresses in A Disc Brake. Thesis Work.

[2] Sowjanya, K., Suresh, S. 2013. Structural Analysis of Disc Brake Rotor. International Journal of Computer Trends and Technology (Ijctt) 4 (7).

[3] Praveena, S., Kumar, M.L., Reddy, S.S. 2014. Modeling and Structural Analysis of Disc Brake. International Journal of Innovative Research in Science, Engineering and Technology, 3 (10).

[4] Manjunath, T.V., Dr Suresh, P.M. 2013. Structural and Thermal Analysis of Rotor Disc of Disc Brake. International Journal of Innovative Research in Science, Engineering and Technology, 2 (12).

[5] Virajparab, Kunalnaik, Dhale, A.D. 2014. Structural and Thermal Analysis of Brake Disc. Ijedr, 2 (2).

[6] Dakhil, M.H., Rai, A.K., Reddy, P.R., Jabbar, A.A. 2014. Design and Structural Analysis of Disc Brake in Automobiles. International Journal of Mechanical and Production Engineering Research and Development (Ijmperd), 4 (1).

[7] Belhocine, A., Bakar, A.R.A., Mostefabouchetara. 2016. Thermal and Structural Analysis of Disc Brake Assembly During Single Stop Braking Event. Australian Journal of Mechanical Engineering, 14 (1).

[8] Bakar, A.R., Ouyang, H., Cao, Q. 2003. Interface Pressure Distribution Through Structural Modifications. Sae Technical Paper, 01-3332.

[9] Shahril, A., Samin, R., Juraidi, J.M., Jufriadidaut. 2015. Structural Analysis of Brake Disc Using Dynamic Simulation. Arpn Journal of Engineering and Applied Sciences, 10 (17).

[10] Noyes, R.N., Vickers, P.T. 1969. Prediction of Surface Temperatures in Passenger Car Disc Brakes. Sae Technical Paper Series: 690457.

[11] Khashan, M.K., Khaleel, H.H., Meteab, A.H. 2017. Numerical Study and Analysis of Ship Propeller. Journal of Mechanical Engineering Research and Developments, 40 (4), 47-53.