Analysis of Car Brake Disc Rotor through FEA Method by Using ANSYS Software

Sachin Jain[1] Prof. Ranjeet Kumar[2] Dr. R.S. Sikarwar[3]
[1]M.Tech. Student [2]Head of the Department [3]Director
[1]Department of (Machine Design) Mechanical Engineering [2]Department of Mechanical Engineering
[1,2,3]Vaishnavi Institute of Technology And Science, Bhopal(M.P.), India

Abstract— Brakes are one of the most important control component of vehicle. They are a mechanical device in which friction torque is used to slowdown or stop the rotating member. They are required to stop the vehicle within the smallest possible distance and this is done by converting the kinetic energy of the vehicle into the heat energy which is must be dissipated into the atmosphere. Disc brakes in the vehicles give much better performance compare to drum to stop the vehicle. Heat generated during braking force can be easily dissipated to atmosphere. But the main problem is with the material used in the disc brakes in some vehicle. Analysis of the contact pressure distributions at the disc interfaces using a detailed 3-dimensional finite element model. Finite element (FE) models of brake-disc rotor are created using CATIAV5R20 and simulated using ANSYS 18.2. The main aim of this thesis is to improve the strength of the disc by taking various materials for analysis. and the materials like Aluminum Nitride, Silicon Nitride, Aluminium Alloy ALSI 398, Aluminium Alloy 1300, Silicon Carbide, Aluminum Oxide, Zirconium Oxide and Composite materials Carbon fibre are taken. And these are the materials which are used for comparison the material behaviour on stress, deformation, heat flux, displacement, elastic stress, and strain and carried out the behavior of maximum and minimum level then we get Carbon fiber is best materials other than materials because its durability and light weight.

Keywords: Disc Brake, Brake Caliper, FEA, Rotor, ANSYS18.2, Stress, Deformation

I. INTRODUCTION

The brakes must be strong enough to stop the vehicle within a minimum distance in an emergency. But this should also be consistent with safety. The driver must have proper control over the vehicle during emergency braking and the vehicle must not skid. Brake discs are installed on the axle or the side of car spokes board, Friction between the mechanical brake shoe and brake disc profile leads to braking effect, which converts kinetic energy into heat energy that finally dissipates in the atmosphere. The working rule of brake operation is the conversion of energy. Braking activity makes kinetic friction in the brakes and static friction between the tire and street to slow the vehicle. A disc brake assembly consists of Disc rotor that rotates with the wheel, Calliper assembly attached to the steering knuckle, disc pads that are mounted to the calliper assembly.

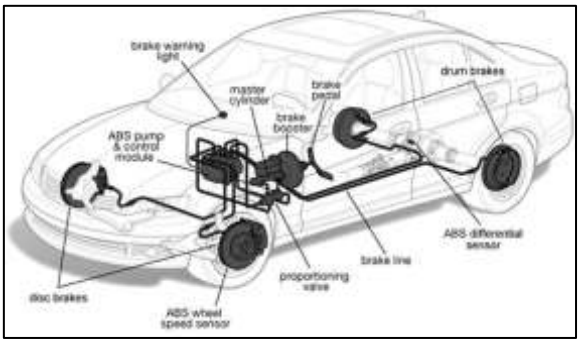
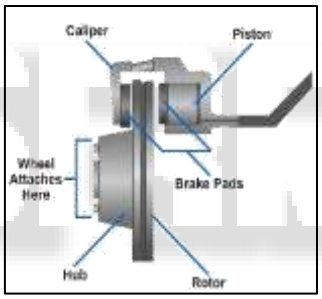


Fig. 1: Vehicle slowing mechanism

A. *Working of Disk Brake*

1) Disc stopping Mechanism –

A disc brake assembly consists of Wheel hub assembly, disc brake rotor, Brake pads, Brake caliper assembly, Wheel and lug nuts.



2) Wheel hub assembly

The wheel hub assembly holds the wheel and disc rotor. And the bearing inside it to allows their smooth rotation of the wheel.

3) Disc brake rotor-

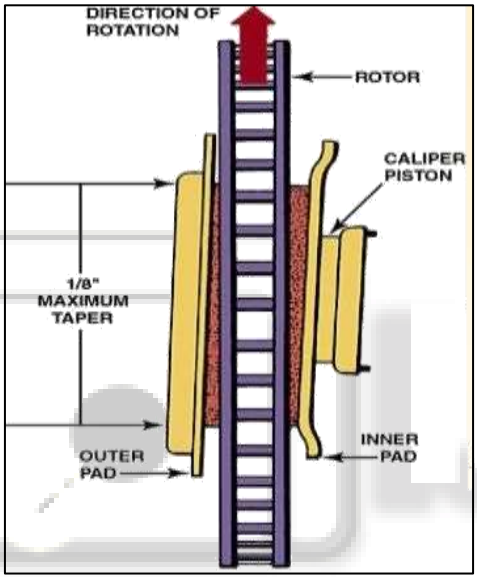
Disc brake rotor is the part to which the brake pads squeez against. This will create friction that retards the rotation of the wheel. Much more amount of heat is generated due to rotation of disc rotor. And the drilled hole provide ventilation to remove this heat.

4) Brake pads-

Brake pads are a component of disc brakes rotor used in automotive and other applications. Brake pads convert the kinetic energy of the vehical through heat energt through friction.

5) Brake Caliper assembly-

The caliper is the non-rotating unit in the system and it may be mounted to the spindle. shield to provide support. Brake caliper assembly uses the hydraulic force from the brake pedal to squeeze the brake pads to rotor surface. Thus creating friction and decelerates the wheel.



II. LITERATURE REVIEW

Naga Phaneendra, S. Junaid Razi, Wasee Ul Kareem L, G. Md. Adnan and S. Md. Abdul Ahad [2018] This work is to analyze the temperature distribution and heat dissipation of the rotor disc during braking operation. The three unique materials studied are Gray Cast Iron, Aluminum Alloy 6262 T-9 and Carbon-Ceramics with two distinct profiles of circle rotor. The analysis shows that different material on similar load conditions during continuous braking shows different temperature distribution. Thus, a comparison is made between the three materials used to know the best material for making disc brake rotor based on the rate of heat dissipation and critical temperature. Hence, it is found that Aluminum Alloy is the most appropriate material among all three material selected for solid disc rotor.

Pravin Mohan and Patel Sudheendra S [2017] Disc brakes offer higher performance braking, simpler design, lighter weight, and better resistance to water interference than drum brakes. The aim of this conceptual design was to increase the strength of the caliper, without increasing the weight of the caliper by a large amount and reducing the thermal deformation at high operating temperatures. The results were studied for displacements and stresses along with thermal effects. the major difference in the passenger car brake system and this system is that the caliper has multiple pistons on both sides of rotor. These four pistons are for applying uniform pressure to the rotor from the brake pads to increases the braking efficiency at high speeds.

Manjunath T. V, Dr Suresh P. M(2013), The disc brake is a device for slowing or stopping the rotation of a wheel. Repetitive braking of the vehicle leads to heat generation during each braking event. Transient Thermal and Structural Analysis of the Rotor Disc of Disk Brake is aimed at evaluating the performance of disc brake rotor of a car under severe braking conditions and there by assist in disc rotor design and analysis. Disc brake model and analysis is done using ANSYS workbench 14.5. The main purpose of this study is to analysis the thermo

mechanical behaviour of the dry contact of the brake disc during the braking phase. The coupled thermal-structural analysis is used to determine the deformation and the Von Mises stress established in the disc for the both solid and ventilated disc with two different materials to enhance performance of the rotor disc. A comparison between analytical and results obtained from FEM is done and all the values obtained from the analysis are less than their allowable values. Hence best suitable design, material and rotor disc is suggested based on the performance, strength and rigidity criteria.

K. Sowjanya & S.Suresh:(2013), presented paper on Structural analysis of disk brake rotor . Disc brake is usually made of Cast iron, so it is being selected for investigating the effect of strength variations on the predicted stress distributions. Aluminum Metal Matrix Composite materials are selected and analyzed. The domain is considered as axis-symmetric, inertia and body force effects are negligible during the analysis. The model of Disc brake is developed by using Solid modeling software Pro/E (Cero-Parametric 1.0).Further Static Analysis is done by using ANSYS Workbench. Thermal solution to the structural analysis and the maximum Von Misses stress was observed to be 50.334 M Pa for CI, 211.98 M Pa for AlMMC1, and 566.7 M Pa for AlMMC2, the Brake disc design is safe based on the Strength and Rigidity Criteria.

III. MODELING

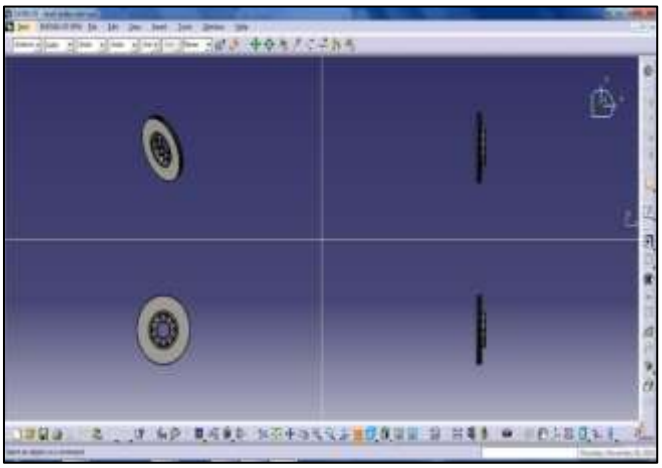


Fig. 1: Isometric View Rotor disc

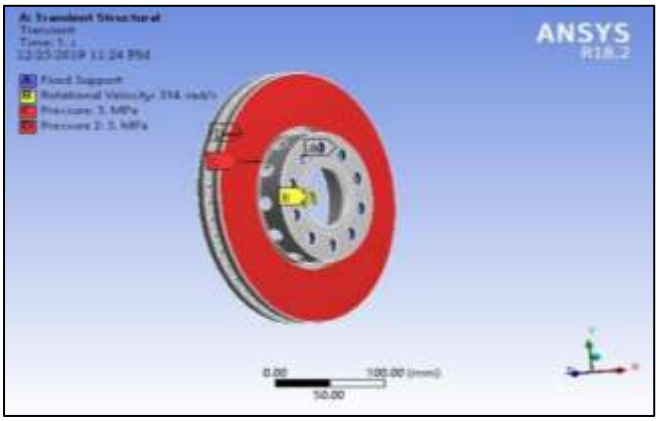


Fig. 2: Boundary Conditions of Disc Rotor

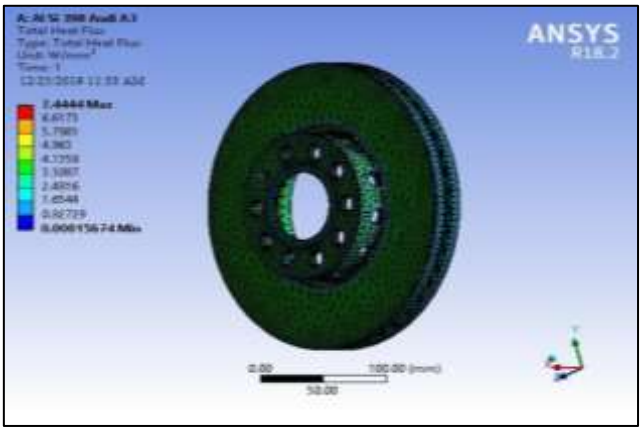


Fig. 6: Rotor disc AL SI Alloy Heat Flux

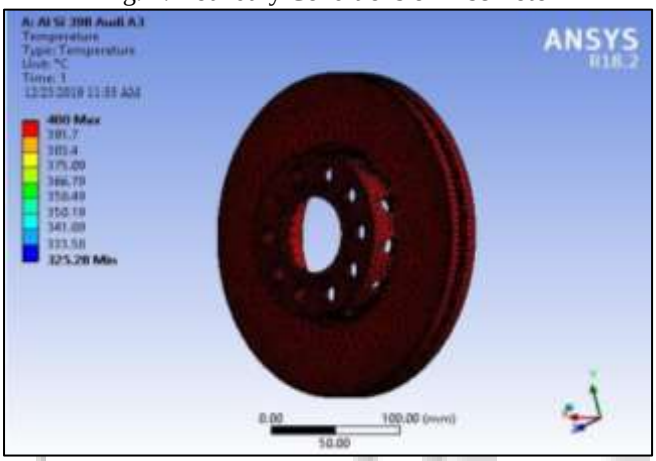


Fig. 3: Rotor disc AL SI Alloy Temperature

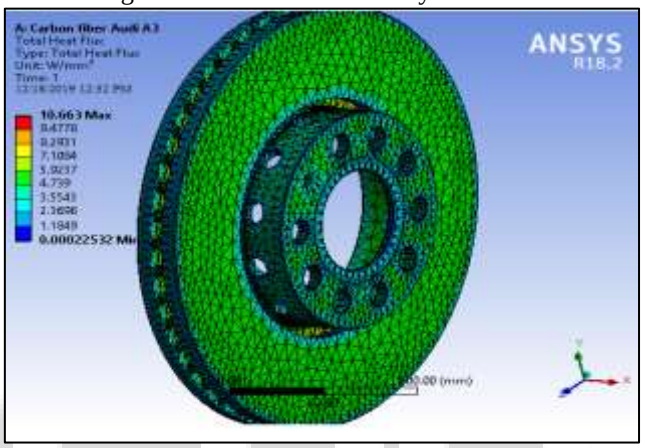


Fig. 7: Rotor Disc Carbon Fiber Heat Flux

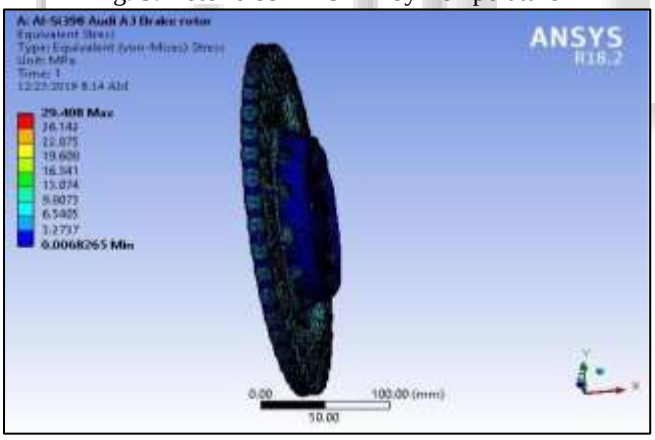


Fig. 4 Rotor disc AL SI Alloy Thermal Stress

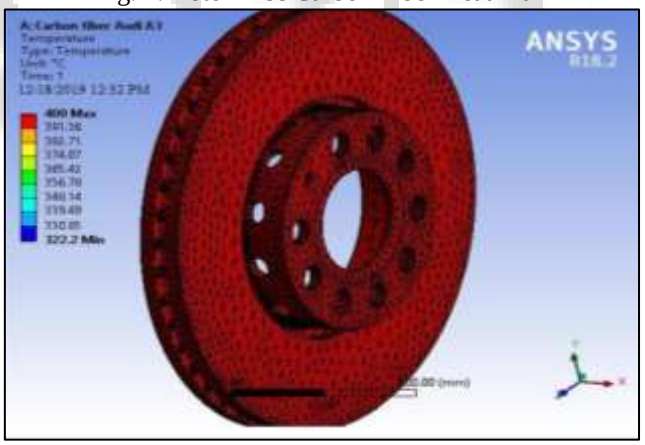


Fig. 8: Rotor Disc Carbon Fiber Temperature

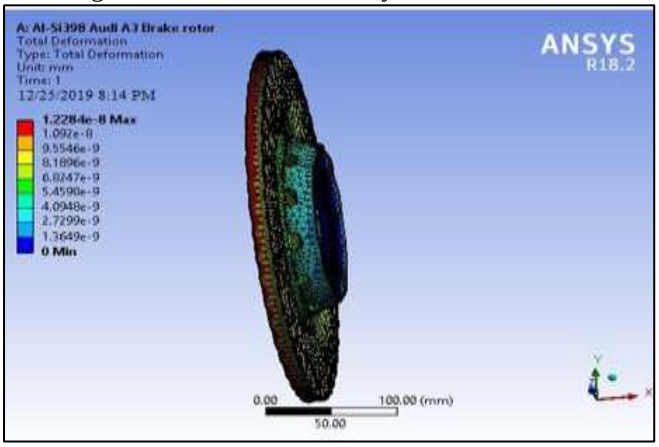


Fig. 5: Rotor disc AL SI Alloy Deformation

Fig. 9: Rotor Disc Carbon Fiber Stress

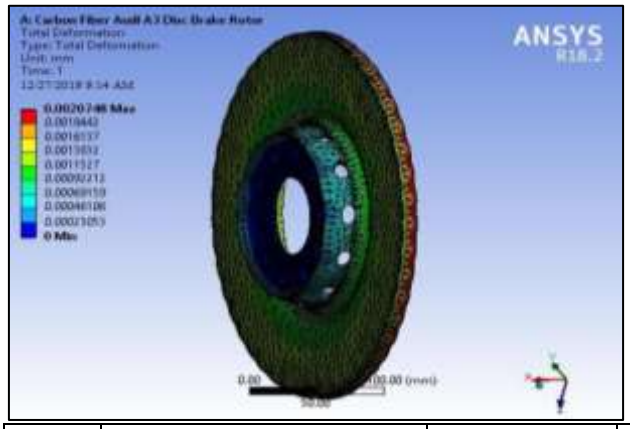


Fig. 10: Rotor Disc Carbon Fiber Deformation

IV. RESULTS & DISCUSSION

We take different nine materials and seen that the maximum von misses stress value for All material like AL SI 398 are 29.41 MPa. Here we can cleared observed that AL SI 398 materials has considerable value of stresses compare to other materials. And also the deformation value is minimum as compare to other materials.

S. No.	Materials	Stresses (MPa)	Deformations (mm)	Temperature(0C)	Heat Flux (W/mm2)
1	Cast Iron Alloy	34.021	0.011	400	6.99
2	AL-GHS 1300	29.41	6.978e-9	400	5.11
3	AL-Si 398	29.41	1.2e-8	400	7.44
4	Aluminum Oxide (Al2 O3)	29.815	0.0019	400	6.42
5	Aluminum Nitride (AlN)	30.07	0.0023	400	9.32
6	Silicon Carbide (SiC)	30.799	0.00146	400	4.67
7	Silicon Nitride (Si3 N4)	30.27	0.00225	400	4.56
8	Zirconium Oxide (ZrO2)	30.791	0.005	400	1.42
9	Carbon fiber	29.337	0.00207	400	10.66

We take different nine materials and seen that the maximum von misses stress value for all material like AL SI 398 are 29.408 MPa. Here we can cleared observed that AL SI 398 materials has considerable value of stresses compare to other materials.

We get maximum value heat flux value for all material, AL SI 398 are 7.44 w/mm^2. Here we can clearly observed that AL SI 398 materials has very high value of heat flux temperature compare to other materials.

So we can suggest AL SI 398 materials for Low budget car's brake rotor in future, whereas Carbon fiber best material especially for Luxury and sports car's. Because it is light weight and durable materials.

V. CONCLUSION & FUTURE SCOPE

The disc brake is a device for decelerating or stopping the rotation of a wheel. Braking is a process which converts the kinetic energy of the vehicle into mechanical energy which must be dissipated in the form of heat. This paper presents the analysis of the contact pressure distributions at the disc interfaces using a detailed 3-dimensional model of a real car disc brake. Determination of the braking force is the most crucial aspect to be considered while designing any braking system. The generated braking force should always be greater than the required braking force. The calculation of required clamping force helps us to decide the parameters of the disc brake rotor. Modeling and analysis o disc brake rotor is done to select the best material which is more durable. Space and assembly constraints are also an important factor while designing the rotor body. Find out the value of deformations and stresses due to cause of pressure. We take nine different materials Cast Iron Alloy, AL-Si 398, AL-GHS 130, Aluminum Oxide (Al2 O3), Aluminum Nitride (AlN), Silicon Carbide (SiC), Silicon Nitride (Si3 N4), Zirconium Oxide (ZrO2) and Carbon fiber. Analysis is done on these materials and conclude that Carbon Fiber shows the minimum stress and deformation values in boundary conditions. So we can suggest AL SI 398 materials for Low budget car's brake rotor in future, whereas Carbon fiber best material especially for Luxury and sports car's.

A. Future Scope

In future this work can be extended by using different composite materials and we can do thermal CFD analysis and Vibrational analysis. The modular design will be analyzed without considering the effects of thermal expansion.

REFERENCES

[1] A.Naga Phaneendra, S. Junaid Razi, Wasee Ul Kareem L, G. Md. Adnan & S. Md. Abdul Ahad ," Thermal Analysis Of Solid Disc Brake Rotor" International Journal Of Mechanical And Production Engineering Research And Development (Ijmperd), Issn(P): 2249-6890; Issn(E): 2249-8001, Vol. 8, Issue 2, Apr 2018, 1039-1048.

[2] Pravin Mohan and PatelSudheendra S," Design and Analysis of Titanium Caliper Disc Brake" International Journal of Engineering Development and Research, Volume 5, Issue 1 | ISSN: 2321-9939, PP 144 – 158, 2017.

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

[4] K. Sowjanya,"Structural analysis of disk brake rotor", International Journal of computer trends and technology (IJCTT)- volume 4 , Issue 7- July 2013

[5] H Mazidi, S.Jalalifar, J. Chakhoo, Mathematical Model of heat conduction in a disc brake system during braking, Asian journal of Applied Science 4(2): 119-

136,2011, ISSN 1996-3343 / DOI:10,3923/ajaps,2011,119,136

[6] K. M. Muniswamy, "Heat transfer enhancement on ventilated brake disk with blade inclination angle variation", international journal of automotive technology, vol. 14, No. 4, PP.569-575, 2013

[7] Oder, G., Reibenschuh, M., Lerher, T., Sraml, M.; Samec, B.; Potrc, I. "Thermal And Stress Analysis Of Brake Discs In Railway Vehicles" at International Journal of Advanced Engineering , ISSN 1846-5900, 2009

[8] Rajendra Pohane, R. G. Choudhari, Design and Finite Element Analysis of Disc Brake, International J. of Engg. Research & Indu. Appls.(IJERIA). ISSN 0974-1518, Vol.4, No. I (February 2011), pp 147-158

[9] S. Arvin Rao, Muhamad Anuwar Jusoh, Rahim Abu Bakar* ,"Reduction of disc brake squal noise using constrained layer dampers" JurnalTeknologi (Sciences & Engineering),83–87, 2017

[10] S. P. Jung, T. W. Park, J. H. Lee, W. H. Kim, and W. S Chung, Finite Element Analysis of Themalelastic Instability of Disc Brakes, Proceedings of the World Congress on Engineering 2010 Vol II WCE 2010, June 30-July 2, 2010, London,U.K.

[11] V.M.M.Thilak, R.Krishnaraj, Dr.M.Sakthivel, K.Kanthavel, Deepan Marudachalam M.G, R.Palani , Transient Thermal and Structural Analysis of the Rotor Disc of Disc Brake , International Journal of Scientific & Engineering Research Volume 2, Issue 8, August - 2011 ISSN 2229-5518

[12] Zaid, M.A., Radzai, M.S., Ahmad, R., Ridzuan, M.M., Nurfaizey, A.H., and Afzanizam, M.M.R , "An investigation of disc brake rotor by Finite element analysis", Journal of Advanced Manufacturing and Technology, Vol. 3, pp 37-48 ,2009

