ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

Modeling and Structural Analysis of Disc Brake

Praveena S[1], Lava Kumar M[2], Sreekanth Reddy S[3]

P.G. Student, Department of Mechanical Engineering, Siddarth Institute of Engineering and Technology, Narayanavanam, Puttur, India[1]

Assistant Professor, Department of Mechanical Engineering, Siddarth Institute of Engineering and Technology, Narayanavanam, Puttur, India[2]

Design Engineer, Satyam Ventures Private Limited, Begumpet, Hyderabad, India[3]

ABSTRACT: The disc brake is a device used for slowing or stopping the rotation of the vehicle. Number of times using the brake for vehicle leads to heat generation during braking event, such that disc brake undergoes breakage due to high stress. The transient stress and structural analysis is preferred to choose the low stress material for better performance. Disc brake model is done by CATIA and analysis is done by using ANSYS workbench. The main purpose of this project is to study the analysis of the stress for the Aluminium, Grey Cast Iron, HSS M42, and HSS M2. The stress and structural analysis is performed for four materials and the stress is established in the disc for different materials. A comparison between the four materials for the stress values and material properties obtained from the stress analysis and structural analysis low stress material is preferred. Hence best suitable design, low stress material Aluminium is preferred for the Disc Brakes for better performance.

KEYWORDS: Disc Brake, CATIA, ANSYS workbench, structural analysis

I. INTRODUCTION

In today's growing automotive market the competition for better performance vehicle is growing enormously. The disc brake is a device used for slowing or stopping the rotation of the wheel. A brake is usually made of cast iron or ceramic composites include carbon, aluminium, Kevlar and silica which is connected to the wheel and axle, to stop the vehicle. A friction material produced in the form of brake pads is forced mechanically, hydraulically, pneumatically and electromagnetically against the both side of the disc. This friction causes the disc and attached wheel to slow or to stop the vehicle. The methods used in the vehicle are regenerative braking system and friction braking system. A friction brake generates the frictional force in two or more surfaces rub against to each other, to reduce the movement. Based on the design configurations vehicle friction brakes are grouped into disc brakes and drum brakes. Our project is about disc brakes modelling and analysis.

Fig.1 Assembly of Disc Brake

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

1.1 Material Properties

The materials properties and chemical compositions are discussed below

1. Grey Cast Iron: Carbon – 3 to 3.5%, Silicon – 1 to 2.75%, Manganese – 0.4 to 1%, Phosphorous – 0.15 to 1%, Sulphur – 0.02 to 0.15% and remaining is Iron. The Grey colour is due to the fact that the carbon has been present in the form of free Graphite. It has low Tensile Strength, high compressive strength and it has no Ductility. This can be easily machined. The Grey Cast Iron castings are widely used for machine tool bodies, Automotive Cylinder blocks, heads, housings etc. Its melting point is 1300°C.

2. Aluminum: Copper – 3.5 to 4.5%, Manganese – 0.4 to 0.7%, Magnesium – 0.4 to 0.7%, and the remaining is Aluminium. It's white metal produced by electrical process from its oxide, which has been prepared from clayey mineral called Bauxite. It's light metal having specific gravity 2.3 and melting point 658°C. The tensile strength of the metal varies from 90Mpa to 150Mpa. It's good electrical conductivity is an important property and is widely used for over head cables.

3. HSS M2: Carbon – 0 to 0.95%, Chromium – 0 to 4%, Molybdenum – 0 to 5%, Vanadium - 0 to 2% and remaining steel. It has Molybdenum based high speed steel in the tungsten-molybdenum series. The carbides in it are small and evenly distributed. It has large wear resistance. When the heat treatment is done, its hardness is same as T1 but its bending strength can reach 4700Mpa and its toughness and thermo-plasticity are higher than T1.

4. HSS M42: Carbon – 0 to 1.10%, Chromium – 0 to 3.75%, Molybdenum – 0 to 9.5%, Vanadium - 0 to 1.15%, Cobalt – 0 to 8%. It is widely used in metal manufacturing process because of its higher red-hardness when compared to more conventional high speed steels allowing for the shorter cycle times in production environments due to higher cutting speeds or from the increase in time between the tool changes.

II. MODELING OF DISC BRAKE IN CATIA

CATIA software is the standard in the 3D product design, featuring industry-leading productivity tools that promote one of the best practices in design while ensuring compliance regarding industry and company standards. The designing of CATIA solution allow you to design you faster than any other software. The figure shows the solid model of the disc brake by using CATIA. By taking the pulsar disc brake dimension we have to draw the disc brake model in CATIA.

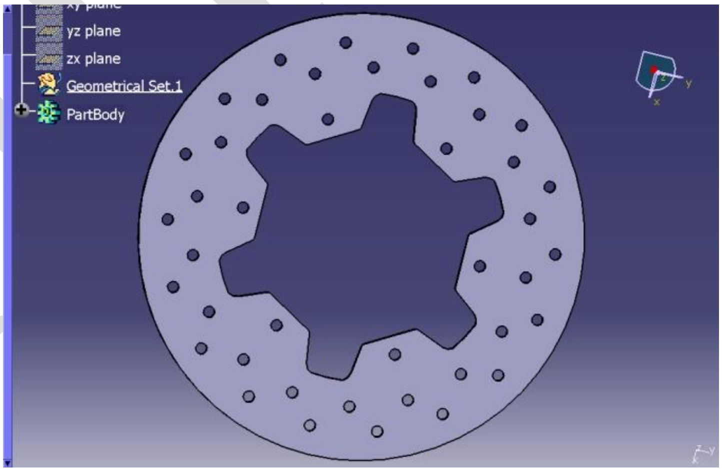

Fig.2.1 Disc Brake Model in CATIA

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

The above shown figure is model drawn in the CATIA software by using the Dimensions of the Pulsar Disc Brake with correct thickness and Dimensions.

III. ANALYSIS BY USING ANSYS

Dr. John Swanson founded ANSYS. Inc in 1970 with a vision to commercialize the concept of computer simulated engineering, establishing himself as one of the pioneers of Finite Element Analysis (FEM). The software implements the equations that govern the behavior of these elements and solve the problems, by creating comprehensive explanation of how the acts as whole. The results can be obtained in the form of tabular column or graphical forms.

Elements considered for Structural and Stress Analysis:
According to given specifications the element type chosen for structural analysis is solid20 node 90 is a higher order version used for three dimensional. The element is defined by 20nodes having three degrees of freedom per node.
Structural Analysis of Solid Disc Brake are shown below with figures obtained in the ANSYS process.

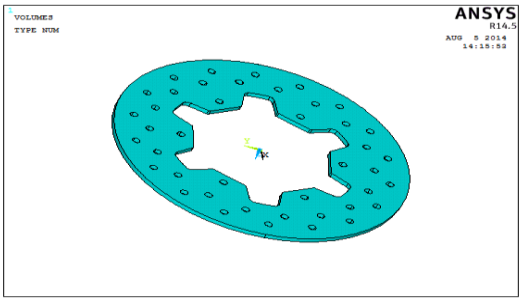

Fig.3.1 Imported Model

The above shown figure is the model which has been imported from the CATIA. After designing the model the model is exported to the 'iges' formatte and then its imported to the ANSYS for further process which is done in the Analysis.

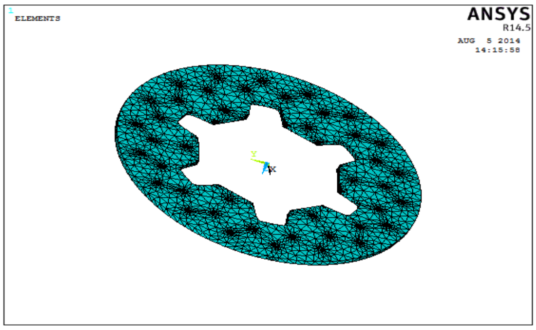

Fig.3.2 Meshed Model

The above figure is the meshed model in the ANSYS analysis for the structural analysis. In this meshed model triangular type meshing is used for the solid disc brake in the analysis procedure. In this regular type meshing is done in the analysis process.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

Table 1 Material Properties

Property	Grey Cast Iron	Aluminium	HSS M2	HSS M42
Density (kg/m3)	7200	2690	8160	7900
Young's Modulus (Gpa)	110	68.9	234	210
Poisson's Ratio	0.28	0.36	0.26	0.29
Thermal Conductivity (w/m-k)	533	210	19	21
Specific Heat (J/Kg-K)	506	900	460	418

The above shown table is the properties of Grey Cast Iron, Aluminium, HSS M2 and HSS M42 which are obtained from their mechanical properties.

Stress Analysis of Disc Brake: The stress analysis for the Aluminium, Grey Cast Iron, HSS M2 and HSS M42 are shown below.

1. Aluminium Stress Analysis

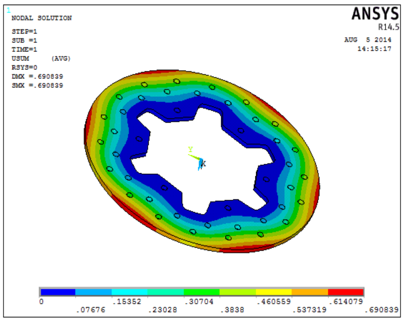

Fig 3.3 Displacement

The above shown figure is the Displacement diagram of the Aluminum obtained in the stress analysis in the ANSYS process. In the Aluminum stress analysis, Displacement minimum load is 0.00000 and the maximum load is 0.690839. It has the maximum load when compared to the remaining materials Grey Cast Iron, HSS M42 and HSS M2.

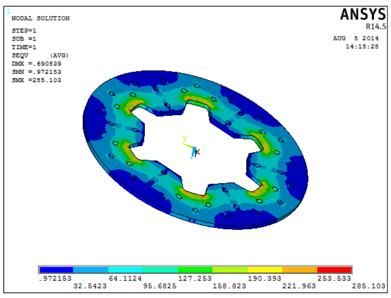

Fig 3.4 Stress

DOI: 10.15680/IJIRSET.2014.0310014

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

The above shown figure is the Stress diagram of the Aluminum obtained in the stress analysis in the ANSYS process. In the Aluminum stress analysis, Stress minimum load is 0.972153 and the maximum load is 285.103. It has the minimum stress when compared to the remaining materials Grey Cast Iron, HSS M42 and HSS M2.

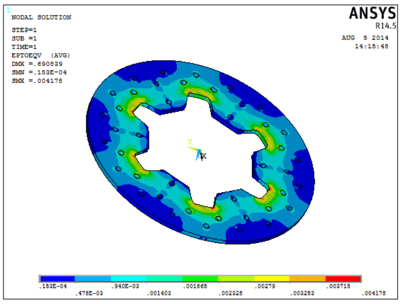

Fig 3.5 Strain

The above shown figure is the Strain diagram of the Aluminum obtained in the stress analysis in the ANSYS process. In the Aluminum stress analysis, Strain minimum load is 0.153024 and the maximum load is 0.004178. It has the maximum strain when compared to the remaining materials Grey Cast Iron, HSS M42 and HSS M2.

2. Grey Cast Iron Analysis

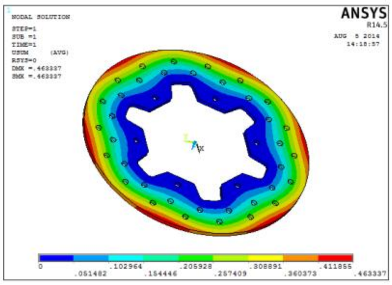

Fig 3.6 Displacement

The above shown figure is the Displacement diagram of the Grey Cast Iron obtained in the stress analysis in the ANSYS process. In the Grey Cast Iron stress analysis, Displacement minimum load is 0.00000 and the maximum load is 0.463337. It has the second maximum load after Aluminum when compared to the remaining materials HSS M42 and HSS M2.

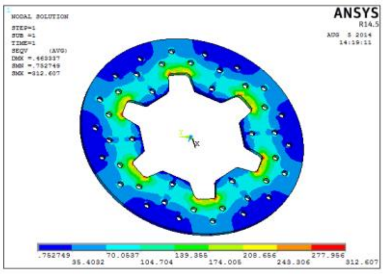

Fig 3.7 Stress

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

The above shown figure is the Stress diagram of the Grey Cast Iron obtained in the stress analysis in the ANSYS process. In the Grey Cast Iron stress analysis, Stress minimum load is 0.752749 and the maximum load is 312.607. It has the third maximum load when compared to the remaining materials Aluminium, HSS M42 and HSS M2.

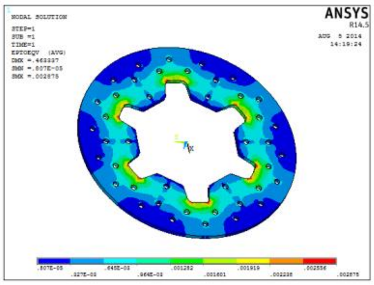

Fig 3.8 Strain

The above shown figure is the Strain diagram of the Grey Cast Iron obtained in the stress analysis in the ANSYS process. In the Grey Cast Iron strain analysis, Strain minimum load is 0.80705 and the maximum load is 0.002875. It has the second maximum load when compared to the remaining materials Aluminium, HSS M42 and HSS M2.

3. HSS M42 Analysis

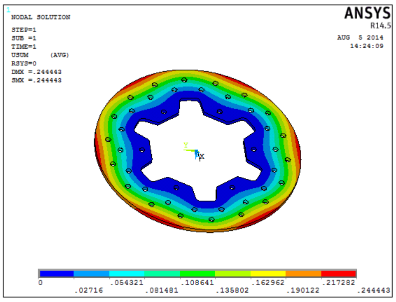

Fig 3.9 Displacement

The above shown figure is the Displacement diagram of the HSS M42 obtained in the stress analysis in the ANSYS process. In the HSS M42 stress analysis, Displacement minimum load is 0.00000 and the maximum load is 0.244443. It has the second minimum load when compared to the remaining materials Aluminum, Grey Cast Iron and HSS M2.

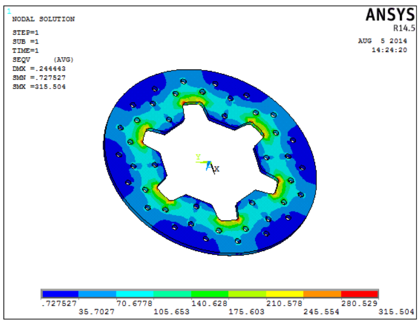

Fig 3.10 Stress

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

The above shown figure is the Stress diagram of the HSS M42 obtained in the stress analysis in the ANSYS process. In the HSS M42 stress analysis, Stress minimum load is 0.727527 and the maximum load is 315.504. It has the second minimum load when compared to the remaining materials Aluminum, Grey Cast Iron and HSS M2.

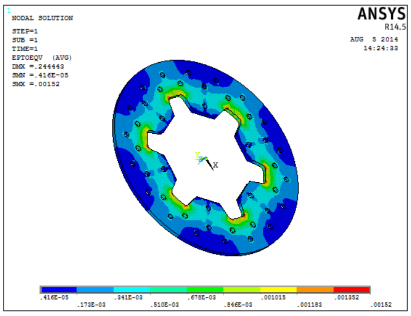

Fig 3.11 Strain

The above shown figure is the Strain diagram of the HSS M42 obtained in the stress analysis in the ANSYS process. In the HSS M42 stress analysis, Strain minimum load is 0.41605 and the maximum load is 0.00152. It has the second minimum load when compared to the remaining materials Aluminum, Grey Cast Iron and HSS M2.

4. HSS M2 Analysis

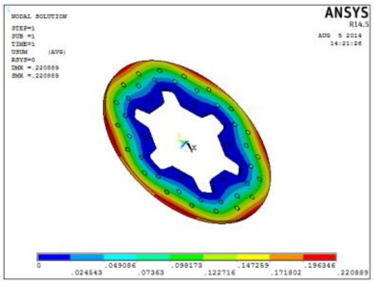

Fig 3.12 Displacement

The above shown figure is the Displacement diagram of the HSS M2 obtained in the stress analysis in the ANSYS process. In the HSS M2 stress analysis, Displacement minimum load is 0.00000 and the maximum load is 0.220889. It has the minimum load when compared to the remaining materials Aluminum, Grey Cast Iron and HSS M42.

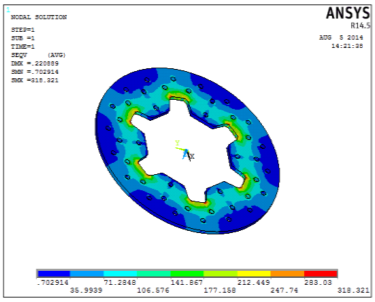

Fig 3.13 Stress

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

The above shown figure is the Stress diagram of the HSS M2 obtained in the stress analysis in the ANSYS process. In the HSS M2 stress analysis, Stress minimum load is 0.702914 and the maximum load is 318.321. It has the second maximum load when compared to the remaining materials Aluminum, Grey Cast Iron and HSS M42.

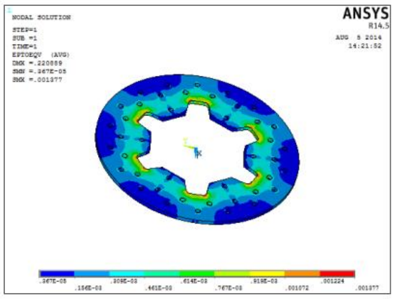

Fig 3.14 Strain

The above shown figure is the Strain diagram of the HSS M2 obtained in the stress analysis in the ANSYS process. In the HSS M42 stress analysis, Strain minimum load is 0.36707 and the maximum load is 0.001377. It has the minimum load when compared to the remaining materials Aluminum, Grey Cast Iron and HSS M42.

IV. RESULTS AND DISCUSSIONS

Table 4.1 Analysis of Stress on Disc Brake

Material	Minimum Load	Maximum Load
Aluminium	0.972153	285.103
Grey Cast Iron	0.752749	312.607
HSS M2	0.702914	318.321
HSS M42	0.727527	315.504

By considering the Table 4.1 Stress Analysis for disc brake we can say that Aluminium has low stress value compared to the remaining materials Grey cast Iron, HSS M42 and HSS M2 from the Analysis in ANSYS.

Table 4.2 Analysis of Strain on Disc Brake

Material	Minimum Load	Maximum Load
Aluminium	0.153024	0.004178
Grey Cast Iron	0.80705	0.002875
HSS M2	0.36707	0.001377
HSS M42	0.41605	0.00152

DOI: 10.15680/IJIRSET.2014.0310014

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

By considering the Table 4.1 Strain Analysis for disc brake we can say that HSS M2 has low strain value compared to the remaining materials Aluminium, Grey cast Iron and HSS M42 from the Analysis in ANSYS.

Table 4.3 Analysis of Displacement on Disc Brake

Material	Minimum Load	Maximum Load
Aluminium	0.00000	0.690839
Grey Cast Iron	0.00000	0.463337
HSS M2	0.00000	0.220889
HSS M42	0.00000	0.244443

By considering the above Table 4.3 we can see the minimum and maximum loads of the Stress, Strain and Displacement in the Analysis of the Stress Analysis in ANSYS.

V. CONCLUSION

The present study can provide a useful design and improve the brake performance of the Disc Brake system by using CATIA and ANSYS. From the above tables we can say that above values are obtained from the Structural and Stress analysis for Aluminium, Grey cast Iron, HSS M2 and HSS M42. Hence the Disc Brake design is safe based on the strength and rigidity criteria. By comparing the above results obtained from the Structural and Stress analysis, we can conclude that Aluminium has low stress and it has best performance.

REFERENCES

[1] Ali Belhocine, and Mostefa Bouchetara, "Structural and Thermal Analysis of Automotive Disc Brake rotor", Arcive of Mechanical Engineering Vol.61, PP. 81-113, 2014.
[2] V.Chengal Reddy, M. Guna Sekhar Reddy, and Dr.G.Harinath Gowd "Modeling and Analysis of FSAE car Disc Brake using FEM" , International Journal of Emerging Technology and Advanced Engineering , Vol.3, PP. 383-389, 2013.
[3] Bourchate Sourabh Sivaji, Prof. N.S. Hanamapure and Swapnil S. Kulakarni, "Design, Analysis and Performance Optimization of Disc Brake", International Journal of Advanced Engineering Research and Studies, Vol.3, PP. 25-27 2014.
[4] Ali Belhocine, and Mostefa Bouchetara, "Simulation of Fully Coupled Thermomechanical Analysis of Disc Brake Rotor", WSEAS TRANSACTIONS on APPLIED and THEORETICAL MECHANICS, Vol.7, PP.169-181, 2012.
[5] Bouchetara Mostefa' and Belhocine Ali "Thermoelastic Analysis of Disc Brake Rotor", American Journal of Mechanical Engineering , Vol.4, PP.103-113, 2014.
[6] Asim Rashid "Simulation of a Thermal Stresses in a Brake Disc," Linkoping Studies in Science and Technology, Vol.1, PP.5-20, 2013.
[7] Guru Murthy Nathy, T N Charyulu, K. Gowtham, and P Satish Reddy, "Coupled Structural/Thermal Analysis of Disc Brake", International Journal of Research in Engineering and Technology, Vol.1, PP.539-553, 2012.
[8] P. Hosseini Tehrani, and M.Talebi, "Stress and Temperature Distribution Study in a Functionally Graded Brake Disc", International Journal of Automotive Engineering, Vol.2, PP.171-179, 2012.
[9] Atul Sharma, and M.L. Aggarwal, "Deflection and Stress Analysis of Brake Disc using Finite Element Method", Proceedings of National Conference on Trends and Advances in Mechanical Engineering, Vol.1. PP.372-376, 2012.
[10] Sung-Soo Kang and Seon-Keun Cho, "Thermal Deformation and Stress Analysis of Disc Brakes by Finite Element Method", Journal of Mechanical Science and Technology, Vol.7, PP.2133-2137, 2012.