International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 07 | July 2019 www.irjet.net p-ISSN: 2395-0072

Design and Steady-State Thermal Analysis of Disc Brake

Mr. Aaqeebsohaib. H.D[1], Dr. S.G. Saraganachari[2], Mr. Sagarchanal[3]

[1]*B.E. Automobile Engineering, M-tech in Machine Design*
[2]*Assosicate professor Mechanical Department, B.V.V.S Engineering College, BGK*
[3]*B.E. Mechanical Engineering, M-Tech in Machine Design, Basaveshwar Engineering College, Bagalkot-587103, Karnataka, INDIA*

---***---

Abstract - The principle of disc brake is to offer simulated frictional resistance to revolving disc directed to slow down the vehicle by the conversion of kinetic energy of the motor vehicle into heat energy which increase the extreme high temperature raise and sequentially directed to detrimental effects such as thermal resilient volatility, untimely wear, fluid vaporization and thermally disturbed vibration. This heat temperature can be dissolute into close surrounding by using thermal solidity materials. Automobile braking systems is usually made up of steel or grey cast iron and are then paired corresponding with polymer composite pads. These forms of materials are appropriate to be used in braking system to restrain the load and by means of restricted temperature capability. Composite brake disc are lighter, reasonable and have exceptional high energy abrasion features. In this project, the analysis of disc brake is done with four different materials such as, grey cast iron, stainless steel, silicon carbide-reinforced composite and titanium 550 alloys. Using CATIA V5 for modelling and analysis is done through ANSYS WORKBENCH 14.5, ultimately a assessment is completed among materials such as grey cast iron(C.I), stainless steel(S.S), silicon-carbide reinforced composite(Sic) and titanium 550(TT-550). The generally exceptional material for fabrication of the disc brake have been intentional based upon the extent of corresponding equivalent stress(von-msies), total deformation, steady-state temperature distribution, from the results of thermal investigation of disc brake. Comparative study is made between analysis results in the end to obtain the best suitable material for manufacturing disc brake.

***Key Words*: Brake, Disc-Brake, Steady-State Analysis, Thermal analysis, ANSYS, CATIA V5**

1. INTRODUCTION

Brake is a device which is operated by a foot pedal, in order to slowdown or halts the vehicle. They are most significantly safety parts in the motor vehicles. To halt the motor wheel, brake pads are compelled exactly next to the spherical disc over both surfaces. The growing number of people travelling, increase in speed and weights of vehicles have led to make essential improvements. An effective braking model is required to complete this task.

In general, brakes turn the kinetic power of the vehicle into heat power, thus causing vehicle to slow its motion speed. Brakes fade is caused because of the decrease in stoppage power that caused because of rehashed or consistent utilization of brakes, particularly during speed or high load of the vehicle.

Brake become lighter and weak is called fade. This plays a vital key role, in all motor vehicle which use abrasion braking stopping method including in autos, heavy trucks, cruisers, planes, and bikes. Compact disc brake fade is caused due to spontaneous increase in high temperature of due to the braking over the surfaces along with the repeated changes and repercussion in brake set up model and can be seen in disc brake as well as drum brake.

Decrease in halting power, or fade, is caused due to friction, mechanical, or fluid darken. Brake fade can be drastically lowered by suitable equipment and material design assortment, as well as good coolant or cooling method. Due to design configuration of drum brakes it occurs more.

Brake fade is lowered in disc brake, due to cooling system in which heat from brake rotor and brake pad, is easily vented away and most of the disc brake are present in front of the vehicles.

1.1 Classification of Brakes:

- Mechanical Brakes
- Electric Brakes
- Hydraulic Brakes
- Hand Brake
- Air Brake

1.2 Disc Brake

Disc brakes are most commonly used bikes; cars in mid range, hatchback, and all types of four wheelers on their front wheel of the vehicles, the disc brake are also used with the combination of hydraulic as well as pneumatic assisted braking system in higher vehicle models, multi utility vehicle and sedan cars.

Following parts used in disc brake are:

- A circular disc
- A dynamic calliper housing containing piston
- Pads on both adjacent side

- Bleed screw

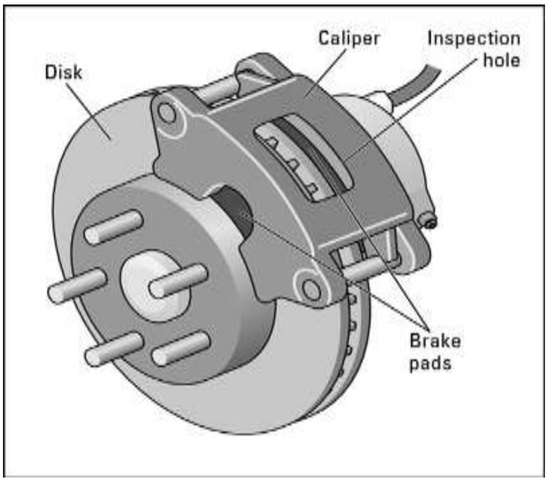


Fig-1: schematic view of disc brake

2. Objective of present work

- To investigate the effect of total deformation, equivalent stress, and thermal dissipation in disc brake.
- To increase the efficiency of the motor vehicle, by using suitable brake material for disc brake from the results.
- To reduce weight of disc brake, overall reducing the weight of the vehicle.

3. Literature Review:

RajendraPohane, R.G.Choudari in this paper, author made an effort to study contact analysis of disc and pad using finite element model, along with this author designed a 3D model brake and pads to study the static structural analysis and transient thermal state analysis. In the end evaluation of done between solid and ventilated disc-brake prepared of same material properties, furthermore the author describes how finite element software can be used to analysis equivalent-stress and transient-thermal analysis on disc-brake and pads.

S.Jalalifar, Mazidi, Chakhoo here the author studies the troubleshooting, caused in disc brake due to raise in high temperature in disc-brake and its pads, analysis is done through mathematical model but its solution is driven through numerically by finite difference method. In this studies time-dependent equation is considered along with this certain parameters are includes that are geometry, material properties and dimension of disc model and its parts, as well as motor vehicle velocity & its braking duration is taken it into account, in addition to this pad & contact pressure distribution is also added in calculations.

Hao Xing, in this paper, author with the help of two approach i.e. transient-analysis & complex-modal analysis, author performs modeling as well as analysis of disc brake design.

Natural frequencies results are extracted with the help of complex modal analysis and thermal effects, along with its steady thermal state of disc brake, is carried out with the help of transient analysis. In complex modal analysis cause and effect of friction is also investigated.

C.Radhakrishnan. Et al. here, author studies the mechanism of how brake works and vehicle gets stopped, in this process he came across through an interesting fact, that frictional heat generated between brake pad and spherical disc caused troublesome effects i.e. are thermal instability, thermal vibrations and wearing of pad surface, causing surface roughness of brake pad, hence the author analyzed ventilated disc brake, and its thermal behavior effects using ANSYS WORKBENCH 14.0 and SOLIDWORKS 2013, and compared the result generated between, disc made up of titanium 550, and grey cast iron, through total deformation, equivalent stress, and temperature distribution and concluded the best material for disc brake through this result.

4. Disc brake material used for analysis are :

- Gray cast iron
- Stainless steel
- Silicon-carbide Composite
- Titanium-550 alloy

Table -1: Material properties of following materials used in disc brake

Material properties	Gray-Cast iron	Stainless steel
Density (g/cm^2)	4.6	7.2
Melting-point (^{0}C)	1650-1670	1200-1300
Elastic-modulus (MPa)	1030	125
Poisson'- ratio	0.31	0.25
Thermal-conductivity(W/m^0 C)	7.5	42.0-62.0
Specific-heat J/(kg K)	586(20-570^{0}c)	460
Coefficient of thermal expansion (x10^{-6} ^{0}C)	8.8	8.1-9.31(20^{0}c)

Material properties	Silicon-carbide Composite	Titanium-550
Young's modulus	193Gpa	250Gpa
Density	7750kg/cm^3	1.8g/cm^3
Poisson's Ratio	0.31	0.32

Ultimate Tensile Strength	580Mpa	185Mpa
Bulk modulus	151Gpa	250Gpa
Shear Modulus	81Gpa	220Gpa
Compressive Strength	250Mpa	3000Mpa

5. Analysis of Disc Brake

In this project the actual dimensions of disc brake and its material properties taken from Hyundai India car. Thus that disc brake are made up of four different materials, and it's carried out for analysis of total deformation, equivalent stress, and steady-state thermal analysis thus in the end it is compared with each other's analysis results.

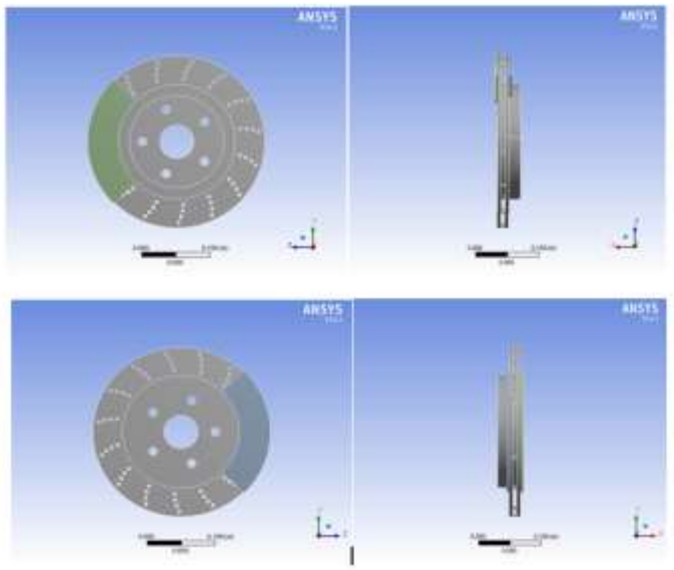


Fig-2 Ventilated disc brake modeled in CATIA V5

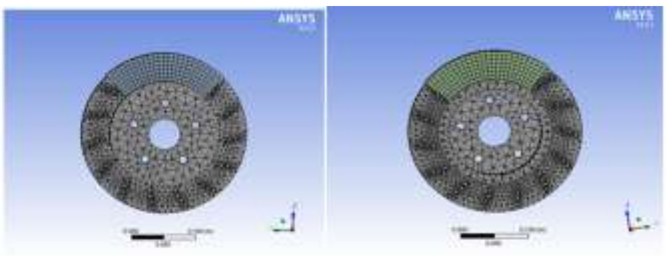
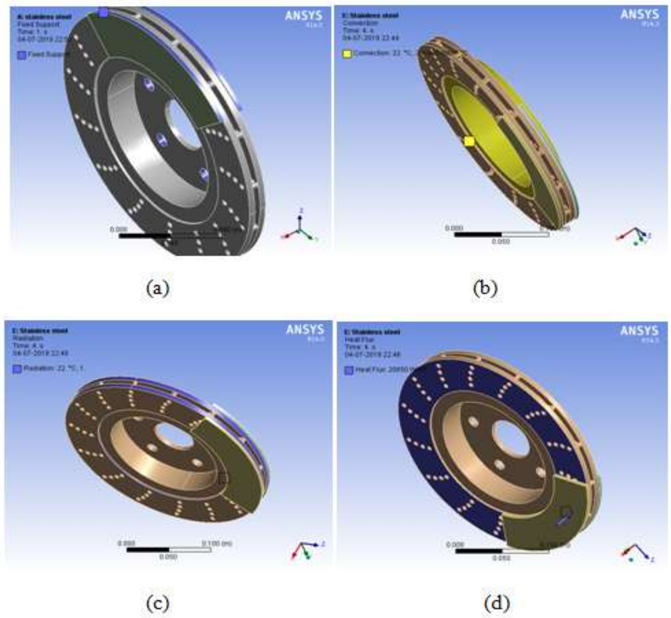


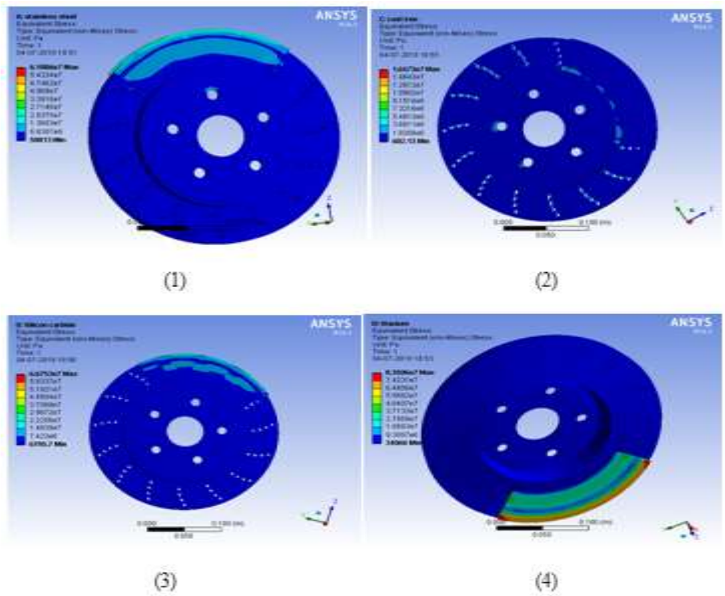
Fig-3 Meshing of disc brake having with 46,949 element and 23,218 nodes.

In this project the actual dimensions of disc brake and its material properties taken from Hyundai India car. Thus that disc brake are made up of four different materials, and it's carried out for analysis of total deformation, equivalent stress, and steady-state thermal analysis thus in the end it is compared with each other's analysis results.



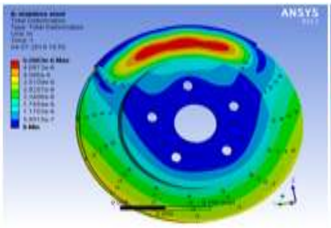
Represents **Fig-**(a) fixed support, **Fig-**(b) Convection, **Fig-**(C) Radiation, **Fig-**(d Heat flux

6. Equivalent stress (Von-Mises) Analysis of Disc brake:

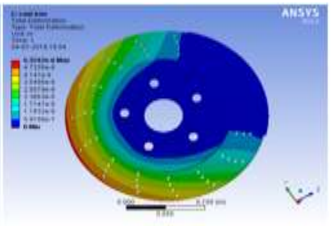


Equivalent stress analysis in **Fig-**(1) stainless steel, **Fig-**(2) grey cast iron, **Fig-**(3) silicon carbide composite, **Fig-**(4) titanium-550 alloy

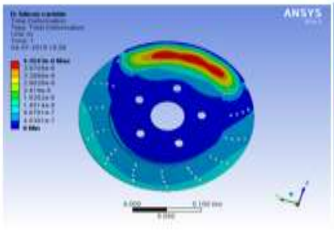
7. Total Deformation Analysis in Disc Brake:



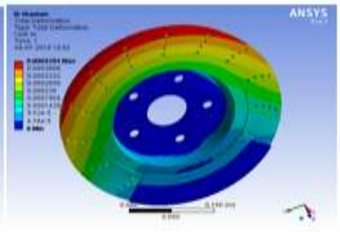
(4)



(5)



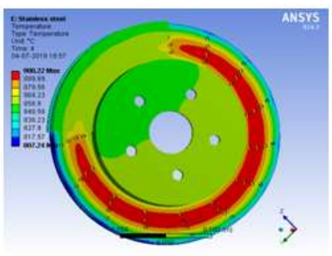
(6)



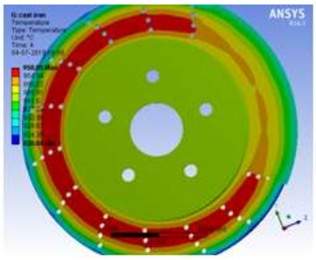
(7)

Total deformation analysis in **Fig-**(4) stainless steel, **Fig-**(5) grey cast iron, **Fig-**(6) silicon carbide composite, and **Fig-**(7) titanium-550 alloy

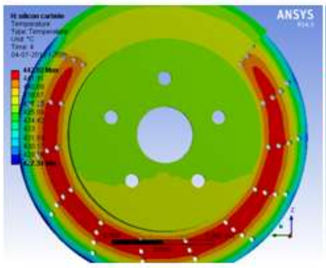
8. Temperature-Distribution Analysis:



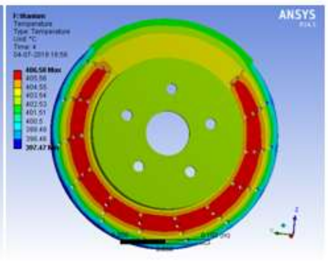
(8)



(9)



(10)



(11)

Steady-State thermal analysis in **Fig-**(8) stainless steel, **Fig-**(9) grey cast iron, **Fig-**(10) silicon-carbide, **Fig-**(11) titanium -550 alloy

9. Result Comparisons:

Material properties	Total deformation (mm)	Equivalent stress (N/mm^2)	Temperature Distribution (^0c) at 4 sec
Grey cast iron	0.00005260	61.006	900.22
Stainless steel	0.00005342	16.47	958.85
Silicon carbide composite	0.00004354	67.53	442.92
Titanium-550 Alloy	0.00004284	83.50	406.58

10. CONCLUSION

In this project, comparative study has been made between stainless steel, grey cast iron, silicon carbide- reinforced composite, and titanium 550 alloys for total deformation, equivalent stress (von-misses) and steady-state thermal analysis. Among these above four materials the best value obtained is titanium 550 alloys for total deformation (0.00004284mm), equivalent stress ($83.50N/mm^2$) and steady-state thermal temperature (406.58^0C) and the titanium is the best material to enhance the performance of the disc brake.

REFERENCES

[1] Avijit Singh Gangwar, "Design Analysis and Optimization of Disc Brake Assembly of A 4-Wheeler Race Car", International Journal of Engineering Research and Technology (IJERT)- ISSN:22780181, Volume-3, Issue-10, October 2014.

[2] S.R. Abhang, D.P. Bhaskar, "Design and Analysis of Disc Brake", International Journal of Engineering Trends and Technology (IJETT) - Volume 8 Number 4-Feb 2014.

[3] Rajeshkumar Gangaram Bhandare, Parshuram M. Sonawane, "Preparation of Aluminium Matrix Composite by using Stir Casting Method", International Journal of Engineering and Advanced Technology (IJEAT)- ISSN:2249-8958, Volume-3, Issue-2, December 2013.

[4] S. P. Ingale, Prof. A.Z. Patel, Prof. D.D. Date, Prof. A.B.Ghalke, "Advanced Transient Thermal and Structural Analysis of Disc Brake by Ansys Work-bench", International Research Journal Engineering and Technology (IRJET) – e-ISSN: 2395-0056, pISSN:2395-0072.

[5] Pratik P. Chaphale, Dr. S.B. Jaju, "A Review On Thermal and Contact Stress Analysis Of Disc Braking System", InternationalJournal of Engineering Research and General Science Volume2, Issue 1, ISSN 2091-2730, January 2014.

[6] Er. N. B. Shinde, Prof. B.R. Borkar, "C.A.D. & F.E.M. ANALYSIS OF DISC BRAKE SYSTEM", International Journal of Engineering and Computer Science, ISSN: 2319-7242,

[7] Volume 4, Issue 3, March 2015, Page No. 10697-10706

[8] 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, ISO 3297: 2007,Vol. 2, Issue 12, December 2013

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 07 | July 2019 www.irjet.net p-ISSN: 2395-0072

[9] Sadi, Viktor Malau, M Waziz Wildan, Suyitno, "Optimization of Stir Casting Process Parameters to Minimize the Specific Wear of Al-Sic Composites," Sadi et al. / International Journal of Engineering and Technology (IJET)

[10] Abhishek Kumar Tiwari, Akhilesh Kumar Tiwari, Pramod Yadav, Harigovind Singh Yadav, Shyam Bihari Lal, "Finite Element Analysis Of Disc Brake By ANSYS Workbench", IJREAT 37

[11] Malcolm P. Macnaughtan and John G. Krosnar, "Cast Iron – a brake disc material for the future?", 2nd International Seminar on Automotive Braking – Recent Developments and Future Trends, University of Leeds, UK. 14-15MAY 1998.

BIOGRAPHIES

AAQEEB SOHAIB.H.D is an aspiring student. He obtained B.E. Automobile engineering & M-tech in Machine design from B.V.V.S engineering college, Bagalkot, KARNATAKA

SAGAR CHANAL is a studious student. He obtained B.E. Mechanical & M-Tech in Machine design from B.V.V.S engineering college, Bagalkot, KARNATAKA