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Design and Analysis of Disc Brake for Bolero using Different Materials of Al-MMCs

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ABSTRACT

In a car system, we are having many safety systems. In that the most critical system in the vehicle which is brake systems. Without brake system in the vehicle will leads to the passenger in unsafe position. Therefore, it is must for all vehicles to have proper brake system. In this project we use Al-MMC materials for calculating normal force, shear force and piston force. The standard disc brake for bolero model designed using CATIA and the Static analysis will be done in ANSYS also calculate the stress, strain, deformation of disc brake model. This is important to understand action force and friction force on the disc brake new material, how disc brake works more efficiently, which can help to reduce the accident that may happen in each day

KEYWORDS: Al-MMC ,CATIA, ANSYS, Static analysis, Stress, strain ,Friction.

1. INTRODUCTION

If looking on the overall automotive parts, besides engines, there are more crucial parts that engineers need to look into consideration. Suspension, brake, electrical, hydraulic and gear are all the crucial systems in the automotive areas. Each of all system has their own functionality, which brings life to the automation industries. Brakes is such a crucial system in stopping the vehicle on all moving stages including braking during high speed, sharp cornering, traffic jam and downhill. All of those braking moments give a different value of temperature distribution and thermal stress. Good performance of disc brake rotor comes from good material with better mechanical and thermal properties. Good designs of disc brake rotor are varying across the range of the vehicles. There are different design and performance of disc brake rotor if compared between passenger, commercial and heavy duty vehicle. There are also other constraints such as cost, weight, manufacturing capability, robustness and reliability, packaging, maintenance and servicing.

For example, heavy-duty vehicle need large size of disc brake rotor if compared to passenger vehicle. Due to that, it will increased total weight ofvehicle as well as fuel consumption and reduces performances of the vehicle. Moreover, high weight of vehicle induces to high temperature increased during braking where the higher value of temperature during braking could lead to braking failure and cracking of disc brake rotor.

This project concerns of the temperature distribution and constraint of the disc brake rotor. Most of the passenger cars today have disc brake rotors that are made of grey cast iron. Grey cast iron is chosen for its relatively high thermal conductivity, high thermal diffusivity and low cost. In this project, the author will investigate on the thermal issues of normal passenger vehicle disc brake rotor, where the investigation are to determine the temperature behavior of the disc brake rotor due to severe braking of the disc brake rotor by using Finite Element Analysis (FEA).

2. RELATED WORK

OBJECTIVE

To design and analysis of disc brake for bolero using different materials of al-mmcs. To check the al-mmc materials will optimize the efficiency of cast iron. Considering the other aspects like weight, corrosion and durability and more to increase the lifespan of disc.

PROBLEM DISCUSSED

Here the problem raised when the brake applied, the stress and deformation occurred by the disc brake are very high. To check weather, the chosen Al -mmc materials will overcome this issue against the present usage material, i.e, Cast Iron.

LITERATURE REVIEW

[1]. Design and Analysis of Disc Brake Rotor

Author: Venkatramanan R*, Kumaragurubaran SB*, Vishnu Kumar C*, Sivakumar S# ,Saravanan B$.

Year of publishing: 2021

In this paper by Kumaragurubaran SB* they mainly investigated on thermal analysis of disc brake and calculated temperature distribution and heat flux finally they concluded that copper line acts as a good heat disparate.

{2}. Investigation of the Penetration and Temperature of the Friction Pair Under Different Working Conditions

Author: N. Stojanovića , O.I. Abdullahb,c, J. Schlattmannc , I. Grujić a,* , J. Glišović .

Year of published : 2020

In this research by the abdullahyhey mainly focused on the penetration and temperature variation in the disc brake at different conditions like friction, heat and more.

[3]. A computational study on structural and thermal behavior of modified disk brake rotors

Author:M.H. Pranta, M.S. Rabbi, S.C. Banik, M.G. Hafez, Yu-Ming Chu

Year of publication:2021

In this journal by M.S. Rabbi: he gave conclutionthet the study steady–state thermal and static structure analysis was performed for proposed disk brake rotors by combination of holes, straight slots, vanes, and edge cuts and compared the characteristics with the usage rotor.

[4]. A thermomechanical model for the analysis of disc brake using the finite element method in frictional contact

Author: Ali Belhocine*, OdayIbraheem Abdullah

Year of published: 2018.

In this work, numerical simulations of the transient thermal and the static structural analysis were performed here sequentially, with the coupled thermo-structural method. Numerical procedure of calculation relies on important steps such that the CFD thermal analysis has been well illustrated in 3D, showing the effects of heat distribution over the brake disc.

[5]Thermal analysis on car brake rotor using cast iron material with different geometries

Author:Ashish Kumar Shrivastava, Rohit Pandey, Rajneesh Kumar Gedam, Nikhil Kumar, T. RaviKiran

Year of publication: 2021

In this paper by Ashish Kumar Shrivastava : he gives information about the modification of brake disc rotor.at the time of designing the rotor body Space and assembly constraints are also an important aspect to increased space geometry can cause an early failure led to short life span of brake disc rotor.

[6]. Structural simulation analysis of a certain vehicle type disc brake based on ANSYS Workbench.

Author: NishantBarik and Sayyad Abdul RazakKhadari, Ziyun Wang and JianrunZhang, S Zhang, C Xue, J Yin et al.

Year of published: 2020.

In this research by the nishanth and group the gave an information about the structural simulation analysis of any particular vehicle in which to find the characteristics of disc brake on ANSYS workbench.Using the maximum stress point and maximum deformation position under the emergency braking state, combined with the results of modal analysis cloud chart, the resonance range is verified by comparing with the natural frequency, which provides reference for the actual tests and structural improvement.

[7]. Thermoelastic Analysis of Disk Brakes Rotor

Author; BouchetaraMostefa, Belhocine Ali*

Year of published: 2014

In this paper by Ali and his partner,The main purpose of this study is to analyze the thermomechanical behavior of the dry contact between the brake disk and pads during the braking phase. The simulation strategy is based on computer code ANSYS11. The modeling of transient temperature in the disk is actually used to identify the factor of geometric design of the disk to install the ventilation system in vehicles .

3. FINITE ELEMENT ANALYSIS USING ANSYS

Finite element method is a numerical method for solving any engineering problem. ANSYS is a FEA software which is used for mathematical representation of physical problems. It is also used if physical prototype is not available and it gives the approximate solutions.
ANSYS involves three stages preprocessing, solution, postprocessing for problem solving. The preprocessing involves preparation of FEA model and in the solution stage ansys automatically generates matrices that describe the behaviour of each element , assemble them & computes the unknown values primary field variables such as stress, deformation etc.,

4. PROPOSED WORK

Coordinate Measuring Machine (CMM) has been used to measure the major coordinate of real disc brake rotor. CMM has been used in order to get accurate dimension of disc brake rotor. Later, the precise dimensions have been used to translate in 2D and 3D drawing by using CATIA.

In this work, the design parameters of Disc Brake is considered from design was developed in CATIA V5 and the file was imported to ANSYS 15 for analysis. The basic understanding of the effect of Disc Brake geometric variables (i.e. width, thickness, length of each part of the component) on the stress and stiffness is clearly understood. The following steps will explain the methods followed for analyzing the artificial ankle joint at neutral position.

Step-1: Firstly, the CATIA V5 CATPART file should be imported into ANSYS 15.0 for doing static analysis.

Step-2: The imported model should be assigned with element type and material properties.

Step-3: Now the model should be meshed with desired mesh shape.

Step-4: After meshing, checking the contact pairs should be assigned to the different parts of the model.

Step-5: Contact status should be checked, boundary conditions and loads should be apply

Step-6: Solve the model for getting stresses, deflections, etc., for different materials of AL-MMCs

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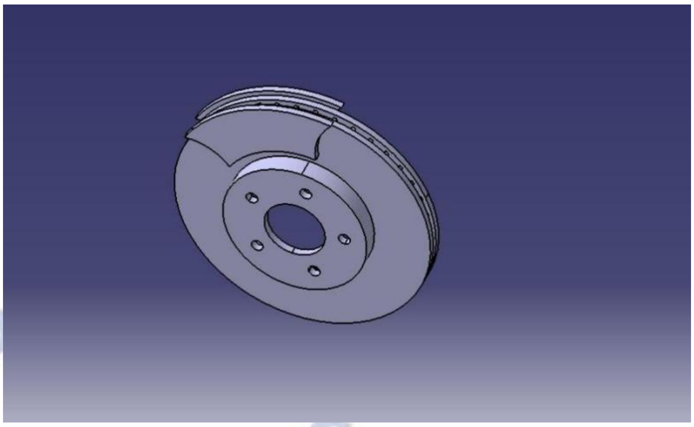

Figure 1:Disc Rotor Assembly 3D model

Methodology includes the Create a 3D model of Disc Brake assembly using parametric model in CATIA V5 software. Convert the Model into IGS File and then import the model into ANSYS workbenck. Doing Static and modal and analysis.

Table 1: Material Properties

MATERIAL PROPERTIES	Cast Iron	AL 6061-AL203	Al 5083-Al2O3	Al 7075-Al2O3	Al 2040-Al2O3
Density(kg/m^3)	7200	2800	2900	2840	2850
Possion's ratio	0.26	0.3	0.31	0.3	0.31
Young's modulus(Gpa)	120	95	94	97	100
Ultimate tensile strength(Mpa)	276	290	317	510	210

5. RESULTS

We analyzed Disc Brake structure in ANSYS 15 and finding out Von misses stress, strain and total deformation by using different materials at different loading conditions as show in below figures and then resulting all the max values of every material and are compared in the form of graphs.

Static Structural Analysis

Cast Iron Material:

We observe Von-Mises stress and Von-Mises strain and Total deformation for Cast Iron material under Loading conditions

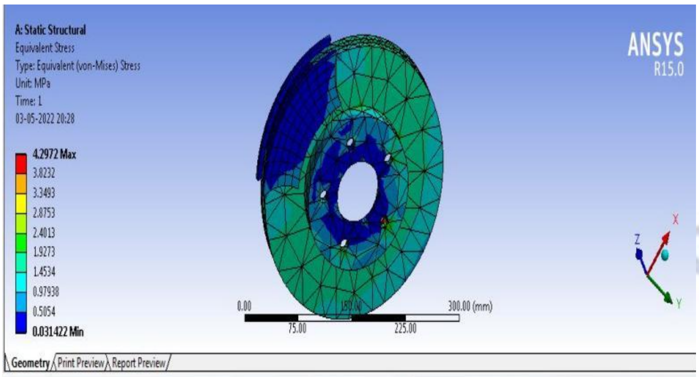

Figure 2: Von-misses stress for cast iron

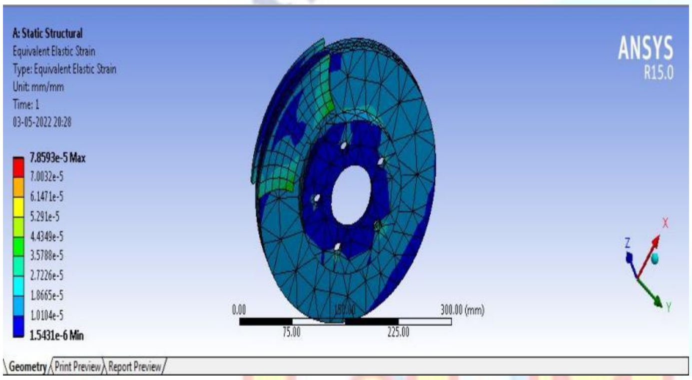

Figure 3: Equivalent strain for cast iron

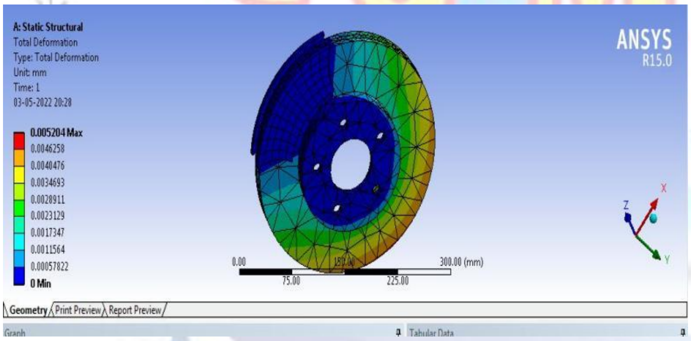

Figure 4: Total deformation for cast iron

<u>Al2024-Al2O3 Material</u>:

We observe Von-Mises stress and Von-Mises strain and Total deformation for Al2024-Al2O3 material under Loading conditions

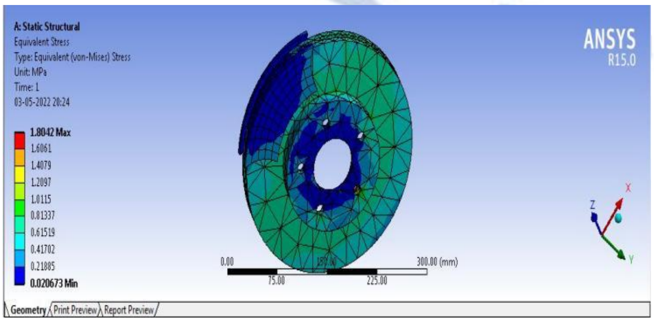

Figure 5: Von-misses stress for Al2024-Al2O3 Material

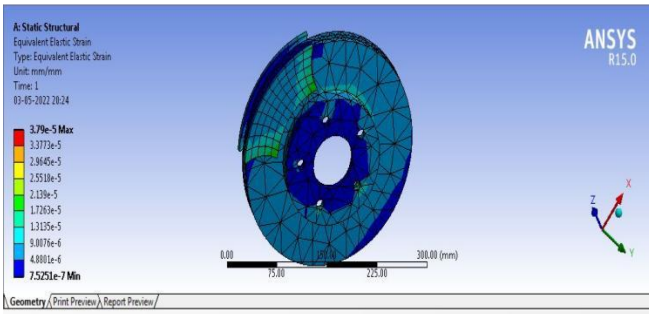

Figure 6: Equivalent strain for Al2024-Al2O3 Material

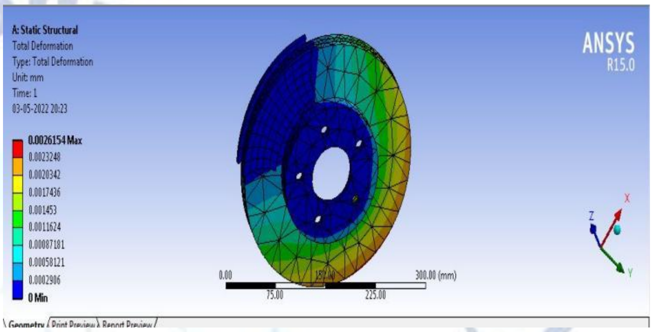

Figure 7: Total deformation for Al2024-Al2O3 Material

<u>Al5083-Al2O3 Material</u>:

We observe Von-Mises stress and Von-Mises strain and Total deformation for Al5083-Al2O3 Material under Loading conditions

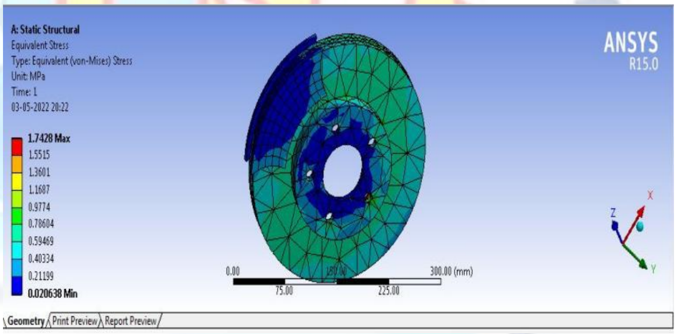

Figure 8: Von-misses stress for Al5083-Al2O3 Material

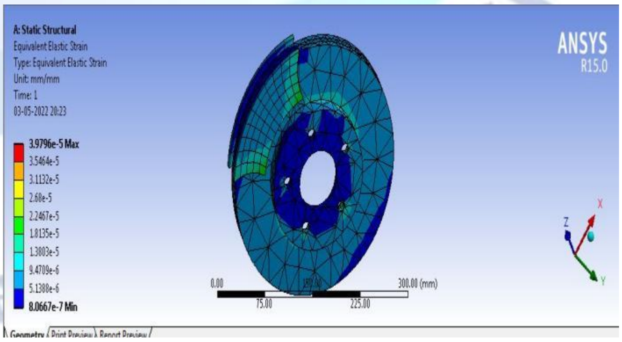

Figure 9:Equivalent strain for Al5083-Al2O3 Material

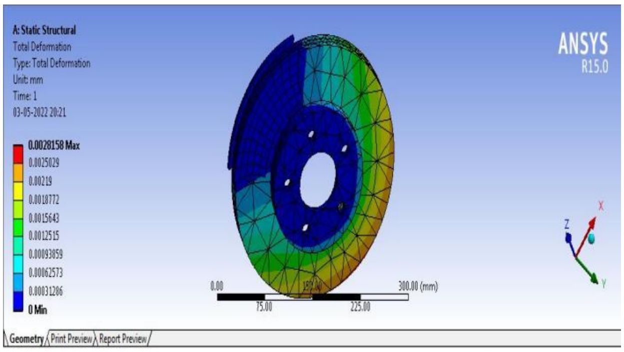

Figure 10: Total deformation for Al5083-Al2O3 Material

Al6061-Al2O3 Material:

We observe Von-Mises stress and Von-Mises strain and Total deformation for Al6061-Al2O3 material under Loading conditions

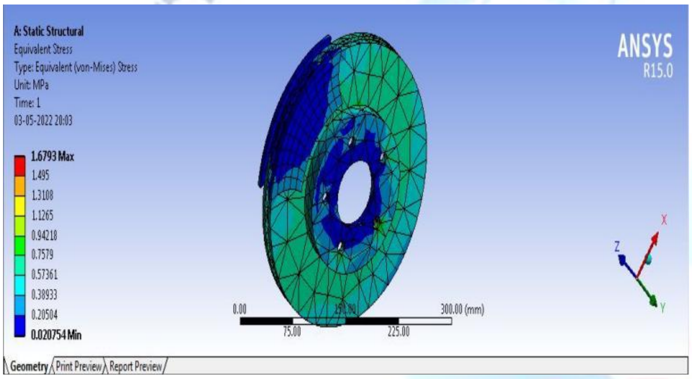

Figure 11: Von-misses stress fotAl6061-Al2O3 Material

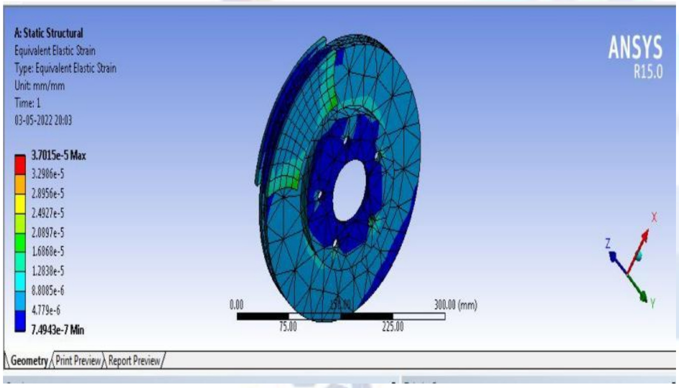

Figure 12: Equivalent strain for Al6061-Al2O3 Material

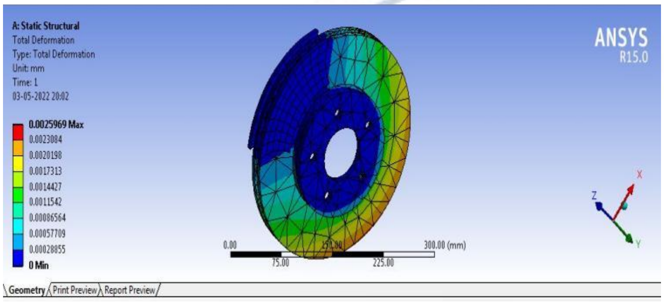

Figure 13: Total deformation for Al6061-Al2O3 Material

Al7075-Al2O3 Material:

We observe Von-Mises stress and Von-Mises strain and Total deformation for Al7075-Al2O3 material under Loading conditions

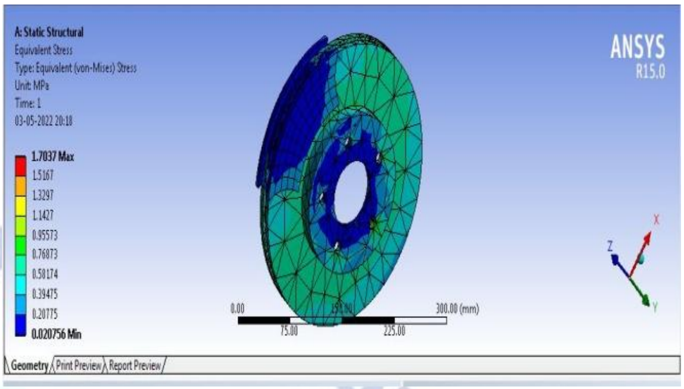

Figure 14: Von-misses stress for Al7075-Al2O3 Material

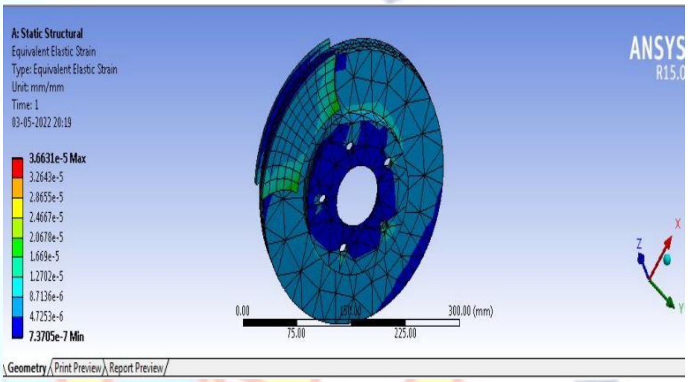

Figure 15: Equivalent strain for Al7075-Al2O3 Material

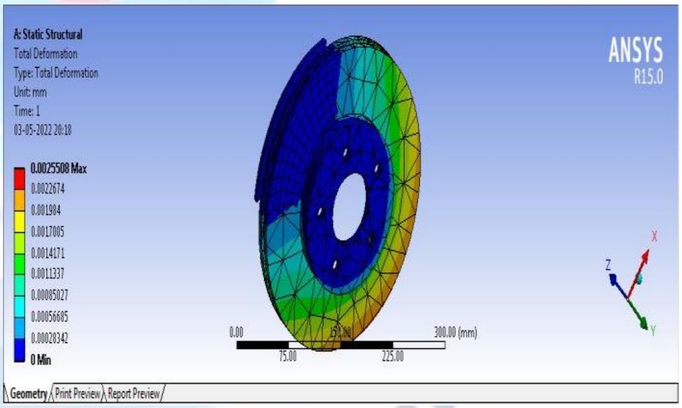

Figure 16: Total deformation forAl7075-Al2O3 Material

6. CONCLUSION

Total Deflection (in mm.) is less in disc brake when material is Aluminum 7075-Al2O3. Von-misesstases (in MPa) are less in Aluminum 6061-Al2O3 & AL7075-Al2O3 ,so best suited material is Aluminum 6061-Al2O3 & AL7075-Al2O3

It is observed that the vented disk brakes can provide better heat dissipation than the solid ones; present study can be provide a useful design tools and improvement of the brake performance in disk brake system. We can say that from all the values obtained from the analysis i.e. the Total Deformation, Von misses Stress exhibit that the vented disc is best suited design. Comparing the different results obtained from analysis, it is concluded that disk brake with material Aluminum 6061-Al2O3 & AL7075-Al2O3 is observed best possible combination for present application

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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