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Comparative Analysis of Brake Disc Materials

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Abstract: ***A brake is a device that applies artificial frictional resistance to a revolving disc in order to stop the vehicle from moving, the frictional heat created at the disc pad interface can cause high temperature during the braking period, thermal elastic stability(TEI), early wear, brake fluid vaporization (BFV), and thermally stimulated vibrations can caused by frictional heat produced on the rotor surface (TEV), better thermal stability materials will decrease these causes, we investigate the thermal and structural characteristics in this research by finite element software, the solid brake disc is made up of various materials such as titanium alloy, structured steel and gray cast iron, further we analyze the brake disc using ANSYS 16.0 and CATIA V5 is used to design the model of brake disc, for this project the heat flux calculation have been made by considering various parameters of material as well as vehicle, finally a comparison made between grey cast iron, titanium alloy and structural steel materials. With respect to equivalent stress, temperature distribution, deformation values. This paper involves selecting a best suitable material to design a brake disc which leads to better safety to passengers.***

Keywords: Titanium alloy, Structured steel, Ansys, Catia, Stress, Deformation

I. INTRODUCTION

A. Braking System

A braking is a mechanism in which it applies the artificial frictional resistance to a moving machine object to bring it to a stop. The brakes absorb kinetic energy from the moving element or potential energy from objects being lowered by hoists, elevators, and other mechanisms while performing this duty. Brakes absorb energy, which is then dissipated as heat.

The most essential safety component in a car is the brakes. Almost all vehicles have their own safety features that allow them to stop. Brakes are used to slow down and halt the spinning of the wheel. Breaking pads are mechanically pushed on the rotor disc on both surfaces to stop the wheel. They are required for all contemporary cars, as well as the safe operation of vehicles. Brakes have a transformative effect. The kinetic energy of the automobile is converted into thermal energy by the brakes.

Some requirements the brake system should follow :

1) The brakes need to be strong in order to stop the vehicle with in a less distance in case of emergency
2) The brakes need to undergo very less deformation
3) Brakes need to contain anti wear characteristics

B. Working Principle of Disc Brake

Most current road vehicles have disc brakes on the front wheels, while most racing cars have disc brakes on all four wheels. The friction material in disc brakes is in the form of pads that are attached around the edge of a revolving wheel. This wheel, known as the rotor, is a distinct device attached to the wheel with automobile disc brakes. Cast iron is commonly used for the rotor.

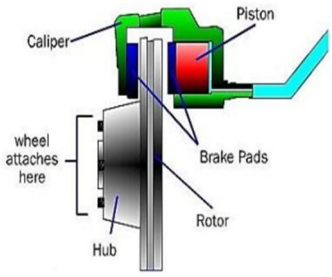

Fig 1: working principle of disc brake

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II. PROBLEM STATEMENT

When we look into all the vehicle parts, except engines, there are so many other things the engineers should consider like braking system, suspension, gear box etc. all these things have their own functionality which will bring liveness to the automobile industries. In this braking system plays most crucial part to stop the vehicle during the vehicle is in high speed, traffic jam, or down hill, in all these events the braking system will give temperature distribution, for that designing a brake with good material which have good structural and thermal properties is so important, This paper concerns the brake discs deformation, von-misses stress and temperature distribution of different materials like titanium alloy, structural steel and gray cast iron, today most of the passenger vehicles have brake discs that are made up of gray cast iron. It creates many overheating problems to overcome that we are analysing the brake disc model using different materials which have high thermal properties, less deformation, minimum wear property , also it should be in minimal cost.

III. METHODOLOGY

A. 3D Modelling

The design of brake disc is completed using CATIA V5 software, the CATIA V5 software is a mechanical design application in this the designers are able to sketch their innovative ideas, do the experiment with different dimensions, and produce the models and detailed drawings. in which we can save the model with different format like .cat, igs, .solid etc for this paper further we need to analyse this model in ANSYS software.

Table 1: The dimensions of this 3D brake disc model is given below:

Parameter name	Parameter value
Outer diameter of rotor disc	288 mm
Inner diameter of rotor disc	149 mm
Hole diameter	68 mm
Thickness of rotor disc	10 mm
Small hole diameter	10 mm
Mass of disc rotor	500 to 650 gms

Three dimensional model generation of already existing brake disc dimensions. A commercial software CATIA V5 is used to create the two dimensional views are created with the help of measured dimensions through the modelling software. different views have applied on the brake disc model to obtain the various orientational views for the better knowing of disc brake rotor model.

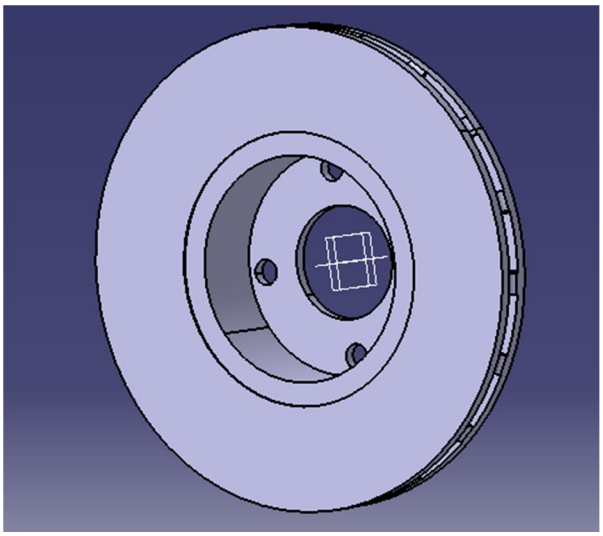


Fig 2 : Three dimensional brake disc model

IV. ANALYSIS

A. *Introduction to FEM analysis*

Steps in Finite element method:

1) *Preprocessor Phase*

a) Create a one finite problem in ansys and divide that one into many pieces

b) Let us assume that the shape of the created object defines physical behaviour of the solution

c) Now start develop the equations for that defined problem

2) *Solution phase*

a) It will generate the soln like temp, pressure, Heat flux, Displacement, Total deformation.

b) Also it will gives the graph for some objects.

3) *Post Processor Phase*

a) In this phase we will showcase our obtained results

b) The results like stress, strain, concentration factor .

B. *Properties of Materials*

SL NO	MATERIAL PROPERTIES	GREY CAST IRON	STRUCTURED STEEL	TITANIUM ALLOY
1	Thermal conductivity, k(W/m c)	42-62	15	7.5
2	Density, (kg/m3)	7200	7600	4420
3	Sp heat, (J/Kg k)	460	502	586
4	Poison's ratio	0.2	0.30	0.31
5	Co-eff Thermal expansion (*10^-6)	20	12.5	8.8
6	Elastic modulus E	125	200	1030

Table 2 : properties of brake disc materials

C. *Importing of 3D model into Ansys*

1) Import the 3D model from catia to ansys, the model should be prepared in catia to analyse it in ansys

2) The file should save it in .igs format

3) Go to the GEOMETRY and click on export the file from external

4) Click on generate button

5) The model is ready for further analysis

D. *Meshing Details of Brake Disc*

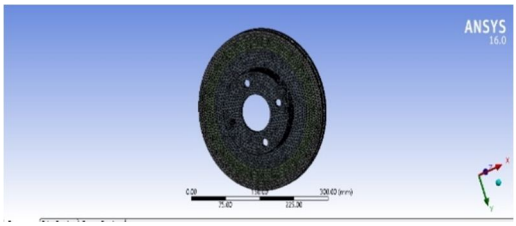
1) Select the part body of the model

2) Go to the project click on the MESH

3) it will allows you to meshing details.

4) In sizing give Relavance center as fine

5) Click on the generate



F ig 3 :meshing of brake disc

MODEL	ELEMENTS	NODES
BRAKE DISC	65114	115218

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V. RESULTS AND DISCUSSIONS

A. *Graycast Iron Brake Disc Results*

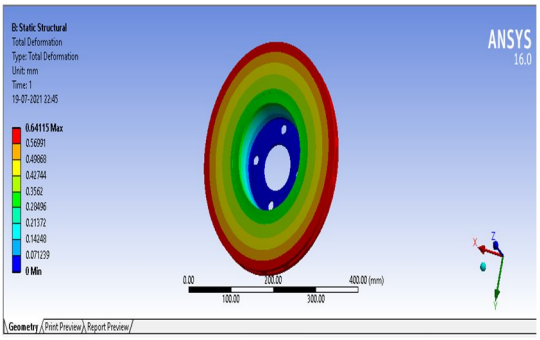

Fig 3 : Deformation

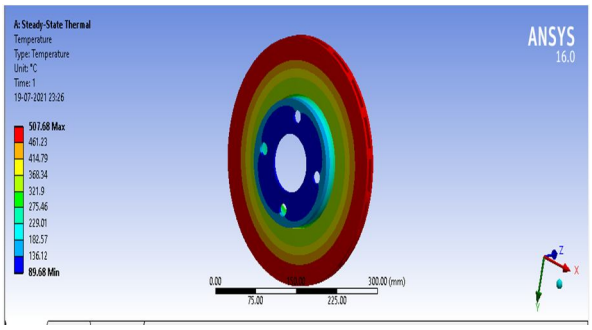

Fig 4 : Temperature distribution

B. *Titanium Alloy Brake Disc Results*

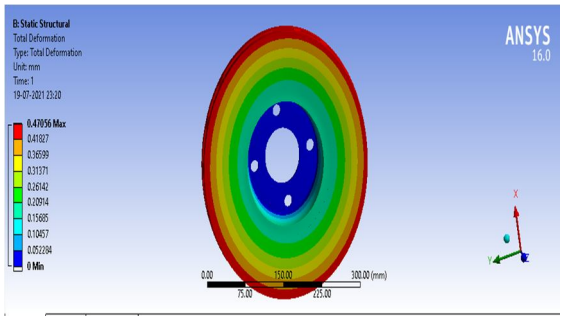

Fig 5 : Deformation

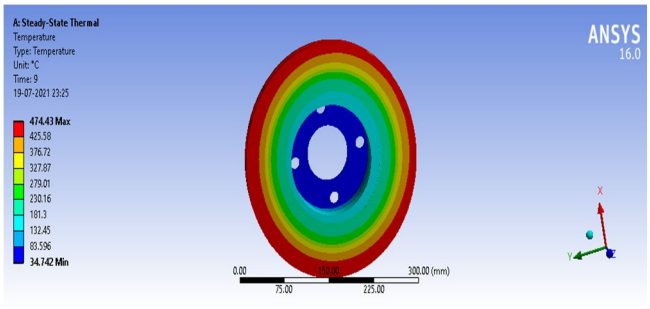

Fig 6 : Temperature distribution

C. *Structural Steel Brake Disc Results*

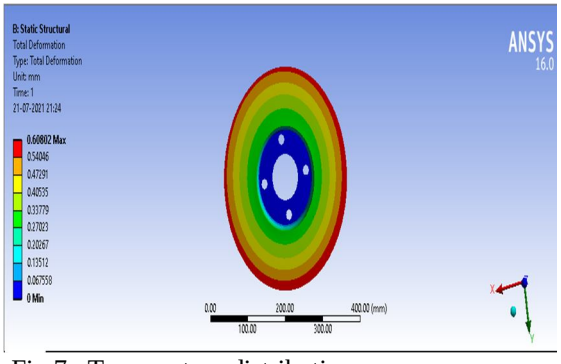

Fig 7 : Temperature distribution

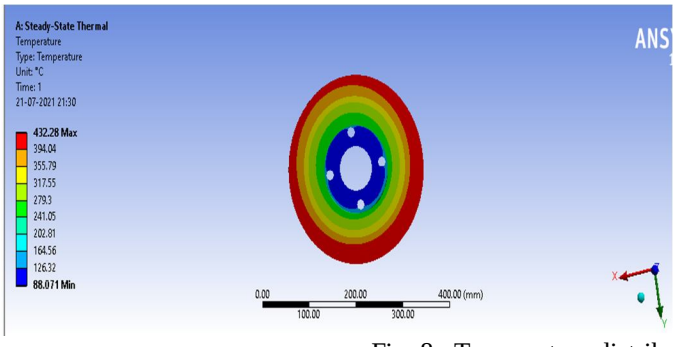

Fig 8 : Temperature distribution

VI. CONCLUSIONS

parameters	Gray cast iron	Titanium alloy	Structural steel
Deformation (mm)	0.64	0.47	0.69
Temperature (C)	507	474	432

A. We can see from the above research and numbers that Titanium alloy and GCI (Grey Cast Iron) both perform substantially better than the other materials. At the specified conditions, grey cast iron deforms just 0.6 mm, whereas titanium alloy deforms about 0.4 mm, which is less than the other materials.

B. When it comes to temperature, both metal matrix materials have a substantial maximum temperature hold, but Grey Cast Iron and Titanium alloy have temperatures ranging from 400 to 500°C.

C. However, when both temperature and deformation are considered, only GCI and Titanium alloy appear to be feasible options. As a result, both titanium alloy and Grey Cast Iron can be utilised successfully for disc brake.

D. Cast iron disc brakes are often utilised in most four-wheel cars, whereas titanium alloy disc brakes are commonly employed in trucks and heavy-duty vehicles.

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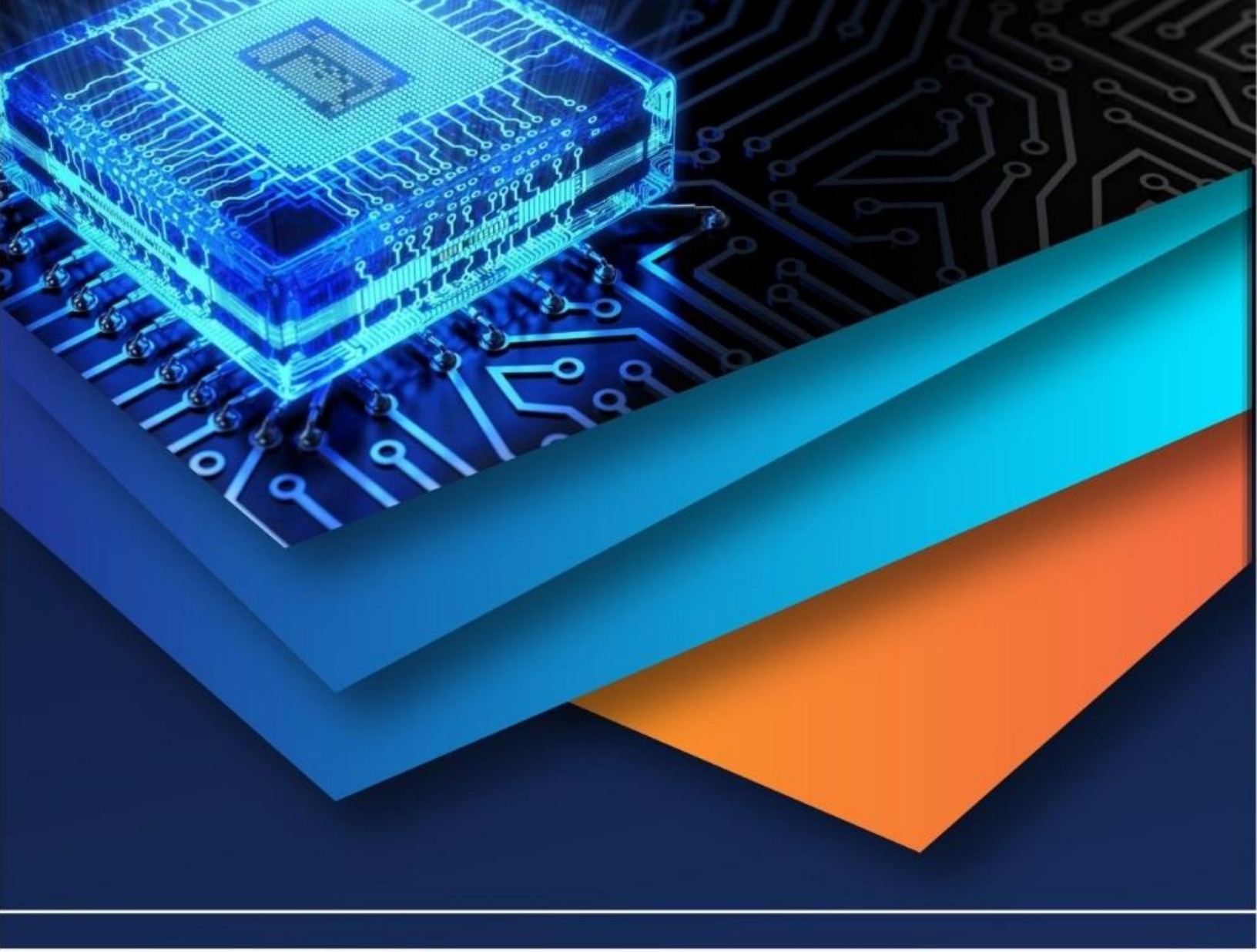

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