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Thermal Analysis of Disk Brake Using FEA Software

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ABSTRACT: This paper presents the review related guideline in thermal analysis for disk brake braking system represents one of important safety components. In automotive vehicles or modern vehicles. Brake absorbs kinetic energy of rotating device and the energy is dissipated in form of heat energy to the atmosphere. A disk brake is a type of various braking system. A disk brake is similar to plate clutch except that one of shaft is replaced by a fixed member. Disk brake dissipate the heat to the surrounding, when applied the brake it temperature and thermal stress increase so a careful in a material selection for temperature and thermal stress distribution. Taking the different material and analysis by FEA software (ANSYS). The result compared various material and select the appropriate material for the brake disk.

KEYWORDS: Brake, Disk rotor , Thermal analysis, FEA, ANSYS.

I. INTRODUCTION

A brake is defined as a mechanical device, which is used to absorb the energy possessed by a moving system or mechanism by means of friction. The primary purpose of the brake is to slow down or completely stop the motion of a moving system, such as a rotating drum, machine or vehicle. It is also used to hold the parts of the system in position at rest. An automobile brake is used either to reduce the speed of the car or to bring it to rest. It is stop to keep the car stationary on the downhill road. The energy absorbed by the brake can be either kinetic or potential or both. In automobile application, the brake absorbs the kinetic energy of the moving vehicle. In hoists and elevators the brake absorbs the potential energy released by the objects during the braking period. The energy absorbed by the brake is converted into heat energy and dissipated to the surroundings. Heat dissipation a serious problem in brake applications.

II. LITERATURE REVIEW

Sok Won Kim investigated the temperature distribution, the deformation, and the stress of automotive brake disks have quite close relations with car safety; therefore, much research in this field has been performed

Viraj parab , kunal naik, Prof A .d. dhale paper present that change in modeling of disk brake . it done design in catia. Find the value of stress in solid model .in conclusion get the allowable stress value .also check the strength of disc model .

Mr. Sumeet Satope Mr. Akshay kumar Bote In this paper mathematical inputs, and thermal loads of brake rotor, calculations of different parameters required for thermal analysis is done by taking suitable assumptions. The design of brake rotor is done on solid works 15 and analysis is done with the help of ansys 14.5. in conclusion observed that the maximum temperature rise for cast iron is much less as compared to stainless steel and thus on the basic of thermal analysis, cast iron is the best preferable material for manufacturing disc brake. but cast iron disc brake suffers a drawback of getting corroded when it comes in contact with moisture and hence it cannot be used in two wheeler and thus we prefer stainless steel

III. MATERIALS OF DISK ROTOR

Brake rotor is the most decisive part in automotive system for controlling the vehicle and safety point of view. Selection of brake rotor material is to be done on basis of consistency, friction and wear properties under varying condition of load velocity, temperature, environment and high durability.

There are many parameters to be taken in consideration while selecting materials, of which most important parameters are friction, density, temperature, stress and total deformation. The required available material must also be selected with respect to cost. It is also very important factor.

- 1- Stainless steel
- 2- Grey Cast Iron
- 3- Carbon Fiber
- 4- Aluminium alloy

IV. METHODOLOGY

FEA (Finite Element Analysis)

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

The finite element method is a very important tool for those involved in engineering design, it is now used routinely to solve problems in the following areas.

- Structural analysis
- Thermal analysis
- Vibrations and Dynamics
- Fluid flow simulations
- Crash simulations

INPUT PARAMETERS AND BOUNDARY CONDITIONS.

1-DESIGN PARAMETER

Mass of vehicle (m) -132 kg
Rotor disk diameter -0.265 meter
Thickness of rotor disk -0.0025 meter
Normal pressure -2 Mpa

2-THERMAL INPUT

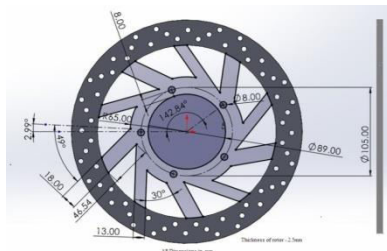
Heat flux at outer ring (friction pad area)- 3.3385×10^{-2} W/mm²
Ambient temperature -22°C
Convection coefficient – 2.3×10^4 W/mm² (Air)

3-STRUCTURAL INPUT

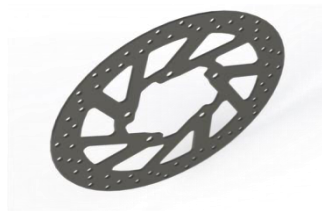
Moment at outer ring -6.627×10^5 N.mm

DIMENSIONAL MODEL

The modelling of brake disk rotor is done with ansys modeler, thus the steady state thermal analysis is min and max temperature, stress and deformation..



(a) Dimensional Model



(b) Cad Model Of Disk



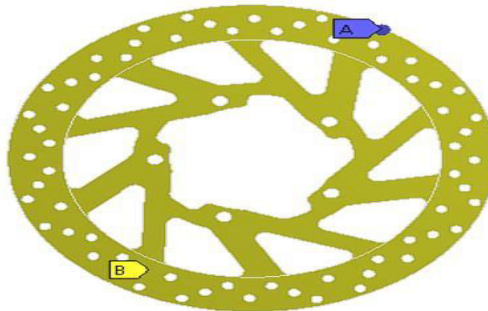
(c) Meshing of Disk

MESHING OF THE DISK: The meshed model of disk brake for Thermal analysis process. For analysis ventilated disk meshing by triangular surface mesher. The number of Nodes used in this meshing is 139520 and elements are 74225. So, the model is meshed and then analyse to get the detail and correct result of the stress of the contact surface.

APPLY BOUNDARY CONDITION :

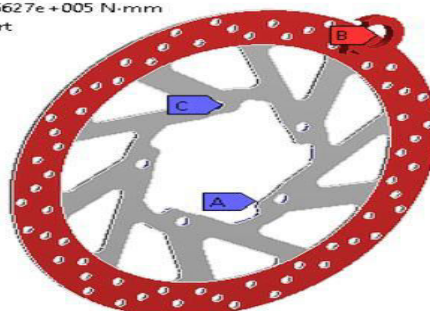
C: Gray Cast Iron
Steady-State Thermal
Time: 1. s
25-04-2021 15:42

A Heat Flux: 3.3385×10^{-2} W/mm²
B Convection: 22. °C (ramped), 2.3×10^{-4} W/mm².°C (step applied)



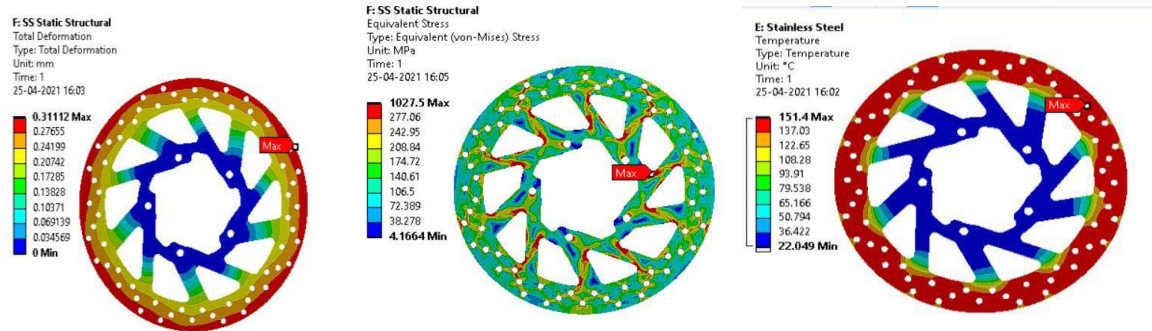
D: GCI Static Structural
Static Structural
Time: 1. s
25-04-2021 15:44

A Frictionless Support
B Moment: 6.6627×10^5 N.mm
C Fixed Support



V. FEA SOFTWARE ANALYSIS RESULT

1-ANALYSIS OF STAINLESS STEEL



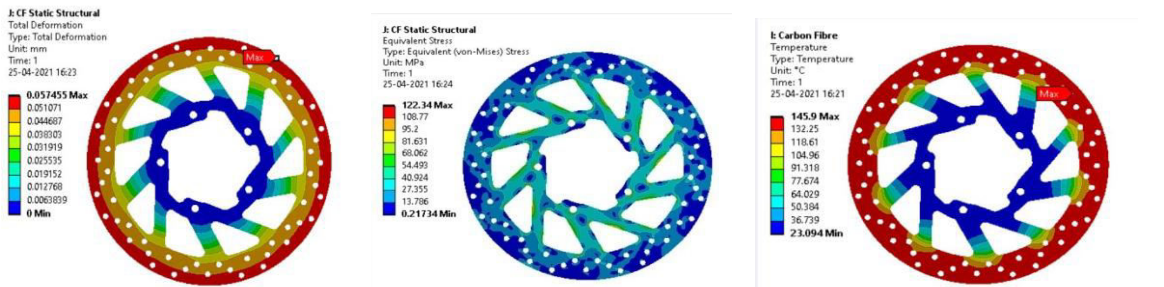
(a) TOTAL DEFORMATION (mm) (b) EQVALENTSTRESS(MPA) (c) TEMPARATURE (°C)

2-ANALYSIS OF GREY CAST IRON



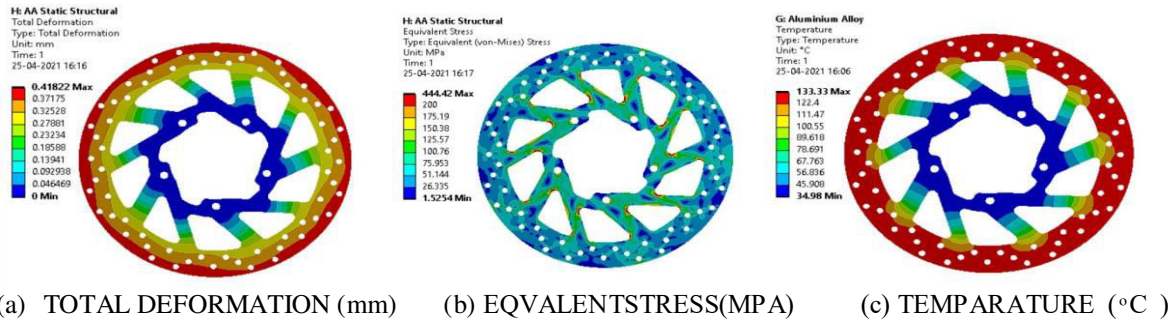
(a) TOTAL DEFORMATION (mm) (b) EQVALENTSTRESS(MPA) (c) TEMPARATURE (°C)

3-ANALYSIS OF CARBON FIBER

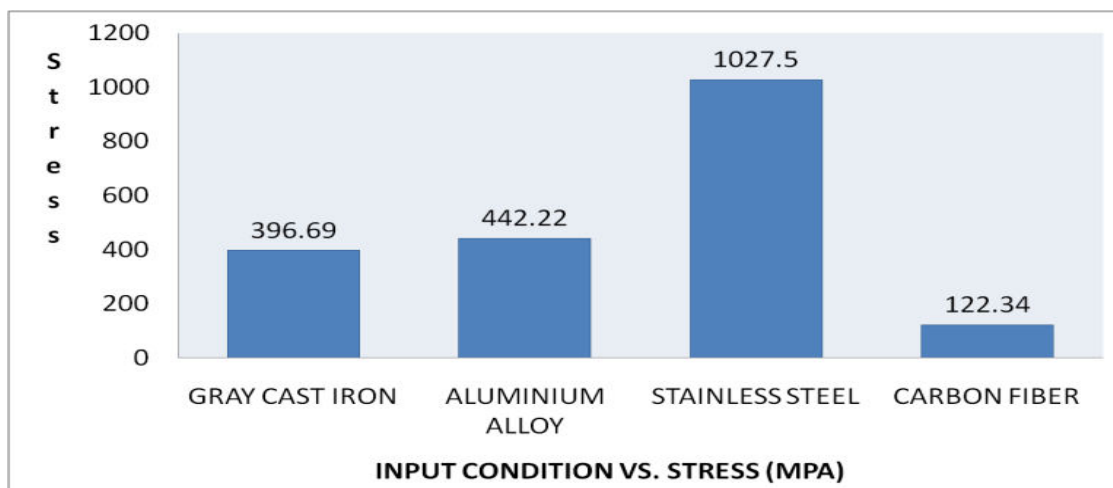
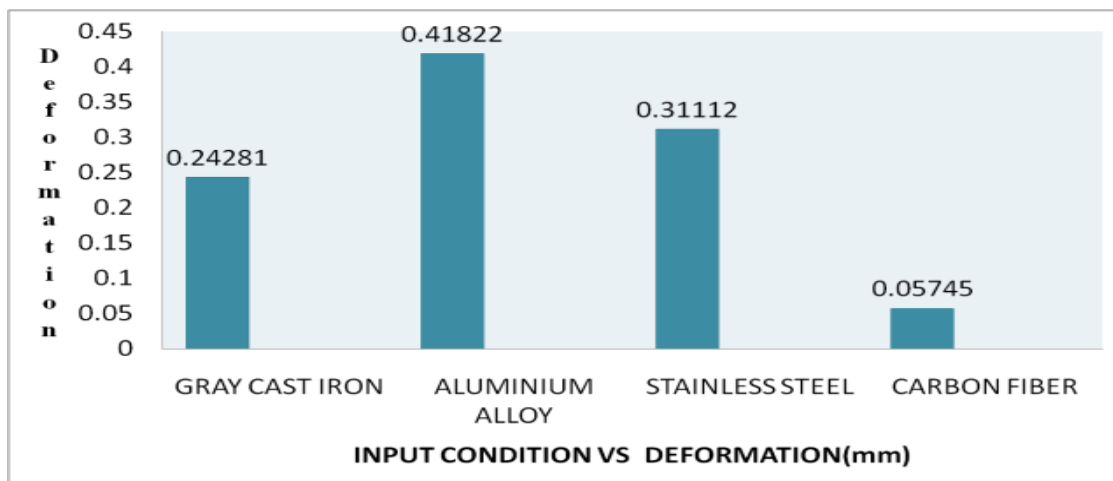


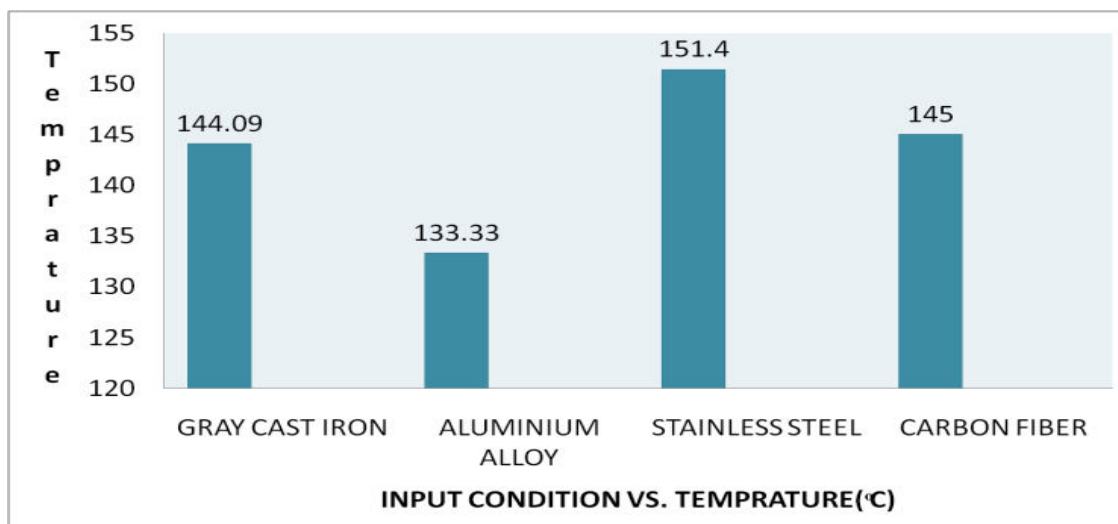
(a) TOTAL DEFORMATION (mm) (b) EQVALENTSTRESS(MPA) (c) TEMPARATURE (°C)

4-ANALYSIS OF ALUMINIUM ALLOY



GRAPH RESULT





RESULT

MATERIAL	TOTAL DEFORMATION (mm)	EQVALENT STRESS (MPA)	TEMPERATURE (°C)
STAINLESS STEEL	0.31112 MAX 0.00000 MIN	1027.5 MAX 4.1664 MIN	151.4 MAX 22.049 MIN
GREY CAST IRON	0.24281 MAX 0.00000 MIN	396.69 MAX 0.69931 MIN	144.09 MAX 24.02 MIN
CARBON FIBRE	0.057455 MAX 0.000000 MIN	122.34 MAX 0.21734 MIN	145.9 MAX 23.094 MIN
ALUMINIUM ALLOY	0.41822 MAX 0.00000 MIN	442.42 MAX 1.5254 MIN	133.33 MAX 34.98 MIN

VI. CONCLUSION

After study of different material result we obtain stress, temperature and total deformation value. It shows minimum to maximum value of parameter which occur in disk brake.

we conclude that present material stainless steel disk occur very high temperature and stress compare to other material then we analysis more better material for disk brake.



In a grey cast iron total deformation, stress and temperature are low compare to present material(stainless steel) but cast iron have some disadvantage. Like –cast iron disk is heavy weight because of more density. it also have corrosion problem . due to this criteria we analysis more better material for disk brake.

In a case of aluminium alloy temperature is very low compared to other material but we cannot select for disk brake because it induce high deformation and equivalent stress. It thermally good but not as per strength and rigidity criteria .

Finally as per analysis data and conclusions carbon fiber is most appropriate for disk brake. it induce low temperature , deformation and equivalent stress compare to other material .then carbon fiber is good as per thermally , strength and rigidity .

Carbon fiber also have low weight, great hardness and reduced wear rate, deformation resistance and decreased brake fade. These positive properties improve the safety, braking performance and comfort.

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