International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.03, April 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Experimental and Computational Investigation Of Brake Disc Using Composite Materials (FGM).

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ABSTRACT- *The study describes the design and finite element analysis of alternating material for brake rotor. The design and finite element analysis is performed by using computer aided design (CAD) software. The objective is to design and analyse the thermal and structural stress distribution of brake rotor at the real time condition during braking process. Transient thermos-elastic analysis of the Rotor Disc of Disk Brake is aimed at evaluating the performance of disc brake rotor of a bike under severe braking conditions and there by assist in disc rotor design and analysis. In the present work, an attempt has been made to investigate the suitable hybrid composite material which is lighter than stainless steel 321 and has thermal strain, Yield strength and density properties. The optimization is carried out to reduce the stress concentration and weight of the brake rotor which keeps the unsprang mass low thereby increasing the stability of the vehicle. With using computer aided design (CAD), Catia v5 software the structural model of brake rotor is developed. Furthermore, the finite element analysis performed with using the software ANSYS 16.*

Aluminium base metal matrix composite, High Strength Glass Fiber and carbon fiber composites have a promising friction and wear behaviour as a Disk brake rotor. The transient thermos-elastic analysis of Disc brakes in repeated brake applications has been performed and the results were compared. The prototype of composite brake disc was tested practically on the Honda Unicorn Bike. The suitable material for the braking operation is carbon fiber and all the values obtained from the analysis are less than their allowable values. Hence the brake Disc design is safe based on the strength and rigidity criteria. By identifying the true design features, the extended service life and long term stability is assured.

Software's Used - With using Computer Aided Design (CAD), CATIA V5 software the structural model of brake rotor is developed. Furthermore, the finite element analysis performed with using the software ANSYS 16.

Keyword s - Disc Brake FEA, Thermal Analysis, Model Analysis

1. INTRODUCTION

The need of efficient use of energy & materials is being felt strongly because of diminishing resources in the present times. There has been an important role of materials in the development of civilizations. In the transportation sector when earlier large bulky automobiles are compared with today's light weight, technologically superior vehicles. The continuously increasing demand for personal mobility has led automobile manufacturers to strive continuously for cheaper, more efficient and safer vehicles. These requirements are competing with respect to each other. However, the tough competition in today's automotive market forces vehicle manufacturers to strive for improvement in each of these fields. To improve vehicle safety without the burden of increasing vehicle weight, more and more active safety features are introduced. However, the most critical part with respect to safety is, and has always been the brake system. Due to its critical role, very high demands are imposed on the brake system with respect to reliability, durability and consistency in its behaviour. These severe demands have forced the brake system development in a rather conservative direction. Introducing

drastically new technology is never completely free of risk and in brake system development there is no room for mistakes. Therefore, the brakes on modern vehicles are an extreme optimization of a very old design.

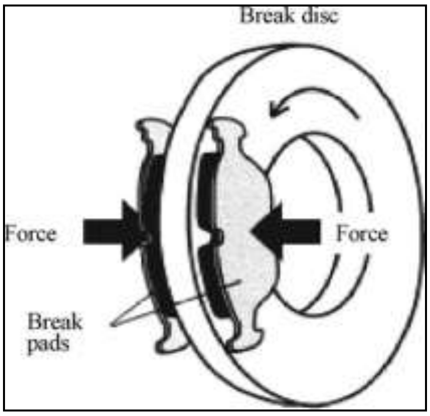


Fig 1: Basic Diagram OF Brake Pads

1.2 PROBLEM STATEMENT

Brakes are often described according to several characteristics including: Peak force - The peak force is the maximum decelerating effect that can be obtained. The peak force is often greater than the traction limit of the tires, in which case the brake can cause a wheel skid.

• Continuous power dissipation - Brakes typically get hot in use, and fail when the temperature gets too high. The greatest amount of power (energy per unit time) that canbe dissipated through the brake without failure is the continuous power dissipation. Continuous power dissipation often depends on e.g., the temperature and speed of ambient cooling air. Fade - As a brake heats, it may become less effective, called brake fade. Some designs are inherently prone to fade, while other designs are relatively immune. Further, use considerations, such as cooling, often have a big effect on fade.

• Smoothness - A brake that is grabby, pulses, has chatter, or otherwise exerts varying brake force may lead to skids. For example, railroad wheels have little traction, and friction brakes without an anti-skid mechanism often lead to skids, which increases maintenance costs and leads to a "thump" feeling for riders inside.

Fig 2: Spots Formation

• Power - Brakes are often described as "powerful" when a small human application force leads to a braking force that is higher than typical for other brakes in the same class. This notion of "powerful" does not relate to continuous power dissipation, and may be confusing in that a brake may be "powerful" and brake strongly with a gentle brake application, yet have lower (worse) peak force than a less "powerful" brake.

• Durability - Friction brakes have wear surfaces that must be renewed periodically. Wear surfaces include the brake shoes or pads, and also the brake disc or drum. There may be trade-offs, for example a wear surface that generates high peak force may also wear quickly.

• Weight - Brakes are often "added weight" in that they serve no other function. Further, brakes are often mounted on wheels, and unsprang weight can significantly hurt traction in some circumstances. "Weight" may mean the brake itself, or may include additional support structure.

• Noise - Brakes usually create some minor noise when applied, but often create squeal or grinding noises that are quite loud.

2. LITERATURE SURVEY –

Abd Rahim Abu-Bakar, Huajiang Ouyang [1],This paper studies the contact pressure distribution of a solid disc brake as a result of structural modifications. Before modifications are simulated, four different models of different degrees of complexity for contact analysis are investigated. It is shown that the contact pressure distributions obtained from these four models are quite different. This suggests that one should be careful in modelling disc brakes in order to obtain correct contact pressure distributions. This work could help design engineers to obtain a more uniform pressure distribution and subsequently satisfy customers' needs by making pad life longer.

Banakar Prashanth & Shivananda H.K. [2], The objective of this research was to gain a better understanding of Mechanical properties of epoxy resin composites reinforced with carbon Fibre. The effect of Fibre orientation of laminates has been investigated & experimentation was performed to determine property data for material specifications, the laminates were obtained by hand layup process. The laminates were cut to obtain ASTM standards. This investigation deals with the testing of tensile and flexural strength on a universal testing machine. The graphs that are obtained from the tests are documented. This research indicates that the mechanical properties are mainly dependent on the Fibre orientation of laminated polymer composites.

Chavan Prashant, Apte Amol [3], Gives simplified yet almost equally accurate modeling and analysis method for thermo-mechanical analysis using brake fade test simulation as an example. This methodology is based on use of ABAQUS Axisymmetric analysis technique modified to represent effect of discrete bolting, bolt preloads, and contacts within various components of the assembly.

Hao Xing [4], A disc brake system for passenger car is modelled and analysed using both approaches i.e. the transient analysis and complex modal analysis. Complex modal analysis is employed to extract natural frequencies and a transient analysis is carried out to study the thermal effects during braking. The effect of friction in complex modal analysis is investigated.

3. DESIGNING THE DISC BRAKE

The first step is development of CAD model according to geometric specifications followed by selection of material. Finite element analysis is done using simulation software for different materials. Deformation, Von Mises stress and Maximum temperature generated are investigated by coupled thermo mechanical.

3.1. GEOMETRICAL MODELLING

3.2. The model is constructed by using CATIAV5R21, the explode view of the model as shown in.

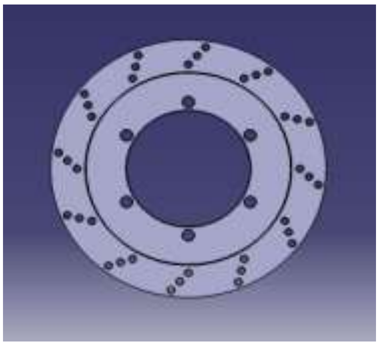
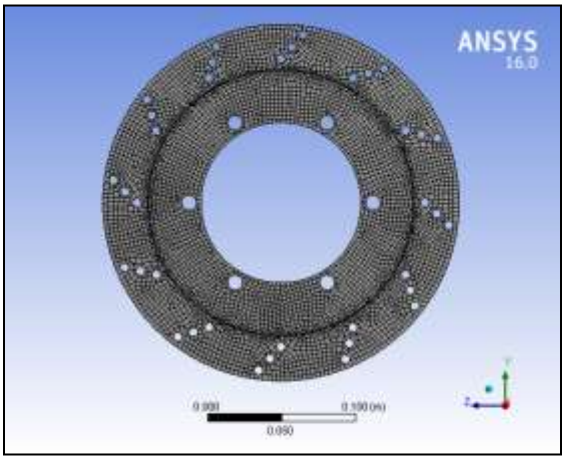


Figure 3: CAD Model of Brake Disc.

3.2 MESHING OF THE DISC



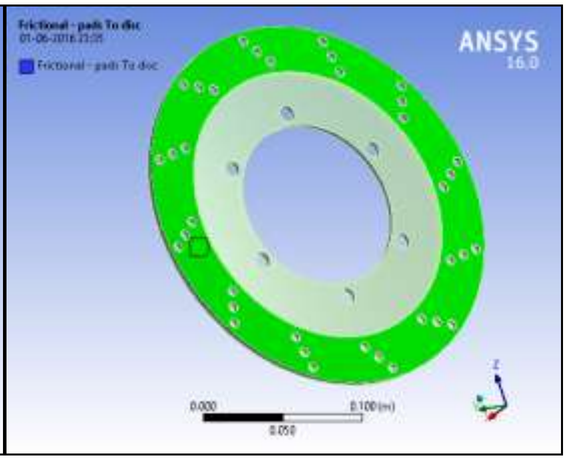
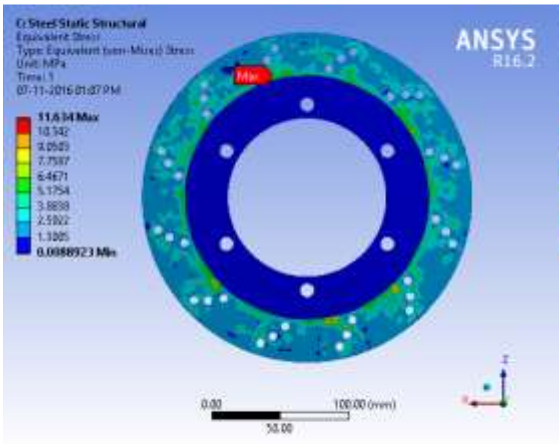


Figure 4: Meshing of Brake Disc

Figure 5: Contact Zone of the Disc and Pad



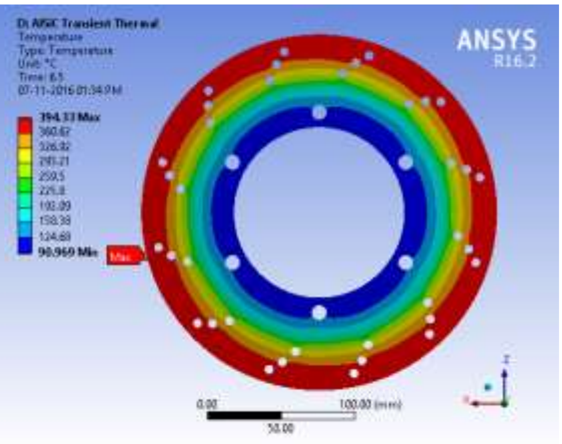


Figure 6: Maximum Stress Developed in in Stainless Steel 321 Brake Disc

Figure 7: Maximum Temperature Generated Aluminium Silicon Carbide MMC Brake Disc.

3.2 DESIGN CALCULATIONS OF BRAKE ROTOR

The dimensions of Honda Unicorn brake rotor were considered for the design purpose

- Disc diameter = 240 mm
- Pad rotor contact = 60 mm (radius)
- P = fluid pressure, Pa
- FP = pedal force = 25 Kg =245 N
- R = pedal lever ratio = 4: 1
- H = Pedal efficiency = 0.8

IJARSE
ISSN: 2319-8354

Standard size of master cylinder is 12.055mm

i. **Actual Pressure Generated by The System:**

P = 6.87MPa.

ii. **Clamping Force Is Calculated as:**

CF = 7240.88 N

iii. **Brake Torque Developed Is :**

T_{Bd} = 228 Nm

iv. **Kinetic Energy:**

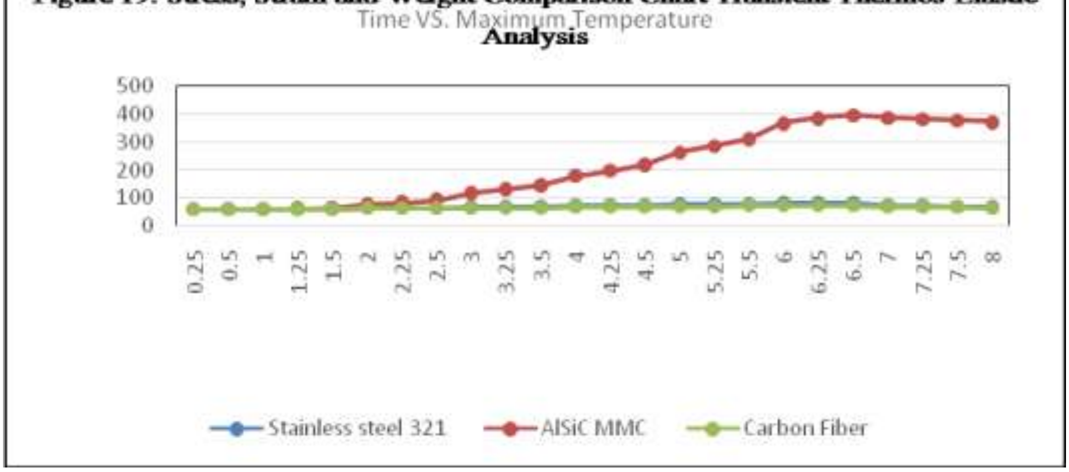
K.E. =84876.543Joule

v. **Braking Power:**

P =13057.93Watt

4. COMPARED RESULT

Figure 19: Stress, Strain and Weight Comparison Chart Transient Thermos-Elastic Analysis



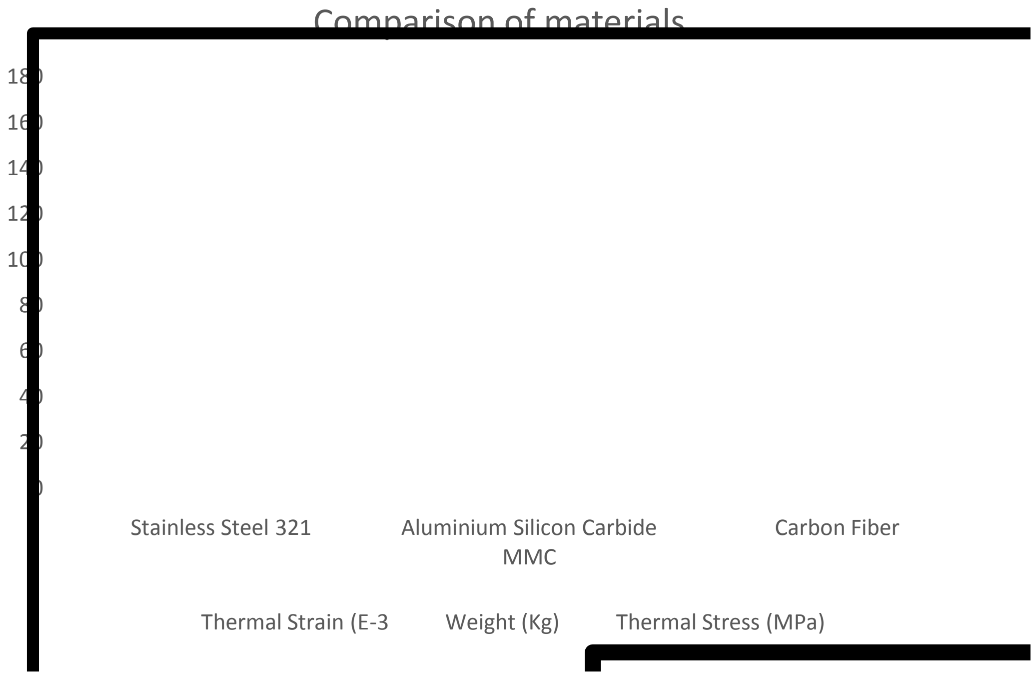


Figure 20: Time VS Temperature Chart of Transient Thermos-Elastic Analysis

5. CONCLUSION

This project gives a numerical simulation of the thermal behaviour of brake disc for four different materials in transient state. By means of the computer software ANSYS 16.In order to improve the braking efficiency and provide greater stability to vehicle, an investigation was carried out and the suitable hybrid composite material which is lighter than traditional materials used for brake disc and has preferably good Young's modulus, Yield strength and density properties.Though the disc has low weight, it has hardness, greater stable characteristics which can withstand high pressure, temperature and resistance to thermal shock.

6. FUTURE SCOPE OF THE PROJECT

In our function, the best a mix of both composite material that's brighter compared to toss in terms of iron and possesses good Young's modulus, provide energy along with density properties is usually been recently looked into. A transient thermal research will likely be carried out to analyse the actual heat alternative over the utilizing asymmetric aspects. Additionally, structural research also is carried out by simply coupling thermal research. A transient thermal research will likely be carried out to produce light weight, cost effective and eco-friendly material having combine properties of Fibre and ceramic.

Refrences

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[2] Abd Rahim Abu-Bakar, Huajiang Ouyang, Recent Studies of Car Disc Brake Squeal.