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Analysis of various brake lining Material used for Disc Brake of Bajaj Pulsar 150CC by using FEA

[1]Mr. V.A.Nehete, [2]Prof. R.B.Barjibhe
[1]P. G. Student, [2]Asso. Prof. Mech Engg Deptt, S.S.G.B.C.O.E & T. Bhusawal, India
vaibhav.nehete1@gmail.com , rahulbarjibhe@yahoo.com

***Abstract*— Vehicle braking system is considered as one of the most fundamental safety-critical systems in modern vehicles as its main purpose is to stop or decelerate the vehicle. The frictional heat generated during braking application can cause numerous negative effects on the brake assembly such as brake fade, premature wear, thermal cracks and Disc Thickness Variation (DTV). Brake pads are important parts of braking system for all types of vehicles that are equipped with disc brake. Brake pads are steel backing plates with friction material bound to the surface facing the brake disc. The brake pads generally consist of asbestos fibers embedded in polymeric matrix along with several other ingredients. The use of asbestos fibre has been avoided due to its carcinogenic nature. A new asbestos free friction material and brake pads has been developed. It is envisioned that future developments in the trend of brake friction materials will closely mimic the current trends of the automotive industry. One of the major differences between drum brakes and disc brakes is that drum brakes tend to be enclosed where disc brakes tend to be exposed to the environment. So there is need to develop the new friction material.**

Keywords- Disk brake, friction material, PRO-E, ANSYS software

I. INTRODUCTION

The main purpose of brake is to decelerate a vehicle by transforming the kinetic energy of the vehicle to heat via friction and dissipating that heat to the surroundings. During this process the break pad play important role during braking. As we apply the brake due to friction the heat is generated and break pad wears. Due to repetitive braking process large amount of heat is generated and break pad wear more rapidly due to thermal stress and it will not working properly.

My aim in this project is to suggest a new brake lining friction material as compared to the existing break pad material. First we have to find out the thermal and contact stress of the existing material the analytically. Then find such material which is having better material properties than existing. Then do the analytical calculation for the suggested material. Comparison is done on the basis of analytical calculation for existing brake pad and the suggested materials. Then choose such a material which is having good result as compared to the existing one. This is the first phase of my project.

Second phase is to validate the result with the software generated results. Simulation is done for existing material and the suggested material. First 3-D CAD model of disc braking assembly is prepared with the help of Pro-E. It represents the surface boundary of the model. The model is the complete solid.Then next stage is to import this model into the simulation software for analysis purpose. The software used for the simulation is ANSYS. By applying the boundary conditions pressure analysis and the thermal analysis is examined by using the software generated results.

II. LITERATURE SURVEY

Friction Material: M.K. Abdul Hamida, G.W. Stachowiakb, S. Syahrullaila in 2013 studies the Changes in friction and contact surfaces characteristics of a brake friction material during drag and stop mode test were investigated using a brake model tribo-tester. Scanning Electron Microscopy (SEM) was utilized to reveal the surface topography characteristics and analyze the external particle size effects on friction coefficients and grit embedment. Silica sand with three different The Effect of External Grit Particle Size on Friction Coefficients and Grit Embedment of Brake particle sizes of 50-180 µm, 180-355 µm and 355-500 µm was used in this work. At higher disc sliding speed, results showed that small grit particles cause higher friction due to greater frequency of particles mixing and modifying the effective contact compared to bigger particles. Good friction stability was attributed to smaller particles size providing more stable contact by actively involved in building up and reducing the rate of changes of the effective contact area. Through SEM analysis, signs of formation and disintegration of contact plateaus correlated well with particle size and hence, suggesting the significant role of particle size as wearing mechanism. Grit embedment (GE) was greatly dependent on presence of compacted wear debris as most particles were found embedded into compacted wear debris.

2) Investigation of temperature and thermal stress in ventilated disc brake based on 3D thermo mechanical coupling model: Ali Belhocine, Mostefa Bouchetara in 2012 studies the thermal behavior of the full and ventilated brake discs of the vehicles using computing code ANSYS. The modeling of the temperature distribution in the disc brake is used to identify all the factors, and the entering parameters concerned at the time of the braking operation such as the type of braking, the geometric design of the disc, and the used material.

3) The numerical simulation for the coupled transient thermal field and stress field is carried out by sequentially thermal-structural coupled method based on ANSYS to evaluate the stress fields and of deformations which are established in the disc and the contact pressure on the pads. The results

obtained by the simulation are satisfactory compared with those of the specialized literature.

Experimental and Simulated Studies on Temperature Distribution for Various Disc Brakes: D.Murali Mohan Rao, Dr. C. L. V. R. S. V. Prasad, Ramakrishna in 2013 studies the Vehicle braking system is considered as one of the most fundamental safety-critical systems in modern vehicles as its main purpose is to stop or decelerate the vehicle. The frictional heat generated during braking application can cause numerous negative effects on the brake assembly such as brake fade, premature wear, thermal cracks and Disc Thickness Variation (DTV). In the past, surface roughness and wear at the pad interface have rarely been considered in studies of thermal analysis of a disc brake assembly using finite element method. The ventilated pad-disc brake assembly is built by a 3D model with a thermo-mechanical coupling boundary condition and multi-body model technique. The numerical simulation for the coupled transient thermal field and stress field is carried out by sequentially thermal-structural coupled method based on ANSYS to evaluate the stress fields and of deformations which are established in the disc which is another significant aspect in this research.

4) Design and Analysis of Disc Brake: Swapnil R. Abhang, D.P.Bhaskar in 2014 Each single system has been studied and developed in order to meet safety requirement. Instead of having air bag, good suspension systems, good handling and safe cornering, there is one most critical system in the vehicle which is brake systems. Without brake system in the vehicle will put a passenger in unsafe position. Therefore, it is must for all vehicles to have proper brake system. In this paper carbon ceramic matrix disc brake material use for calculating normal force, shear force and piston force, also calculating the brake distance of disc brake. The standard disc brake two wheelers model using in Ansys and done the Thermal analysis and Modal analysis also calculate the deflection and Heat flux, Temperature of disc brake model.

5) Optimization of a Non Asbestos Semi metallic Disc brake pad formulation with respect to friction and wear: M.A.Sai Balaji, Dr. K.Kalaichelvan in 2012 studies A semi metallic friction formulation consisting of Zircosil, barites, Copper fiber, synthetic graphite, NBR (Nitrile Butadiene rubber), steel wool and Alkyl benzene modified phenolic resin with acceptable friction coefficient and low wear was developed using Golden Section approach to search the optimal weight fraction of each ingredient in the formulations.

III. THEORY

3.1 Characteristics required for brake linear

The material use for the brake lining should have the following characteristics:

1. It should have high coefficient of friction with minimum fading.
2. It should have low wear rate.
3. It should have high heat resistance.
4. It should have high heat dissipation capacity.
5. It should have adequate mechanical strength.
6. It should not be affected by moisture and oil.

TABLE 1
Material Properties of Rotor and Existing Pad

Properties	Cast Iron (DISC)	Existing pad
Density	7.4 g/cm^3	2.58 g/cm^3
Young's modulus (E)	130 GPa	72.9 GPa
Poisson's ratio	0.27	0.22
Thermal conductivity	55 W/m K	1.3 W/m K
Specific Heat	447 J/Kg K	810 J/Kg K
Coefficient of thermal expansion	10 e-6 /K	5.4 e-6 /K

3.2 ANSYS Result of Existing material of Disc brake

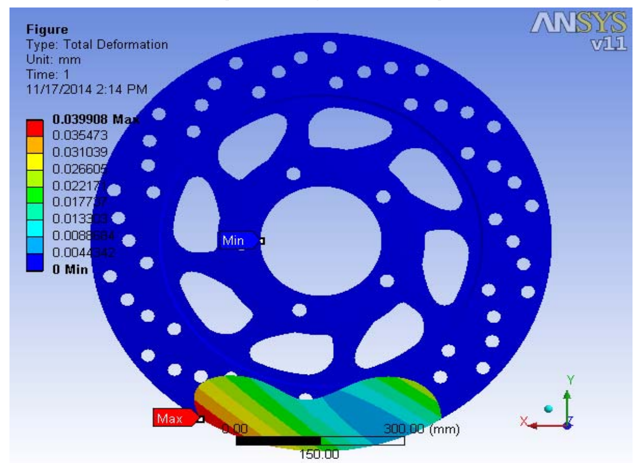

Fig 3.1: Total Deformation induced in Non Asbestos Semi Metallic

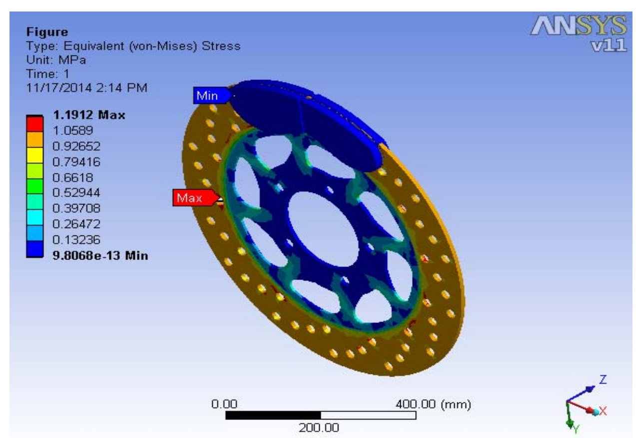

Fig 3.2: Equivalent Stress induced in Non Asbestos Semi Metallic

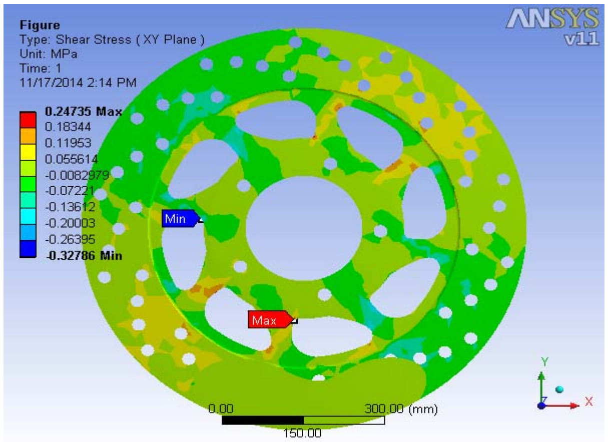

Fig 3.3: Shear Stress induced in Non Asbestos Semi Metallic

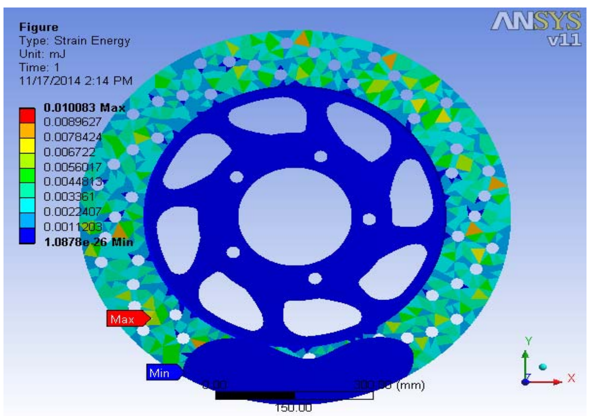

Fig 3.4: Strain Energy Loss in Non Asbestos Semi Metallic

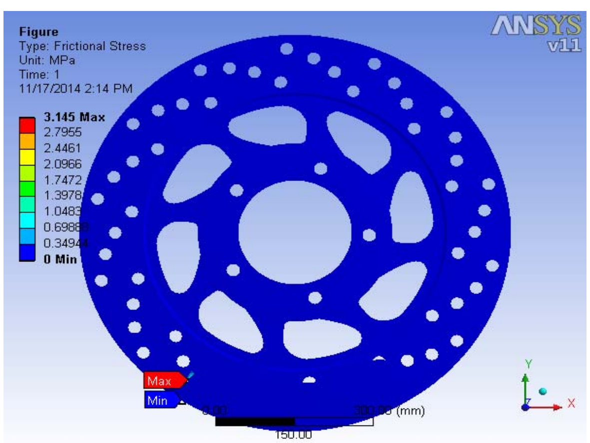

Fig 3.5: Frictional Stress Induced in Non Asbestos Semi Metallic

3.3 Material Selection Type

As discuss earlier in the research methodology, before 1970 most of the car makers were made of an asbestos material because its ability to quickly dissipate the heat and the durability brake pad.

There are two basic types of replacement linings being used in today's marketplace. Although most manufacturers like to keep their recipe hidden from their competitors, and up to 20 different ingredients are blended into proprietary linings, all fall into one of two categories.

3.3.1 Semi-Metallic Pad

In semi-metallic pad contains the mixture of metallic and organic ingredients and the non asbestos organic contains only the minerals fibres. The semi-metallic pads are made of hard resin matrix with the steel fibre. also it will have the following disadvantages.

a) It wears the brake disc/ rotors.
b) It also creates brake sequel/noise.

3.3.2 Non-Asbestos Organic

Both low metallic and non-metallic brake linings are frequently called non-asbestos organic (NAO). In non-asbestos organic brake pad contains the composition of polymer/ceramic/mineral fibres such as glass fibre, armide fibre. By using the appropriate composition the mechanical properties of these types of the brake pad increases. Also it covers the disadvantages as in semi-metallic brake linear.

3.4 Material Selection Procedure

These materials having a lower density and higher thermal conductivity as compared to the conventionally used gray cast irons are expected to result in weight reduction of up to 50 – 60 % in brake systems Since brake disc or rotor is a crucial component from safety point of view, materials used for brake systems should have stable and reliable frictional and wear properties under varying conditions of load, velocity, temperature and environment, and high durability. The most important consideration is the ability of the brake disc material to withstand high friction and less abrasive wear. Another requirement is to withstand the high temperature that evolved due to friction. The brake disc must have enough thermal storage capacity to prevent distortion or cracking from thermal stress until the heat can be dissipated. This is not particularly important in a single stop but it is crucial in the case of repeated stops from high speed.

The material selection is done on the basis of strength, strength, higher friction coefficient, wear resistant, light weight, and good thermal capacity and economically viable. Following are the non-asbestos organic suggested materials

3.4.1 Carbon reinforced fibre

Carbon fibre reinforced plastics (CFRP) are used in various fields due to their high specific modulus and strength. Carbon fibres have high thermal conductivity, their composites are expected to be used as heat control materials. Carbon materials with covalently bonded atoms possess very high specific strengths and retain this strength at high temperatures in the temperature range over 1500^0C. Over the past three decades, carbon fibres have proved to be the main reinforcement for advanced composites for a wide range of applications.

Carbon fibres are a few microns thick light weight, very strong and stiff black synthetic fibres with long aromatic molecular chains comprising mainly carbon. These fibres are capable of maintaining their structure and properties under extreme conditions of temperature and pressure, fluids etc. and therefore can be used with all types of matrices, polymer, ceramic and metal, employing different composite processing techniques.

The properties of interest are strength and stiffness, fracture toughness, frictional properties, thermal conductivity and resistance to oxidation at high temperatures. both reinforcement and matrix, are likely to undergo a change in properties during processing as influenced by heat treatment temperature, differential dimensional changes, thermal stresses etc. For the comparison with the existing brake pad carbon reinforced fibre shows good thermal properties hence, we choose this material as alternative.

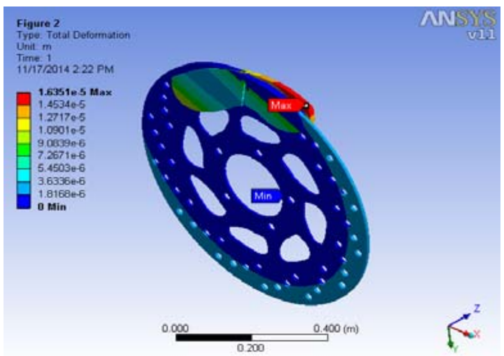

Fig: 3.6 Total Deformation of Carbon reinforced fibre

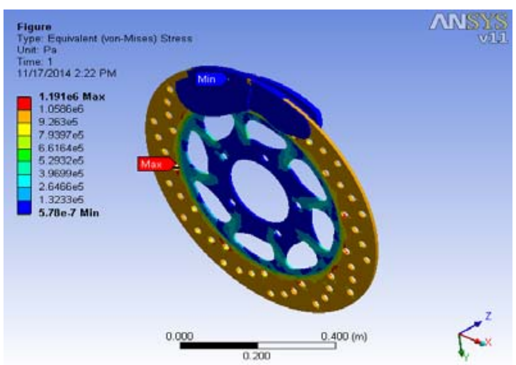

Fig: 3.7 Equivalent Stress Induced in Carbon reinforced fibre

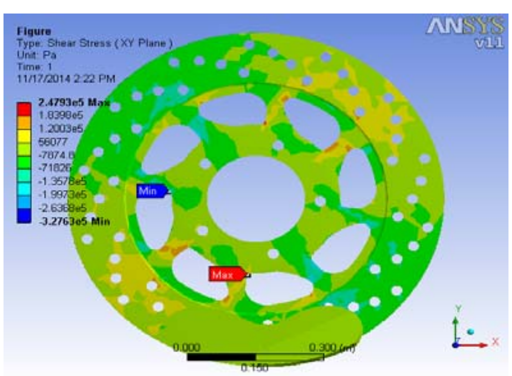

Fig 3.8: Shear Stress Induced in Carbon reinforced fibre

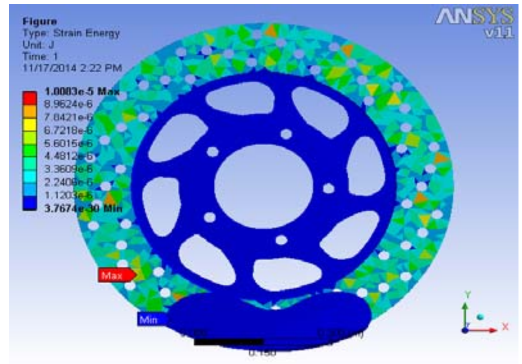

Fig: 3.9 Strain Energy Loss in Carbon reinforced fibre

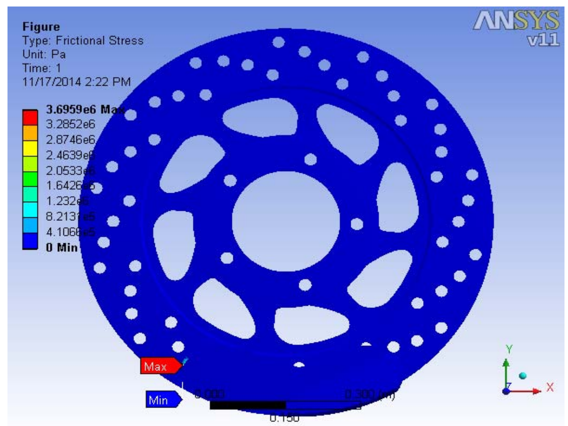

Fig: 3.10 Frictional Stress Induced in Carbon reinforced fibre

3.4.2 Ceramic

Ceramic brake pads are generally a term for a group of pads known as NAO or non asbestos organic pads. Ceramic fibres are a relatively new addition in brake. They are typically made of various metal oxides such as alumina as well as carbides such as silicon carbide. With a high thermal resistance melting points ranging from 1850 to 3000 °C light weight and high strength they are very suitable as reinforcing fibres. Their high strength–weight ratio means that they are preferred over metallic fibres which are much heavier.

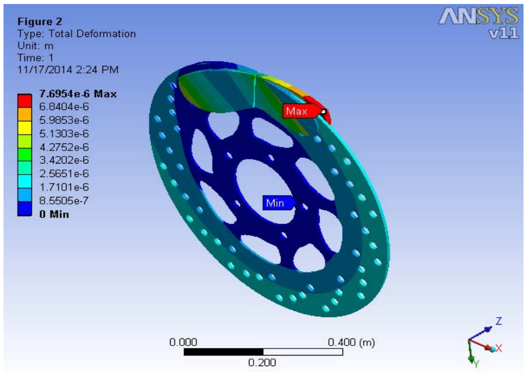

Fig 3.11: Total Deformation Of Ceramic Fibre Brake Pad

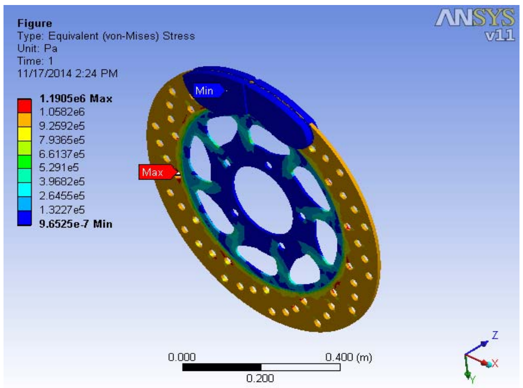

Fig 3.12: Equivalent Stress Induced in Ceramic Fibre Brake Pad

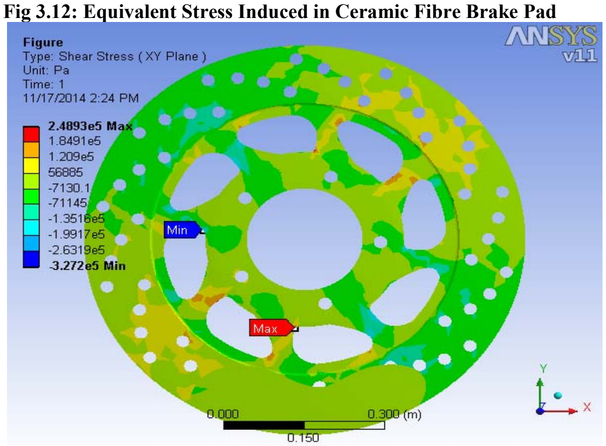

Fig 3.13: Shear stress Induced in Ceramic Fibre Brake Pad

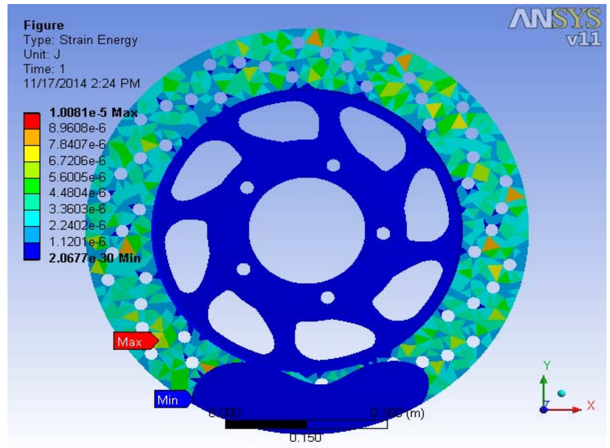

Fig 3.14: Strain Energy Loss in Ceramic Fibre Brake Pad

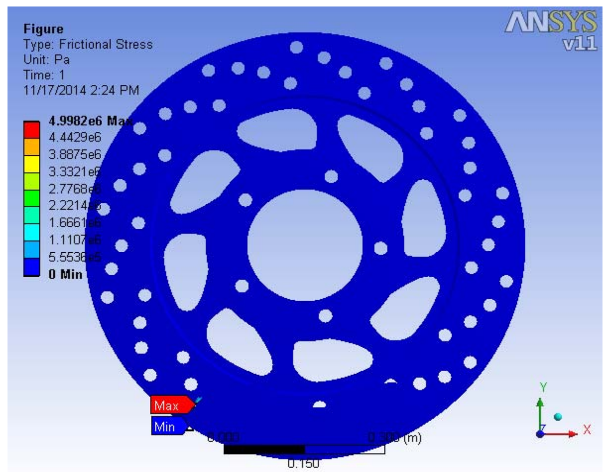

Fig 3.15 : Frictional Stress Induced in Ceramic Fibre Brake Pad

IV. RESULT AND DISCUSSION

The results obtained from the above Finite Element Analysis of different materials are collected and make it in tabulated form.

TABLE 2
Results for Non Asbestos Semi Metallic, S2 Glass Fiber and S2 Glass Fiber

	Existing Material (Non Asbestos Semi Metallic**)**	**S2 Glass Fiber**	**Carbon Reinforcement Fiber**
Young's Modulus (E)	110000	86900	100000
Poisson's Ratio(ν)	0.28	0.28	0.3
Density (ρ)	7.20E-06	2.40E-06	2.10E-06

Total Deformation (mm)	3.9908e-002	2.0249e-002	1.6351e-002
Equivalent Stress (MPa)	1.1912	1.1911	1.191
Shear Stress (MPa)	0.24735	0.24769	0.24793
Strain Energy Lost (mJ)	1.0083e-002	1.0083e-002	1.0083e-002
Frictional Stress Lost (MPa)	3.145	3.4538	3.6959

TABLE 3
Results for Kelvar 29, Ceramic

	Kelvar 29	**Ceramic**
Young's Modulus (E)	74000	390000
Poisson's Ratio(ν)	0.36	0.24
Density (ρ)	1.44E-06	3.21E-06
Total Deformation (mm)	1.5347e-002	7.6954e-003
Equivalent Stress (MPa)	1.1912	1.1905
Shear Stress (MPa)	0.24733	0.24893
Strain Energy Lost (mJ)	1.0083e-002	1.0081e-002
Frictional Stress Lost (MPa)	3.2007	4.9982

IV. CONCLUSION

In this paper the disc brake material model was created by PRO-E wildfire 4.0. Then, the created model was import into ANSYS software for static structural analysis.

The methodology developed is allowed to evaluate the most suitable material for Disc brake friction lining which gives good performance during working condition.

Analysis result showing that the value of total deformations, equivalent stress, shear stress, strain energy loss, frictional stress loss, in result table 2 and table 3. From this table concluded that, the best material for Disc brake friction lining is Ceramic, which gives best performance as compared to other materials.

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