DESIGN AND ANALYSIS OF BRAKE LINING OF COMMERCIAL CAR

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ABSTRACT:- A curved thin strip of an asbestos composition riveted to a brake shoe to provide it with a renewable surface. The brake liner is the part which results to bring to rest or slow down a moving body. Safe operation of vehicle demands dependable brakes is required to absorb the kinetic energy of the moving parts or the potential energy of the object being lowered by host when the rate of descent is controlled. The energy absorbed by brakes is dissipated in the form of heat. This heat is dissipated in the surrounding atmosphere to stop the vehicle. Due to the friction between the brake drum and brake lining the brake lining will lose its life soon. In order to increase its life we are going to design a new brake lining and to use different composite for brake liner. We are going to design the brake liner with CATIA V5 and can analyses the friction between the drum and lining by using ANSYS. Along with the result obtain we can give the conclusion about the effective brake lining material.

KEY WORDS

Brake lining, Asbestos, Al-6061, Al2O3, SiC, ZrO2, Al-6061-Al2O3 and Al-6061-Al2O3-ZrO2.

1. INTRODUCTION

Brake lining is a part of braking system, situated in between brake drum and shoe. A brake is a device which is used to bring to rest or slow down a moving body. Safe operation of vehicle demands dependable brakes is required to absorb the kinetic energy of the moving parts or the potential energy of the object being lowered by host when the rate of descent is controlled. The energy absorbed by brakes is dissipated in the form of heat. This heat is dissipated in the surrounding atmosphere to stop the vehicle.

A curved thin strip of an asbestos composition riveted to a brake shoe to provide it with a renewable surface. The brake liner is the part which results to bring to rest or slow down a moving body. Safe operation of vehicle demands dependable brakes is required to absorb the kinetic energy of the moving parts or the potential energy of the object being lowered by host when the rate of descent is controlled. The energy absorbed by brakes is dissipated in the form of heat. This heat is dissipated in the surrounding atmosphere to stop the vehicle.

1.1. LITERATURE SURVEY

Mahmut Unaldi, et al (2017), in this study, brake pad components in powder form such as miscanthus, cashew, alumina, phenolic resin and calcite, were used to manufacture ecological brake pads. In the brake pad applications trial and error method is often used to find the optimum proportion providing the best characteristics of the component in composite. The evaluation process became complicated and time consuming due to the number of components used for the manufacture of brake pad, randomly selected mixing ratios, many samples produced with trial and error method and a vast variety of results obtained from the measurements. Taguchi method was utilized in order to determine how the compositions of the brake pad components in the range of 5-20 wt. % had an effect on the properties of the brake pads. As a result of the experiments such as density, hardness, porosity and wear rate, the characteristics of the brake pad samples were more affected by the proportions of Miscanthus and phenolic resin in the mixture.

Sadiq Sius Lawal, et al (2017), this paper presents research work on new alternative materials for brake pad. A new asbestos free brake pad was developed using an agro waste material of sawdust along with other ingredients. This was with a view to exploiting the characteristics of sawdust which are largely deposited as waste around sawmills in replacing asbestos which has been found to be carcinogenic. A brake pad was produced using sawdust as a base material following the standard procedure employed by the manufacturers. The sawdust was sieved into sieve grades of 100µm, 355µm and 710µm. The sieved sawdust was used in production of brake pad in ratio of 55% sawdust, 15% steel dust, 5% graphite, 10% silicon carbide and 15% epoxy resin using compression moulding. The properties examined are microstructure analysis, hardness, compressive strength, density, ash content, wear rate and water absorption. The results obtained showed that the finer the sieve size the better the properties. The results 22 obtained in this work were compared with that of commercial brake pad (asbestos based) and showed a close correlation. Hence sawdust can be used in production of asbestos-free brake pad.

Ungureanu, et al (2016), in this paper the friction coefficient in the brake linkages has an important influence on the braking efficiency and safety of machines. The paper presents a method for the study of the friction coefficient of the friction couple brake shoe-drum for mining hoist. In this context, it is interesting to define the friction coefficient, not just according to the materials in contact, but according to the entire ensemble of tribological factors of the friction couple.

Brijendra Gupta, et al (2015), in this research the gradual phasing-out of asbestos in automotive brake friction materials in many parts of the world has sparked the onset of extensive research and development into safer alternatives. As a result, the brake friction industry has seen the birth of different brake pads and shoes in the past decade, each with their own unique composition, yet performing the very same task and claiming to be better than others. This suggests that the selection of brake friction materials is based more on tradition and experimental trial and error rather than fundamental understanding. This review strives to eliminate the cloud of uncertainty by providing an insight into the pros and cons of the common ingredients and make-up used in contemporary friction pads and shoes. In this paper typical brake materials are reviewed and their advantages and disadvantages in contemporary brake applications are discussed.

Masrat Bashir, et al (2015), in this paper Brake Pad material is a heterogeneous material and is composed of a few elements and each element has its own function. The ideal brake material should have constant coefficient of friction under various operating conditions such as applied loads, temperature, speeds and mode of braking. During adverse braking conditions excessive frictional heat is generated which results in the drop of coefficient of friction of the brake pad material. This drop in coefficient of friction is due to the degradation of resin which is associated with the loos of its binding ability. In order to maintain constant coefficient of friction at higher temperature new brake pad material has been formulated which retains the binding ability of the resin. The formulation of new brake pad material includes four friction composites containing 13 ingredients including phenolic resin and banana peel powder as a modified binder. A 23 reciprocating friction monitor is used to carry friction and wear tests. Three tests via t1, t2 and t3 with different loads and temperatures were conducted for duration of 10 minutes. The results showed that the coefficient of friction increased at higher temperature and friction and wear characteristics indicate that banana peel powder can be effectively used to increase the binding ability of phenolic resin at higher temperature.

Uma maheswara Rao, et al (2015), studying about alternate materials for brake pads is necessary as the asbestos brake pads causing the carcinogenic effects and these are phased out. There are so many alternatives for asbestos are investigated from different journals. In this review paper some of the most suitable environment friendly and best performed compositions are presented. Fibers made up of agricultural wastes like banana peels, palm kernel shells, palm wastes, rock wool, aramid fibers, flax fibers etc are studied. Different alternatives for filler materials, Different binders like phenolic resin, epoxy resin are also studied and it effect on the performance of brake pads are presented. Formulations that are made by varying compositions of filler, fiber, binder etc and possibility of replacing the existing formulations and its effect on the physical and tribological properties of the brake pad are studied.

Elakhame, et al (2014), in this paper development and production of asbestos-free brake pad using palm kernel shell (PKS) was studied with a view to replace the use of asbestos whose dust is carcinogenic. The PKS were sieve into sieve grades of 100,350,710μm and 1mm. The sieve PKS was used in production of brake pad in ratio of 20% resin, 10% graphite, 15% steel, 35-55% PKS and 0-20% SiC using compression moulding. The properties examined are microstructure analysis, hardness, compressive strength, density, flame resistance, water and oil absorption. The microstructure reveals uniform distribution of resin in PKS. The results obtained showed that the finer the sieve size the better the properties. The results obtained in this work were compared with that of commercial brake pad (asbestos based and optimum formulation laboratory brake pad Palm Kernel Shell based (PKS), the results are in close agreement. Hence PKS can be used in production of asbestos-free brake pad.24

Mukesh Kumar, et al (2014), in this study phenolics and alkyal benzene modified versions are commonly used as binder in friction materials. However, the poor shelf life, evolution of harmful volatiles during processing, and shrinkage/voids in final products are some of the major problems associated with these binders. In order to overcome these, a binder based on ploybenzoxazine (which was synthesized in laboratory and presented in our previous work) was used as alternative resin in this work. Hence present case study discusses the comparative behavior of these three different binders (ploybenzoxazine, phenolic, and alkyal benzene modified). Brake lining materials based on these binders were developed as per standard industrial practice in laboratory and tribo-evaluated on inertia brake dynamometer. It was observed that the brake linings developed with the ploybenzoxazine binder performed better in all aspects (friction, wear, fade) compared to traditional binders such as phenolic and alkyal benzene modified versions.

Priyanka S. Bankar, et al (2014), In this paper, Woven brake linings are designed for all types of brakes and drum clutches in most critical applications. They feature high and stable friction coefficient and guarantee meeting the strictest safety requirements as their design assures resistance to rapid failures. Woven friction linings are difficult to mould and it is difficult to incorporate any inserts in the lining that are used in lifting machine applications where high temperature and high pressure conditions are common. In such cases it is recommended to use the pressed linings. Thus it is proposed to develop composite lining in curved geometry with Fibre reinforced asbestos and Reybestos or commercial name Ferodo as base material and graphite insert material. It is expected that such linings are based on highly durable and heat resistance to temperature, featuring high friction coefficient of friction ad high durability. Paper includes investigators work done on analysis design was analyzed considering the different parameters. This review can help analysts to choose right methods and make decisions on new areas of method development.

Sachin kumar patel, et al (2014), in this paper a brake lining composition was investigated experimentally to investigate the effects of the manufacturing parameters on the tribological properties and to obtain optimal manufacturing parameters for improved tribological behaviour. Brake linings are important parts in 25 braking systems for all types of vehicles. They convert the kinetic energy of the car to thermal energy by friction in the contact zone.

Sarvendra Kumar Mehra, et al (2013), this work is aimed to study the tribological properties difference of potentially new designed non-commercial brake pad materials with and without asbestos under various speed and nominal contact pressure. Binder resin and reinforcing fibers used in friction materials have substantial influence in determining the friction characteristics. Frictional heat generated during the brake application can easily raise the temperature at the interface beyond the glass transition temperature of the binder resin resulting in an abrupt change in the friction force during braking . Brake pads convert the kinetic energy of the car to thermal energy by friction. Two brake pads are contained in the brake caliper with their friction surfaces facing the rotor. When the brakes are hydraulically applied, the caliper clamps or squeezes the two pads together into the spinning rotor to slow/stop the vehicle.

Sivarao, et al (2009), in this paper brakes and tires are the major contributors for catastrophic failure of ground vehicles. Braking system is the utmost important besides tire to ensure the safety of users and vehicle. Ensuring good condition of brake lining is very crucial to ensure the efficiency of the braking system, where, the worn off brake lining not only endangers life but also damages the entire brake associated parts such as hub, disk, shaft, etc. In this paper, Malaysian made luxury car Proton Perdana V6 brake pads were investigated to be embedded with a lining wear limit alert system. The current spring steel alert system has some drawbacks where, the alerting sound is only activated while the car moves and secondly, when the car is on move , rarely the alerting sound reaches the driver. Therefore, a critical investigation of the existing pads manufactured in Malaysia and their characterizations are conducted to identify the most suitable sensor spot on the brake pad. Later, a micro sensor is embedded into the pad and fully tested on a specially designed test rig. The evaluation of thickness, hardness, layer properties and critical wear region has enabled the spotting of exact sensor location. The embedment of the micro switch was successfully done and tested to be very efficient in alerting the driver upon reaching the maximum lining wear limit.

PROBLEM STATEMENT

Drum Brake and Drum Brake lining are connected on the wheels of automobile for the braking of the vehicle on road. The drum brake and brake lining under goes several rough conditions on road different types of loads and temperatures will be acting on the brakes. The brakes are surely essential for the effective stopping of the vehicle. Here in this project we are taking the load condition as 1.5Mpa pressure on the face of the brake lining. We are using ceramic composite material Al6061-Al_2O_3-ZrO_2, Doing the analysis on materials using the load condition we will find which the best appropriate material for use is. Also when the brake is applied due to the friction between the drum and the brake lining certain heat is distributed and released. Here we consider the thermal conditions to be as 90deg temperature and 22deg convection. Thus applying all the load and thermal conditions for three different materials Drum Brake and Brake lining we conclude the best desirable materials.

OBJECTIVES OF THE PROJECT

The objectives of the project are as follows

1. To develop structural modelling of Brake lining.

2. To perform finite element analysis of Brake lining of Drum Brake.

3. Suitable material study.

4. Study of load and Thermal factors.

5. Study of stress, deformation, temperature and heat flux induced in the

Brake lining

The aim of this project work is to design the new Brake lining by new composite material with 4 mm thickness. That composite material Al6061 reinforced with Al2O3 and ZrO2.This material of brake lining will give more strength and will give long life. while brake it will generate very less stress and deformation due different load and temperature. This research project shows the best mechanical properties of combination of Al6061, Al2O3 and ZrO2 materials.

MATERIAL AND THEIR PROPERTIES OF EXISTING AND SELECTED MATERIAL.

Material	Density Kg/m3	Young's Modulus GPa	Poisons atio	Tensile strength Pa	Thermal Conductivity
Asbestos	2500	35	0.35	131	1 w/m k
Al6061	2700	68.8	.33	115	173 w/mk
Al2O3	3980	412	.33	665	38.5 w/mk
SiC	4100	105	.36	1625	10.7 w/m k
ZrO2	5170	250	0.32	711	2.7 w/m k

By the help of base material and selected materials, following seven type of

Composition formed.

1. Aluminium Silicon Carbide: Al-SiC
2. Aluminium- Al2O3:
3. Aluminium - ZrO2
4. Al-Al2O3-ZrO2-Sic
5. Aluminium -Al2O3- ZrO2:
6. Al-Al2O3-SiC
7. Al-SiC-ZrO2

I took its physical and mechanical properties.and did analysis with different –different percentage of Al,Al2O3,Sic and ZrO2 etc.after i did comparison between all analysis result ,deforation,Eq.stress due to applied pressure on brake lining and heat flux,deforation,eq.stress due to temperature.

Then i have selected two material which become less deform and less stress due to pressure and temperature. Such as -

1. Al 6061 - Al2O3:
2. Al 6061 -Al2O3- ZrO2:

1 Aluminium 6061 - Al2O3:

Ferrotec's metal matrix composites take advantage of various material mixes to deliver unique material properties and performance characteristics. The material properties of Aluminium-Aluminium Oxide metal matrix composites make it a good solution for large size structural products. Al-Al_2O_3metal matrix materials are good for contributing to weight reduction and provide excellent damping for high speed and precise equipment motion applications like robot parts.

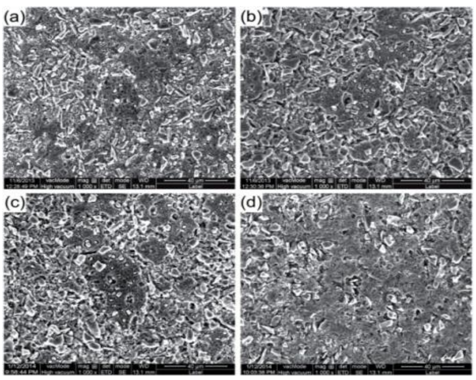


Fig – Al 6061- Al2O3 mixture

Aluminium 6061 -Al2O3- ZrO2:

For fabrication of hybrid metal matrix composite (h-MMC), stir casting technique was adopted. For fabrication commercially available Aluminium alloy (Al6063) was used as a matrix material and ZrO2(~20μm)and Al2O3 (~30μm)were used as reinforced material. Figure 2.SEM image of fabricated Al-MMC During stir casting route the matrix material was melted at 8500 C in a graphite crucible under the controlled argon environment in the resistance heated furnace. The specific amount of Al2O3 and ZrO2 particles equal to 5wt% preheated up to 3000 C and 12000 C and then mixed into the molten bath of Al6063. Reinforced particles were stirred by a stirrer at 700rpm. After complete stirring, the material mixture was again reheated into the furnace and then poured into the mould at 7500 C to 8500C.

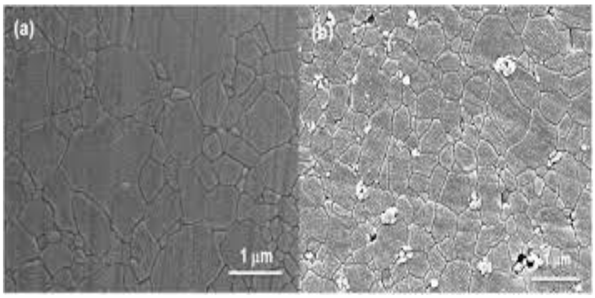


Fig – Al 6061- Al2O3-ZrO2 mixture

Design procedure of Brake lining

Brake lining by using Catia V5 software

The analysis of Brake lining models are carried out using ANSYS software using Finite Element Method. Firstly the model files prepare in the CATIA V5 SOFTWARE.

DESIGN DEFINATION & STEPS:

1. Select the X-Y plane
2. Go to the sketch.
3. Create 2D sketch diagram of brake shoe by help of profile.
4. Give the thickness 4 mm.
5. .Then Extrude the close profile
6. later go the insert.
7. Add new body.
8. sketch brake lining profile over brake shoe.
9. .Afterward Extrude the close profile.
10. .By these steps brake lining with brake shoe has generated.

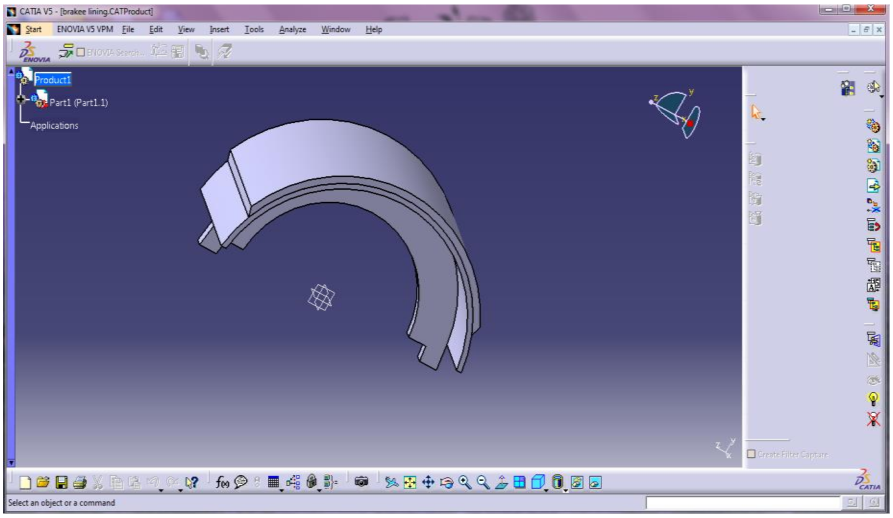


Figure- Design of Brake lining

ANALYSIS DEFINATION & STEPS:

The steps needed to perform an analysis depend on the study type. You complete a study by performing the following steps:

1. Create a study defining its analysis type and options.
    a. If needed, define parameters of your study. A parameter can be a model dimension, material property, force value, or any other input.
    b. Define material properties.
    c. Specify restraints and loads.

2. The program automatically creates a mixed mesh when different geometries (solid, shell, structural members etc.) exist in the model.
    a. Define component contact and contact sets.

3. Mesh the model to divide the model into many small pieces called elements. Fatigue and optimization studies use the meshes in referenced studies.
    a. Run the study.
    b. View results.

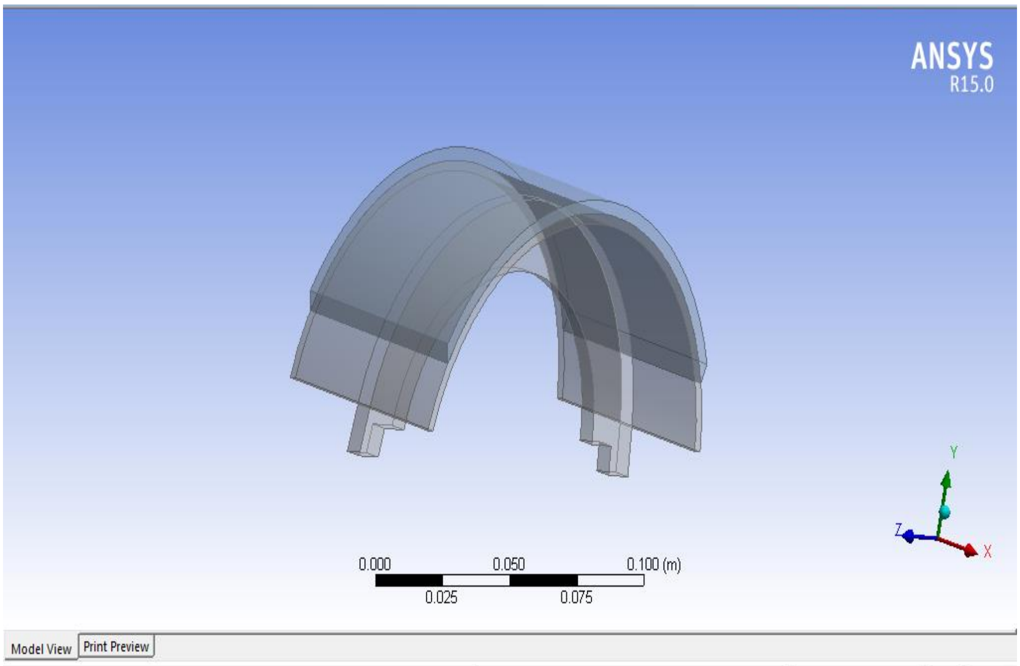


Figure- structural analysis of Brake lining

Analysis on Brake lining by using Catia V5 software

The analysis of Brake lining models are carried out using ANSYS software using Finite Element Method. Firstly the model files prepare in the CATIA V5 SOFTWARE. Then are exported to ANSYS software as an IGES files as shown in figure

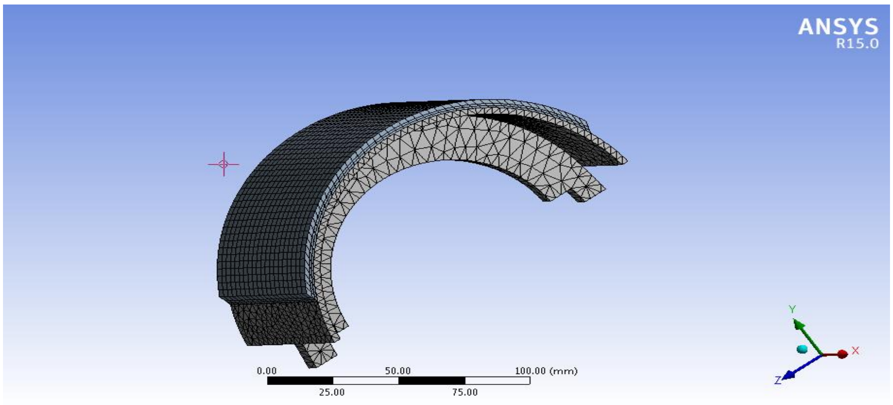
Materials and their properties

Material	Density Kg/m3	Young's Modulus GPa	Poisons Ratio	Tensile strength MPa	Thermal Conductivity
Asbestos	2500	35	0.35	131	1 w/m k
60%Al6061-40%Al2O3	3212	213.9	.34	342.8	119.36 w/mk
60%Al6061-0%Al2O3-10%ZrO2	3331	196.9	.32	339.6	115.6 w/m k

Load & fixed support

• Fixed support

It's done with a variety of tools & options available in the software. The results are calculated by solving the relevant governing equations numerically at each of the nodes of the mesh. The governing equations are almost always partial differential equations, and Finite element method is used to find solutions to such equations. The pattern and relative positioning of the nodes also affect the solution, the computational efficiency & time.



Mesh Type: Tetrahedral

No. of nodes: 33758

No. of elements: 11566

Details of "Mesh"

Relevance	0
Sizing	
Use Advanced Size Fun...	Off
Relevance Center	Coarse
Element Size	3.50 mm
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Minimum Edge Length	3.0260 mm

STRUCTRUALANALYSIS RESULTS FOR BRAKE LINING

Material: Asbestos

EQUIVALENT STRESS

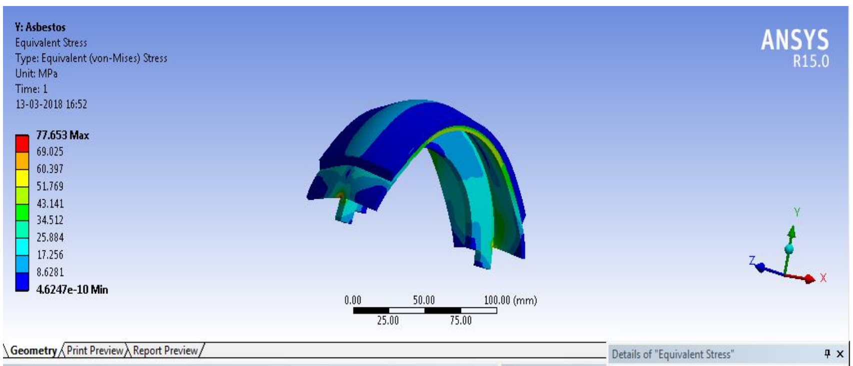


***FIG.**-ASBESTOS (EQUIVALENT STRESS)*

HEAT FLUX

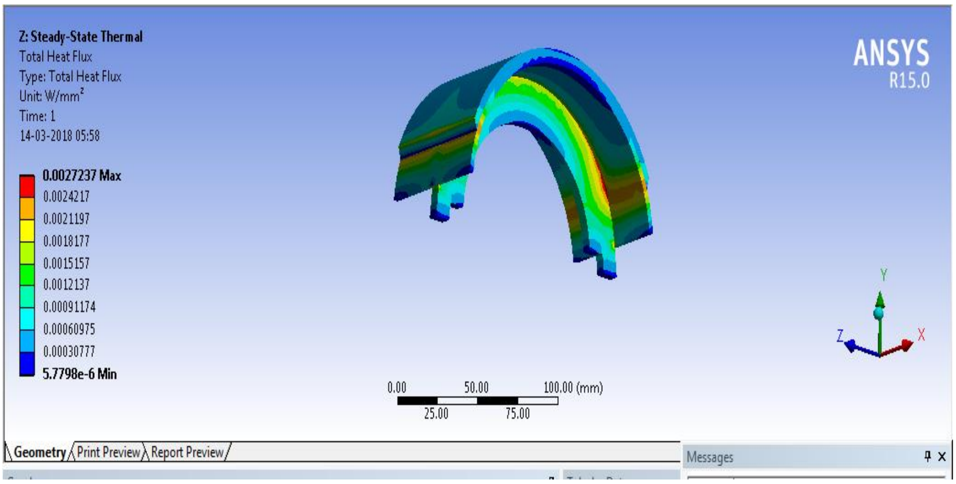


***FIG.**-ASBESTOS (TOTAL HEAT FLUX)*

STRUCTRUALANALYSIS RESULTS FOR BRAKE LINING WITH 1.5 Mpa

EQUIVALENT STRESS(AL6061-AL2o3)

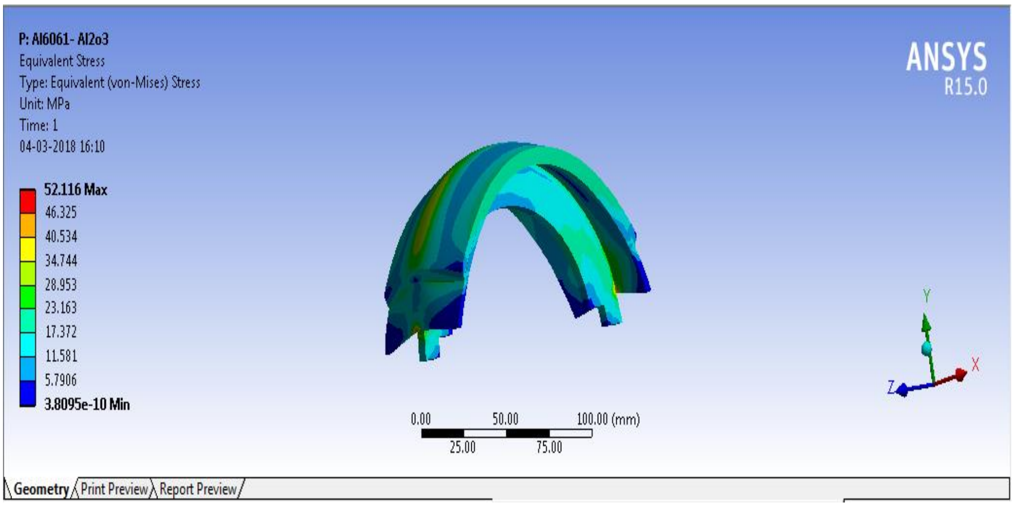


Fig.- AL6061-AL2o3 *(EQUIVALENT STRESS)*

HEAT FLUX)

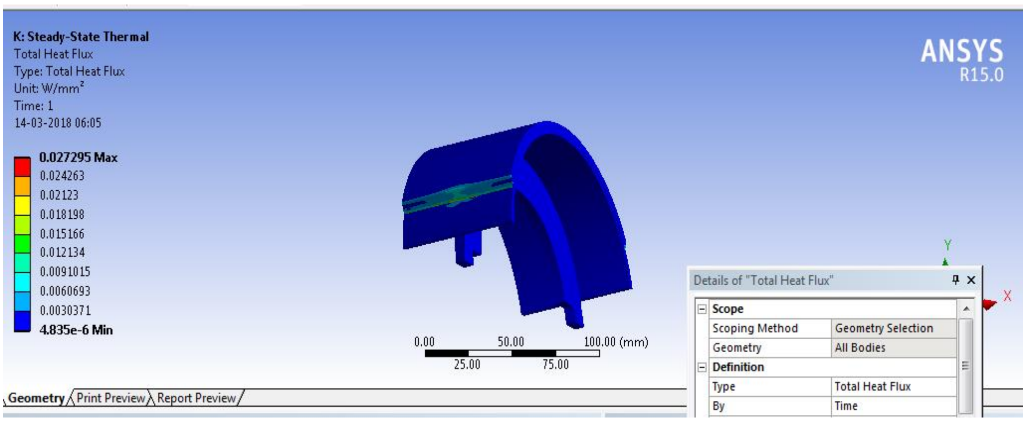


Fig.- AL6061-AL2o3 *(HEAT FLUX)*

STRUCTRUALANALYSIS RESULTS FOR BRAKE LINING WITH 1.5 Mpa

EQUIVALENT STRESS (AL6061-Al2o3-Zro2)

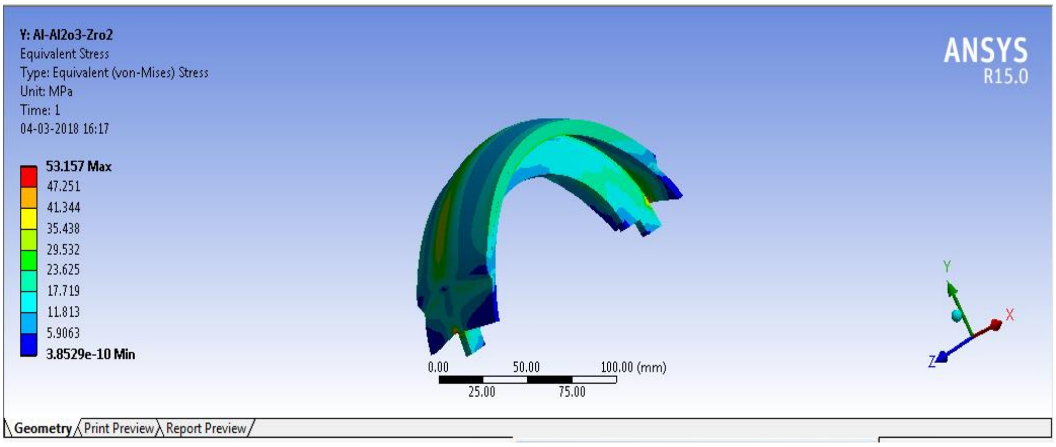


Fig.- AL6061-Al2o3-Zro2(*EQUIVALENT STRESS)*

HEAT FLUX

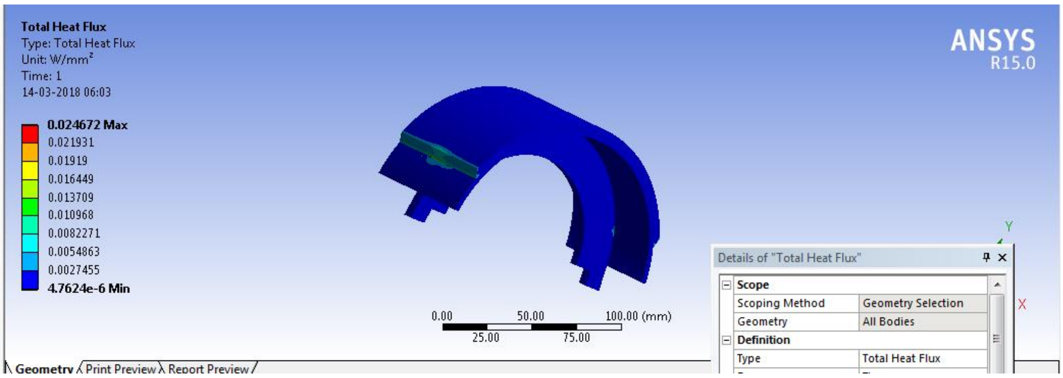


Fig.- AL6061-Al2o3-Zro2(*HEAT FLUX)*

ANALYSIS RESULTS OF CERAMIC COMPOSITE MATERIAL COMPERISION OF BRAKE LINING

Material	Eq.Stress(Mpa)	Heat flux(w/mm^2)
Asbestos	77.653	0.0027237
60%Al6061-40%Al2O3	52.116	0.024965
60%Al6061-30%Al2O3-10%ZrO2	53.157	.024672

DISCUSSION

1. Maximum stress, deformation, Temperature and Heat flux are found and tabulated.
2. Next steady state thermal analysis of brake lining with Asbestos ,later Al6061- Al2O3 and Al6061- Al2O3 - ZrO2 90°C temperature and 22°C ambient temperature of convection is applied and also did analysis on 100 °C and 150°C for comparison.
3. Maximum stress, deformation, and Heat flux are obtained and tabulated.
4. Thus the stress and total deformations values are obtained and tabulated.

5. From result we can conclude that beside Al6061- Al2O3 and Al6061-Al2O3 - ZrO2 which is economically less cost and less weight ratiogives nearly less stress and deformation value in static analysis and giving good thermal distribution value so it can also use as the material for brake lining beside general materials.

6. Thus the modeling and analysis of brake lining is done with different materials at different boundary conditions.

SUMMERY AND CONCLUSION

1. Modelling and analysis of brake lining has done.

2. Modelling of brake lining has done in CatiaV5 design software.

3. Thus both files are saved as igs to import into ansys workbench.

4. Structural and thermal analysis is carried on brake lining in ansys workbench.

5. First structural analysis of pressure of 1.5,5,10,50 and 100 Mpa is applied with Asbestos and then withAl6061-Al2O3 and Al6061-Al2O3-Zr02**.**

Al6061-Al2O3 and Al6061-Al2O3-Zr02 : -

1. Maximum stress, deformation, Temperature and Heat flux are found and tabulated.

2. Next steady state thermal analysis of brake lining with Asbestos ,later **Al6061-Al2O3 and Al6061-Al2O3-Zr02** 90°C temperature and 22°C ambient temperature of convection is applied and also did analysis on 100 °C and 150°C for comparison.

3. Maximum stress, deformation, and Heat flux are obtained and tabulated.

4. Thus the stress and total deformations values are obtained and tabulated.

5. From result we can conclude that beside**Al6061-Al2O3 and Al6061-Al2O3-Zr02**.which is economically less cost and less weight ratio gives nearly less stress and deformation value in static analysis and giving good thermal distribution value so it can also use as the material for brake lining beside general materials.

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