ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 2, Special Issue 12, April 2016.

STRUCTURAL ANALYSIS OF DIFFERENT COMPOSITE MATERIALS IN THE APPLICATION OF AUTOMOTIVE DISC BRAKE

Dr.S.JEYAKUMAR[1], P.KARTHICKMANI[2],

Assistant Professor, Department of Mechanical Engineering, PSNACET, Dindigul, INDIA[1]

Final Year PG Scholar, Department of Mechanical Engineering, PSNACET, Dindigul, INDIA[2]

Kmk_jai@yahoo.com[1],mani281292@gmail.com@gmail.com[2]

Abstract

Owing to the versatility of metal matrix composites and urge for improving performance forced the researchers to integrate the best composites with various applications, which make the design and manufacturing engineer job tougher. Hence this project aims to compare the existing material, aluminium silicon carbide with Alumina reinforced Aluminium metal matrix composite in the application of automotive disc brake. Initially experimental analysis will be done on composite material and from the obtained experiment data; it further processed with finite element simulation.Candidate materials considered for the analysis with the application of air brake are Aluminium silicon carbide (existing) and Alumina reinforced Aluminium metal matrix composite (proposed).

Keywords: Metal matrix composite, Mechanical properties, CREO, ANSYS

1. Introduction

A disc brake is a type of brake that uses calipers to squeeze pairs of pads against a disc in order to create friction that retards the rotation of a shaft, such as a vehicle axle, either to reduce its rotational speed or to hold it stationary. The energy of motion is converted into waste heat which must be dispersed [1]. Compared to drum brakes, disc brakes offer better stopping performance because the disc is more readily cooled. As a consequence discs are less prone to the brake fade caused when brake components overheat. Disc brakes also recover more quickly from immersion. Hence, disc brake can be seen in many filed of applications including bikes, motor cycles, cars and other heavy brake applications too. Hence, many studies were raised with the concern of disc brake in order to improve the braking efficiency, for an instance**,** Shinde and Borkar [2] describe one such approach based on modified FEM axisymmetric analysis. This paper reviews numerical methods and analysis procedures used in the study of automotive disc brake. It covers Finite element Method approaches in the automotive industry, the complex contact analysis. However from the existing literature it is clearly evident that very few studies explored the automotive disc brake with the context of material optimization from which many studies focused with various concepts like exploring brake caliper, thermal diffraction, dimensional analysis, exploring tribological properties and so on. Also these literaturesfail to consider new materials available in design realm, since some study do consider different materials, for an instance, Balaji and Kalaichelvan [3] used aramid, cellulose and various fibre reinforced in application of automotive disc brake, but the major limitation of this project is the polymeric composite not far suited to the heavy applications like brake discs. Hence, with keeping above point in mind this study sought to explore the optimization in material selection in the application of automotive disc brakes with the assistance of CREO and ANSYS. The following sections of the paper are as follows. Section 2 elevates the core problem of the study. Section 3 explains the solution methodology employed in the study Results and their relevant discussion were detailed in Section 3 along with the conclusion in Section 4.

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 2, Special Issue 12, April 2016.

2. Problem description

Owing to the numerous alternatives in materials makes the designers to rethink in the selection of optimized material for any application. In the row, this project considers the material selection problem for automotive disc brake application. In which the existing material was compared with the proposed material for which experimental investigation will be made and based on the results the computational analysis will be done. The computational results are further compared with the existing material results and finally this project tends to conclude with optimized material for automotive disc brake. However, already aluminium silicon carbide was explored with this application, hence this study introduced alumina reinforced aluminium metal matrix composite.

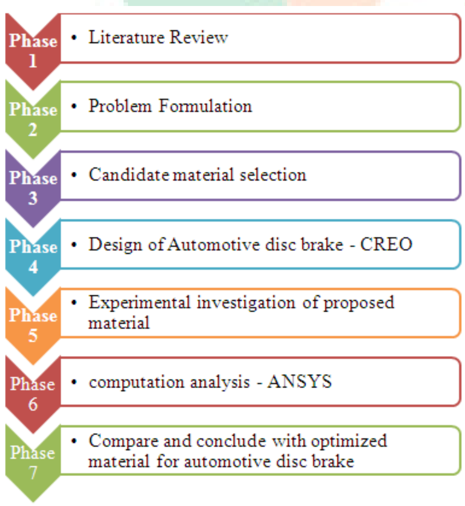
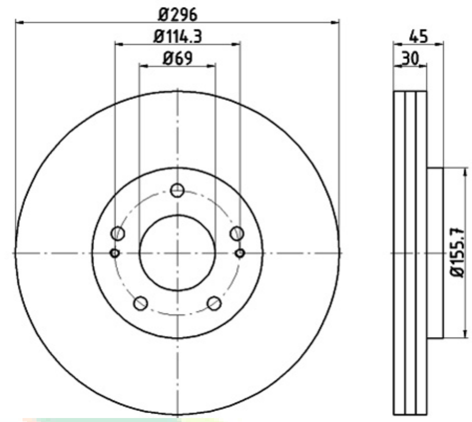


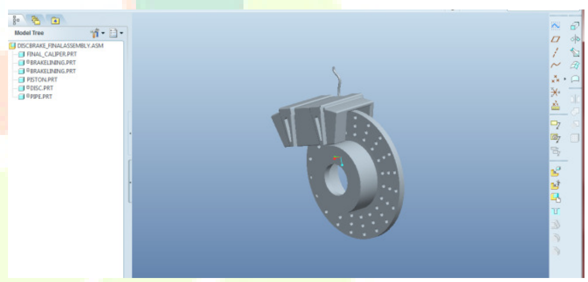
Fig 1 Framework of the study

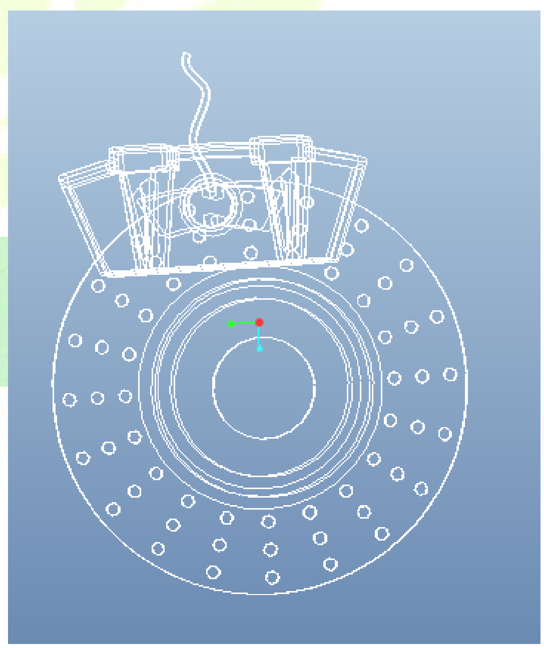
3. Materials and Methods

As discussed earlier CREO and ANSYS were used to design the disc brake and analysis respectively. The design of the disc brake adapted from the existing literatures from which disc brake design was made with the assistance of CREO modeling software.

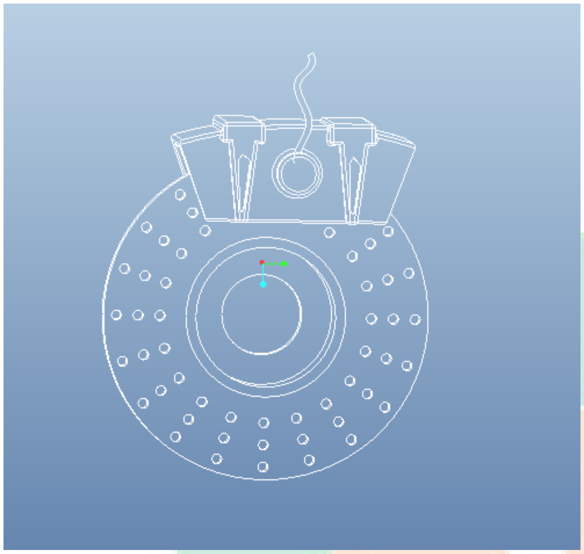


Design of disc brake by CREO:





ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 2, Special Issue 12, April 2016.



Experimental investigation:

Existing material: **Aluminium silicon carbide**

AlSiC composites are suitable replacements for copper-molybdenum (CuMo) and copper-tungsten (CuW) alloys; they have about 1/3 the weight of copper, 1/5 of CuMo, and 1/6 of CuW, making them suitable for weight-sensitive applications; they are also stronger and stiffer than copper. They are stiff, lightweight, and strong. They can be used as heat sinks, substrates for power electronics (e.g. IGBTs and high-power LEDs), heat spreaders, housings for electronics, and lids for chips, e.g. microprocessors and ASICs.

Proposed material: **Alumina reinforces aluminium composite**

It is nothing but the aluminium alloy reinforced by Alumina or alumina oxide, it is a chemical compound of aluminium and oxygen with the chemical formula Al_2O_3. It is the most commonly occurring of several aluminium oxides, and specifically identified as aluminium(III) oxide. It is commonly called alumina, and may also be called aloxide, aloxite, or alundum depending on particular forms or applications. It commonly occurs in its crystalline polymorphic phase α-Al_2O_3, in which it composes the mineral corundum, varieties of which form the precious gemstones ruby and sapphire.Al_2O_3 is significant in its use to produce aluminium metal, as an abrasive owing to its hardness, and as a refractory material owing to its high melting point

Table 1: Comparison of alumina reinforcement with other rivals:

	Silicon dioxide (SiO_2)	Alumina (Al_2O_3)	Silicon carbide (SiC)	Tungsten carbide (WC)	Zirconia (ZrO_2)
Molar mass (g/mol)	60.08	101.96	**40.10**	195.86	123.22
Density (g/cc)	2.00-2.30	3.70-3.97	**~3.22**	~15.80	~6
Melting point (°C)	~1600	~2072	**~2730**	~2870	~2700
Elastic Modulus (GPa)	70-90	~375	**~410**	450-650	~200
Compressive strength (MPa @ RT)	~1100	~2600	**~3900**	~4000	~4800
Hardness (kg/mm^2)	~500	~2600	**~2800**	~2700	~1300
Thermal conductivity (W/m.K @ RT)	~1.40	~50	**~120**	75-110	~2
Coefficient of linear thermal expansion (µm/m- °C)	~0.50	~8.40	**~4**	~5	~10
Specific heat (J/Kg.K)	~700	~900	**~750**	~200	~400
Maximum operating temperature (°C) (No load)	~950	~1750	**~1650**	~800	~1000
Resistivity (Ωm @ RT)	10^{12} - 10^{14}	~10^{12}	**~10^4**	~2 x 10^{-7}	~10^8

4. Results and Discussion

This section lies as two, namely experimental results and computational results.

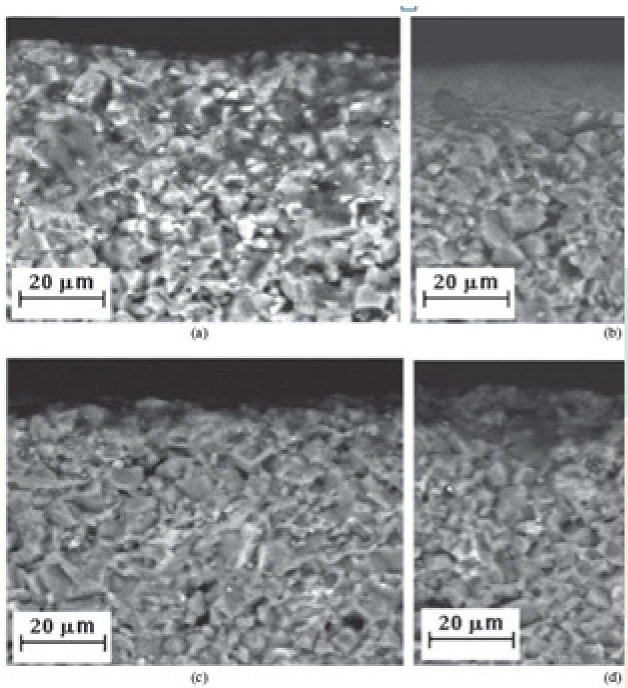
Experimental results:

The proposed material alumina aluminium composite speciemen was experimentally investigated in private lab situated in chennai and we here comparing the results with other reinforced material to ensure the value of alumina reinforced aluminium over other reinforcement materials.

Table 2 Experimental results

	Equipment	Findings
Tensile strength in Mpa	UTM 40 TN	113.87
Yield Stress in Mpas	UTM 40 TN	120.46
Elongation	UTM 40 TN	10%
Hardness (Kg)	HV1	85

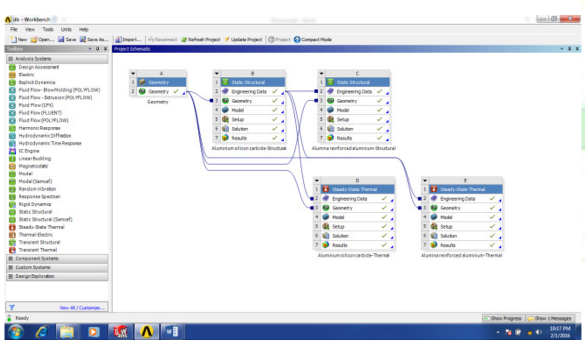
ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 2, Special Issue 12, April 2016.



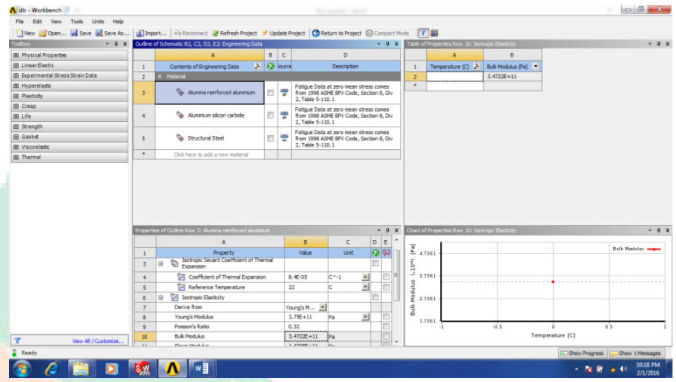
Computational results:

Computational analysis completely carried out through ANSYS 14.0 workbench. In detail manner static structural and static thermal analysis tools were used to justify the computational analysis. In ANSYS we should give three inputs to attain results, such are Material Importation, Engineering data, and Degrees of freedom.

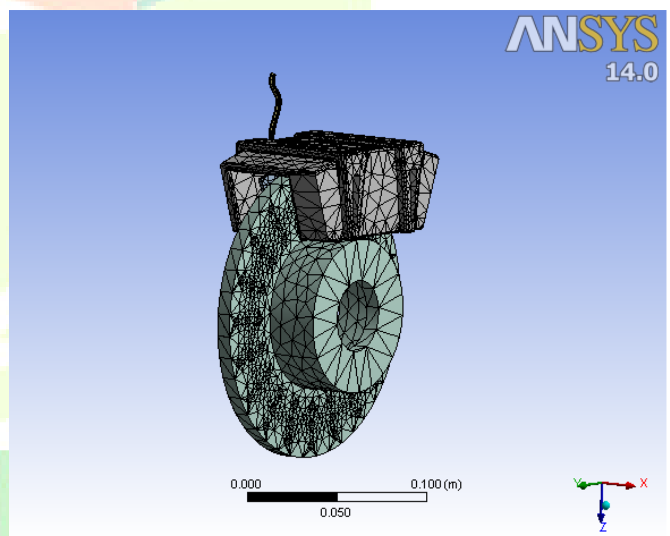
In ANSYS software, workbench tool was vital for the Initiation. The layout designed as per our convenience, which was shown in figure. Object to be analyzed must be imported in this stage.



Followed by the Layout design, existing and proposing materials and Its Mechanical and Thermal properties were gave as input, Formally in ANSYS, that was known as engineering data.



Material assignment were already discussed in workbench layout as in the engineering data. Meshing is the most important step in computational analysis. The Object have meshed by Triangle type standard mechanical shape. Object has contained 38461 nodes, and 19115 elements after meshing. Meshed object shown in figure.



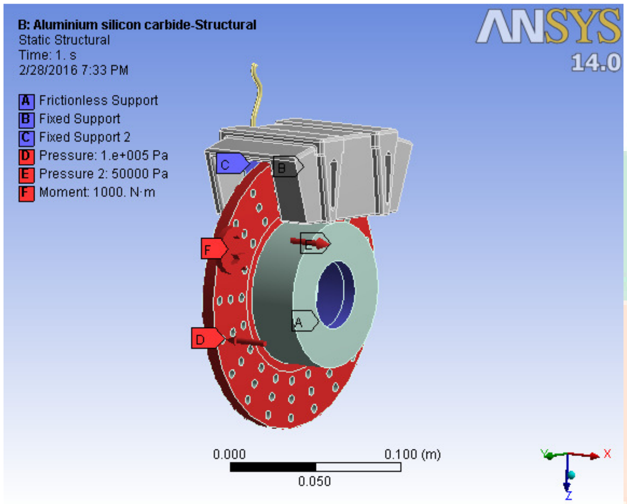
Number of Independent coordinates, Supports, Loading conditions were mentioned in this step. Results completely depends upon this input. These inputs were taken from the real-time observations. Even its based on Workbench tool, Solver target depends on the Mechanical APDL tool only. Applied Degrees of freedom shown in figure. Applied Load details

FORCE APPLIED=1250N;

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 2, Special Issue 12, April 2016.

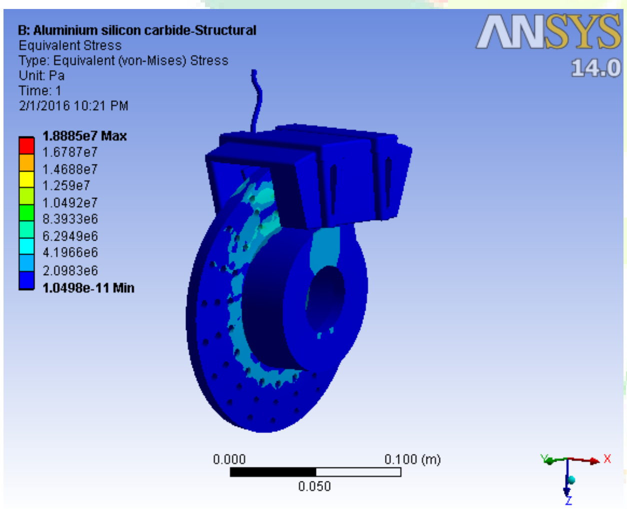
DISC DIA=0.0124m;

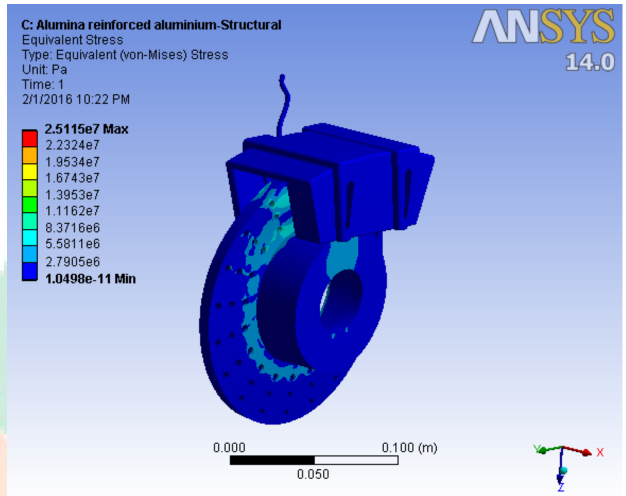
HENCE PRESSURE=1X10^5

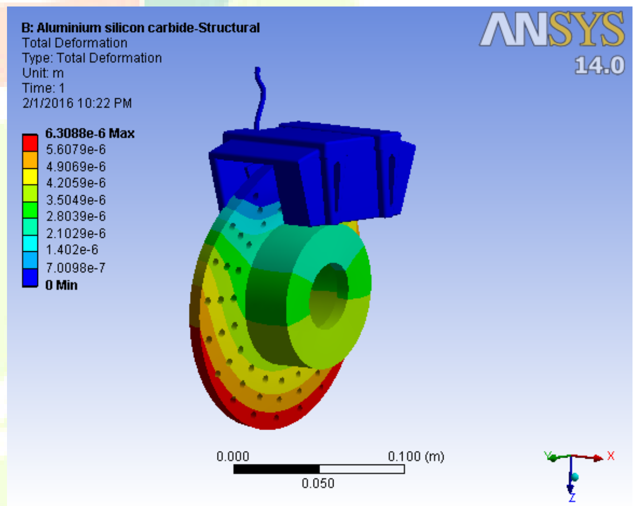


After all inputs, The Object was ready to solve for Structural analysis. In this case Solution tool contains, Von-mises stress, Shear Stress, Deformation, and Factor of Safety.

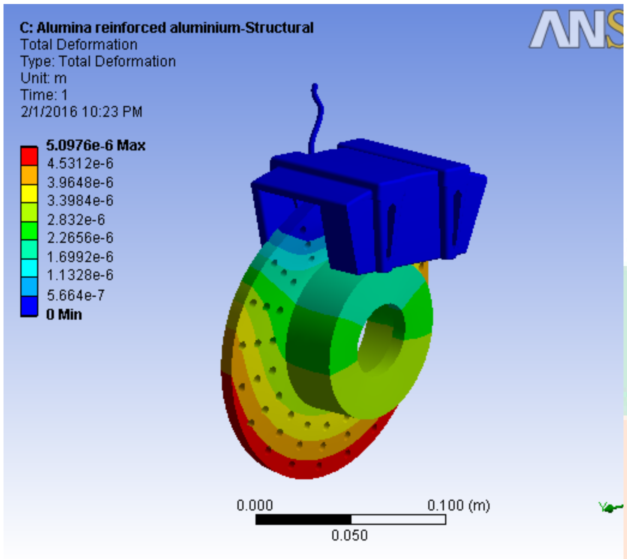
Von-mises stress of existing and proposed materials were shown in figure.



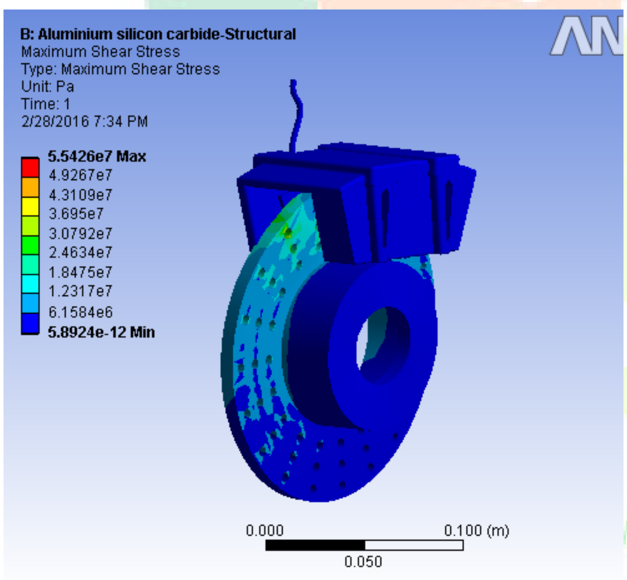


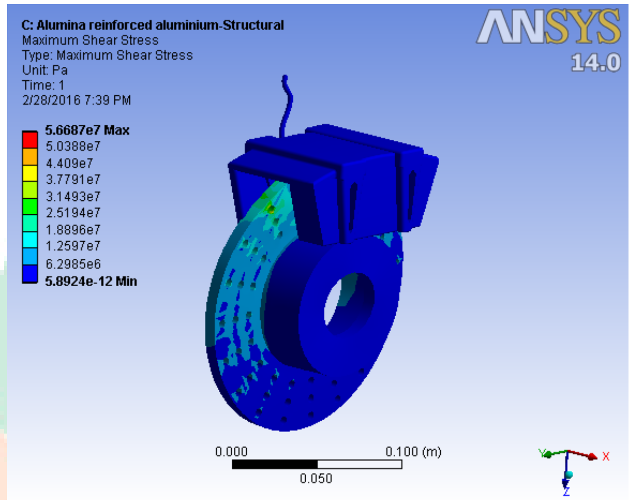


ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 2, Special Issue 12, April 2016.

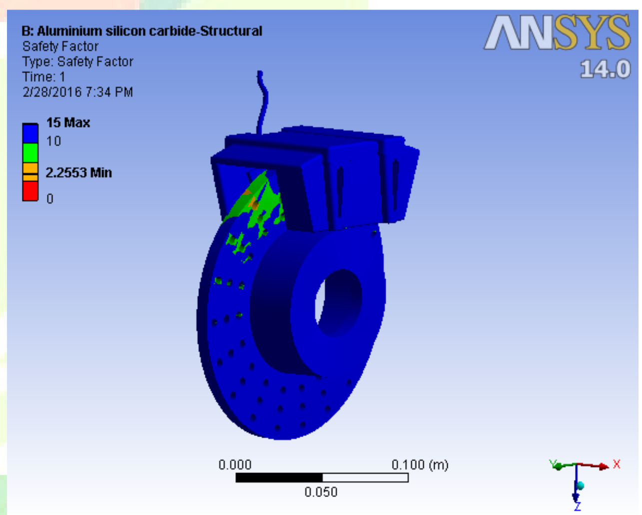


Shear stress occurred due to moment caused on the Disc were shown in upcoming figure.

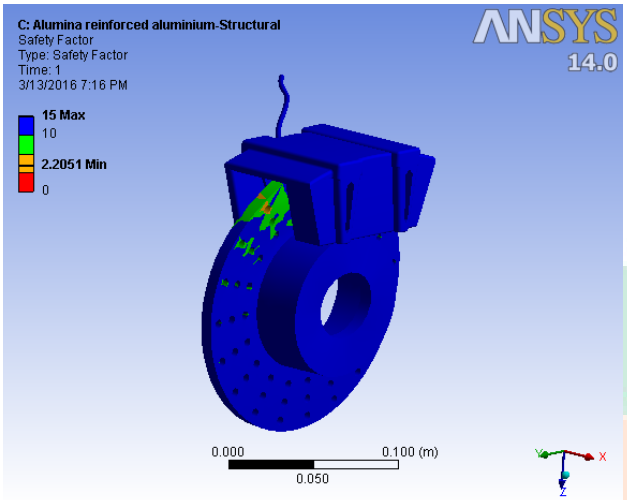


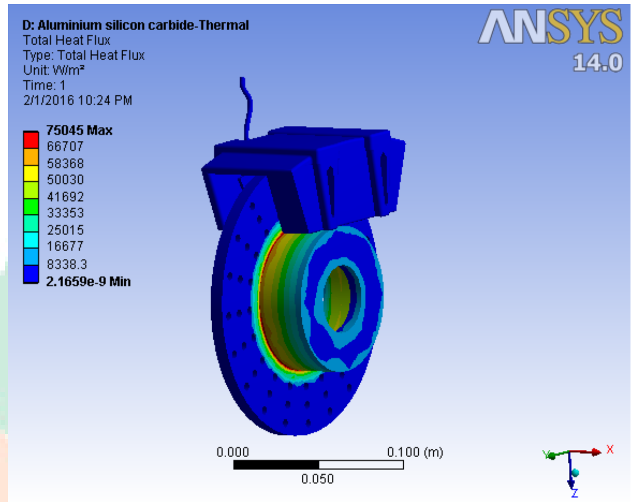


Factor of safety with consideration of Stress formation for the existing and proposed materials were shown in figure.

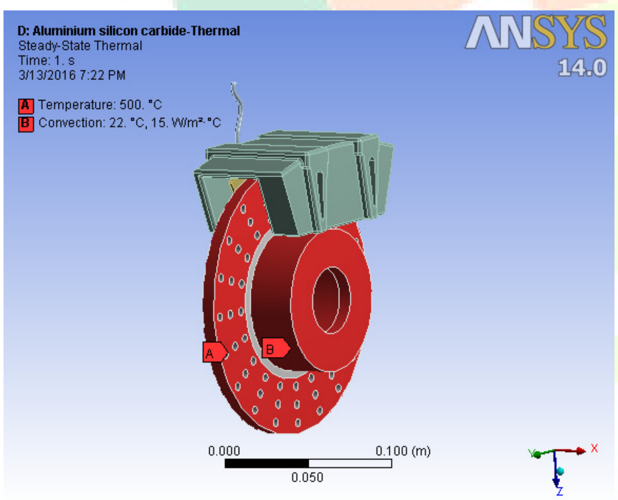


ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 2, Special Issue 12, April 2016.

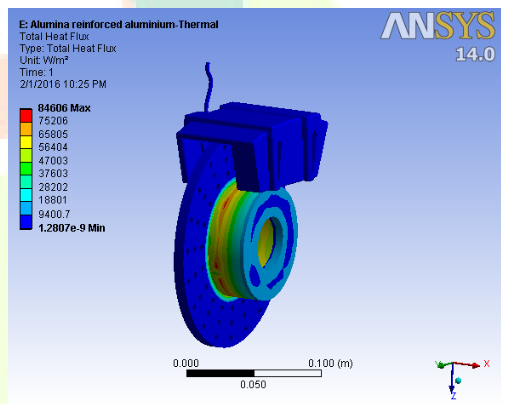




Thermal analysis of the object needs Thermal degrees of freedom, which was mentioned in the figure. Applied temperature is 500 degree Celsius, and the Convection coefficient was 15W/m^2



Thermal analysis solver also depends on the Mechanical APDL. The Heat flux results were shown in figure.



The results attained from the ANSYS are all tabulated in table.

Table 3 computational comparison of chosen materials for disc brake

Material	VON-MISES (Pa)	DEFORMATION(m)	HEAT FLUX(W/m^2)	SHEAR STRESS(Pa)
Aluminium silicon carbide	1.8885 X10^7	6.3088 X10^{-6}	75045	5.5426X10^7
Alumina Reinforced Aluminium	2.5115 X10^7	5.0976 X10^{-6}	84606	5.6687X10^7

ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com
International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE) Vol. 2, Special Issue 12, April 2016.

5. Conclusion

Owing to the importance of analyzing the disc brake material, literature review was conducted as per the systematic procedures to form the Problem conceptualization with the application of automotive disc brake with the concern of optimized material selection. The Candidate materials Alsic (existing) and alumina reinforced aluminium composite was found from the existing literatures for this study. As per the standard dimensions, design of automotive disc brake was made with the assistance of designing software CREO. Experimental investigation were made for the proposed material by manufacturing the work piece with the assistance of oil fired furnace, muffled furnace and surface machine set up. Material properties including its characterization and mechanical properties of the proposed material were explored. Based on the experimental results, computational analysis was made among the candidate materials with the application of automotive disc brake through ANSYS software. Comparison was made among the candidate materials (proposed and existing) available results. From the comparison, it is clearly revealed that having some good hands with von mises stresses, deformations and heat flux. Hence, it can clearly confirm that the proposed material (Aluminium reinforced alumina) is more suited for automotive disc brake than the existing material (Aluminium silicon carbide). With the assistance of this study, design engineers can select the proposed future material for disk brake application.

6. References

[1] Kinkaid, N. M., O'Reilly, O. M., & Papadopoulos, P. (2003). Automotive disc brake squeal. Journal of sound and vibration, 267(1), 105-166.

[2] Shinde, E. N., & Borkar, (2015) B. R. CAD & FEM analysis of disc brake system. Applied Thermal Engineering,31(14), 2439-2448

[3] Balaji, M. S., &Kalaichelvan, K. (2012). Experimental studies of various reinforcing fibres in automotive disc brake pad on friction stability, thermal stability and wear. International Journal of Materials and Product Technology,45 (1-4), 132-144.

