International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-2, December 2019

Weight Reduction and Structural Validation of Four Wheeler Disc Brake with Various Materials

M Purusothaman, T Jitendra Siva Prasad, J Mohan Krishna, K Manoj kumar,

ABSTRACT: ***Safety side in engineering has been thought of as variety one priority in development of latest vehicle. Each single system has been studied and developed so as to satisfy safety demand. Instead of having bags, sensible suspension systems, sensible handling and safe cornering, there's one of most crucial system within the vehicle that is brake systems. Without brake within the vehicle can place a traveller in unsafe position. Therefore, it's a requirement for all vehicles to own correct brake. Due to vital system within the vehicle, several of researchers have conducted a study on brake and its entire part. In this project, the author has conducted a study on aerated and traditional disk brake of traditional traveller vehicle with full load of capability. The brake must be sufficiently designed in order to dissipate the heat generated from the braking process adequately for safe braking system performance. The aim of our project is to design and investigate the braking performance of the low cost passenger car with various materials like stainless steel, cast iron and aluminium alloy. The disc brake structure is changed with cross-drilled holes on the rotor of the disc for more heat dissipation using CATIA V5 R21 and performance study in term of its Structural property was determined using ANSYS finite element analysis software.***

Keywords: Disc brake, Vonmises stress and displacement, ANSYS.

I. INTRODUCTION

Most of the disastrous occurs in a car due to the failure of braking system. It is an energy conversion system in which it converts kinetic energy (momentum) of our vehicle into thermal energy [6]. When we step in the brake, it will converts into a force in which it's ten times more than we applied, when he car is in motion. The braking system will exert thousands of pounds of pressure on their brakes.

The brake system composed of master cylinder- located under the hood, converts mechanical pressure into hydraulic pressure by connecting through brake pedal. Steel "brake lines" and flexible "brake hoses" are used to connect master cylinder to the "slave cylinder" located at each wheel, where brake fluid is used. To slow down the cars, slave cylinder pushes "shoes" and "rotors" in which causes drag.

Revised Manuscript Received on December 30, 2019.
***** Correspondence Author

M Purusothaman*, Assistant Professor, School of Mechanical Engineering, Sathyabama Institute of Science and Technology, Chennai-600119, Tamilnadu, India.

T Jitendra Siva Prasad, Students, School of Mechanical Engineering, Sathyabama Institute of Science and Technology, Chennai-600119, Tamilnadu, India.

J Mohan Krishna, Students, School of Mechanical Engineering, Sathyabama Institute of Science and Technology, Chennai-600119, Tamilnadu, India.

K Manoj kumar, Students, School of Mechanical Engineering, Sathyabama Institute of Science and Technology, Chennai-600119, Tamilnadu, India.

The main advantage of rotor over drum is brake fade. In rotor type, it will provide significantly better resistance over drum type.[4] Greater ventilation can be achieved by disk brakes compared to drum brakes[6].

Disc brake is directly connected to the wheel or axle. In this paper, the disc made up of three materials namely stainless steel, aluminium and cast iron, in which the structural analysis is carried out.

In Structural analysis, the displacement and Von Mises stress is calculated in order to select the best material by FEA method [1] and FEM method [8] and with help of taguchi method analyzed the disc break [5].

Mostly disc brakes will damage due to these four reasons namely: Warping, Scarring, Cracking and Rusting. In service shops, they will change the discs entirely if the cost of new disc is lower than the cost of labour to resurface the original disc. Warping is caused by excessive heat. When friction area of disc substantially higher temperature than inner portion. Hence thermal expansion will be greater than inner portion and warping occurs and it can be reduced by floating [3]. Scarring is due to that the brake will reach the end of their service life and are considered worn out. To prevent worn out or scarring, prompt checking is necessary. Cracking is only limited to drilling disc. As the brake disc is heat sink, hairline cracks may appears in cross drilled metal disc. It can't be reworked, if crack occurs, the disc should be replaced. Surface rust will occurs because mostly the disc is made up of cast iron. It can be avoided by regular usage of brake pads [7]. The design and thermal evaluation of the four wheeler disc break has been carried out by the researcher [11]. Even in small modification in the design leads to major change may happen in results and it is proved with automobile suspension [12], Automobile radiator [14], Passenger cabin comfort [9] and tractor tow pin [10].

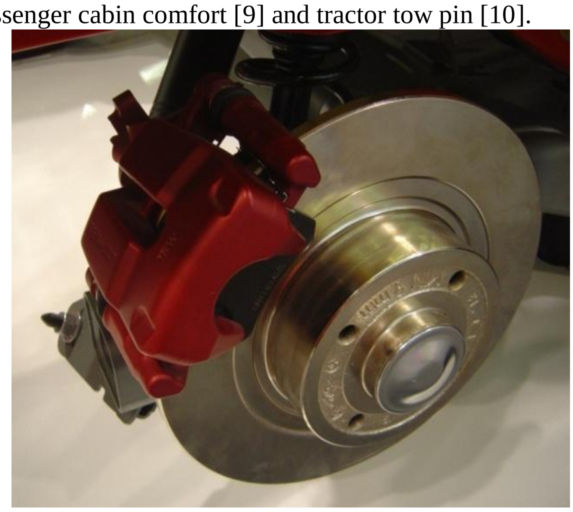

Fig.1 Disc brake of car

II. MATERIALS

Materials will plays a major role in automotive. So, the selection of materials should be more important. In this process, three materials are taken and analyses are carried out, namely: Stainless steel, Cast iron and Aluminium. The material properties of stainless steel are given above in which the young's modulus is 200000N/mm^2 and Poisson's ratio is 0.3.

The some other properties which cause to select these materials are aesthetics, resistance to fire, corrosion resistance, clean ability and recycling. The material properties of cast iron are given above in which young's modulus is 103000N/mm^2 and Poisson's ratio is 0.21. The some other properties which cause to select this material are: strong in compression and weak in tension, good fluidity, hard and little brittle, shrinks on cooling and low melting point. The material properties of aluminium are given above in which young's modulus is 70000N/mm^2 and Poisson's ratio is 0.32. The some other properties of aluminium which causes to select are: density, strength, corrosion resistance, and thermal conductivity [2].

III. STRUCTURAL ANALYSIS OF DISC BRAKE

The designs of disc brake with cross holed and without cross holed are done with using CATIA V5 R21. The weight of disc brake with cross holed is 2.58kg and weight of disc brake without cross holed is 2.733kg. Structural analysis is the one of the most common application in the finite element method. Structural analysis is used to known the effects of load on the physical structure and its components. As name implies, it doesn't applied only in civil engineering structures like, buildings and bridges etc., it's also used in all departments of sciences. There are two types of structural analysis carried out in this project namely: displacement analysis and Von Mises stress analysis. In displacement analysis, the analysis of object in the direction in which the object is moved is carried out. That is the length between the initial and final point is measured due to the effects of load applied on it, whereas in Von Mises stress analysis, the analysis of uniaxial tension is carried out, because it is used to check whether the selected material and selected design can withstand on given load or not.

IV. RESULT AND DISCUSSIONS

Pre-processing of the disc brake without holes with holes was done considering meshing type as tetrahedral mesh [13], with load of 1.2 N/mm$^{2.}$. Structural analysis of disc break with cross drilled holes and without cross holes for different material properties like Stainless steel, cast iron and aluminium alloy were done after meshing the component in tetrahedral mesh type and giving load of 1.2 N/mm^2 common for all three materials. Amount of displacement and stress occurred for each material property was determined and results are discussed below.

A. Stainless steel analysis

Structural analysis of disc break without cross drilled holes for Stainless steel was done and the amount of displacement maximum occurred is 0.002556 mm as shown in Fig.2 .Structural analysis of disc break without cross drilled holes for Stainless steel was done and the amount of stress maximum occurred is 44.636 N/mm^2 as shown in Fig.4. Structural analysis of disc break with cross drilled holes for Stainless steel was done and the amount of displacement maximum occurred is 0.011731 mm as shown in Fig.3 and the amount of stress maximum occurred is 70.002 N/mm^2 as shown in Fig.5.

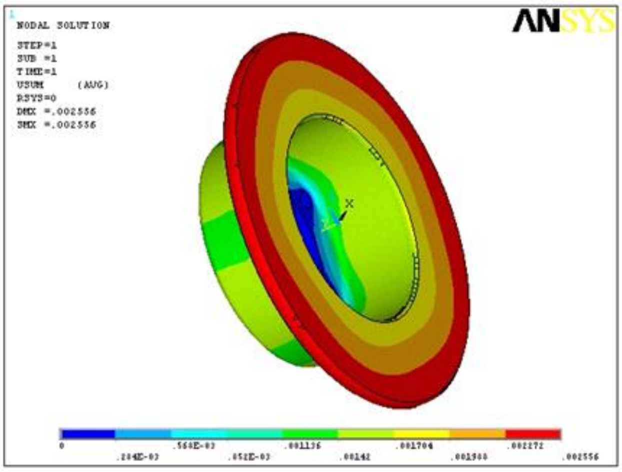

Fig.2 Displacement for stainless steel without holes

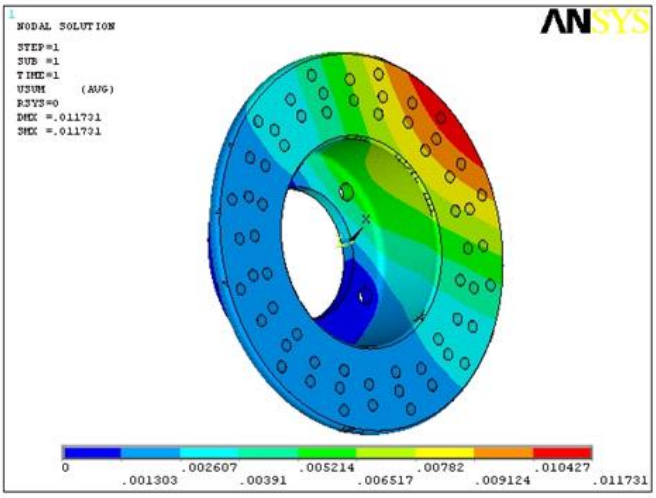

Fig.3 Displacement for stainless steel with holes

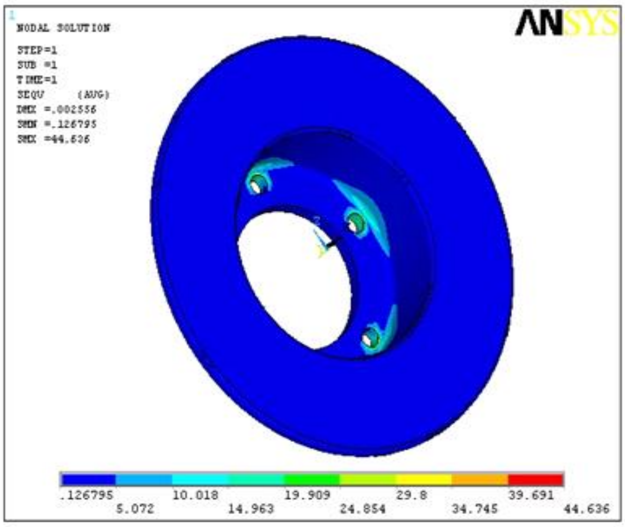

Fig.4 Stress analysis for stainless steel without holes

ISSN: 2278-3075 (Online), Volume-9 Issue-2, December 2019

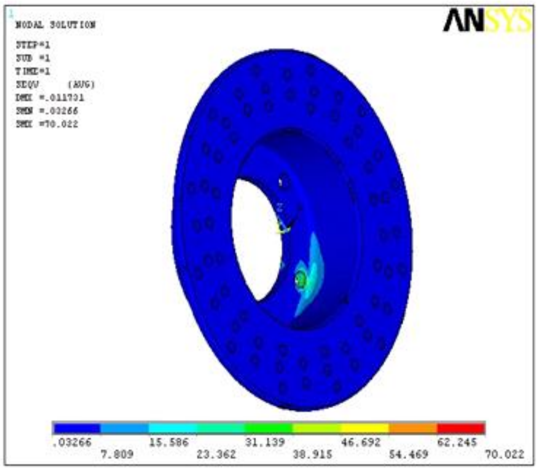

Fig.5 Stress analysis for stainless steel with holes

B. Cast Iron analysis

structural analysis of disc break without cross drilled holes for Cast Iron was done and the amount of displacement maximum occurred is 0.005003 mm as shown in Fig.6 and the amount of stress maximum occurred is 46.254 N/mm^2 is shown in Fig.8. Structural analysis of disc break with cross drilled holes for Stainless steel was done and the amount of displacement maximum occurred is 0.005143 mm as shown in Fig.7 and the amount of stress maximum occurred is 45.174 N/mm^2 is shown in Fig.9.

Fig.6 Displacement on cast iron without holes

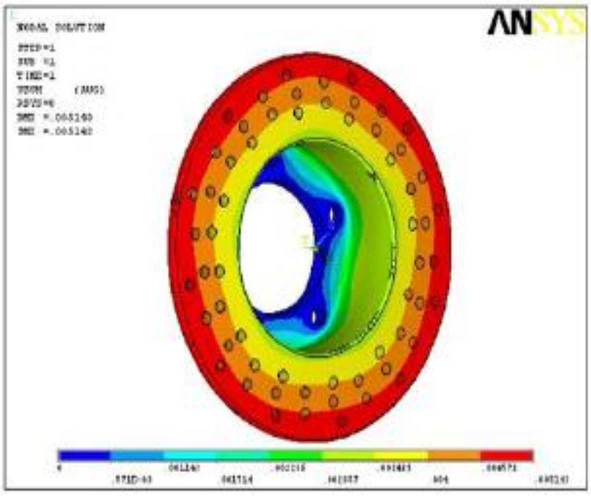

Fig.7 Displacement on cast iron with holes

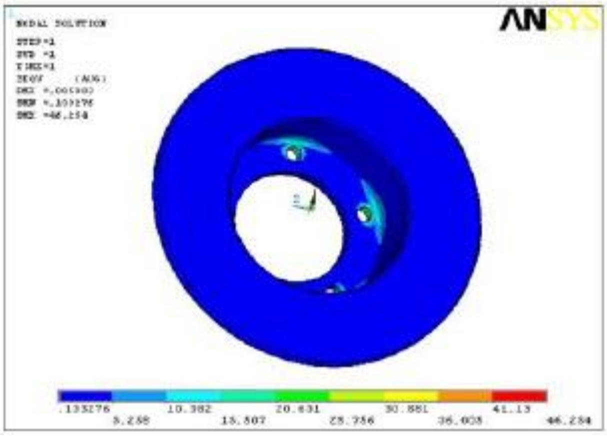

Fig.8 Stress analysis on cast iron without holes

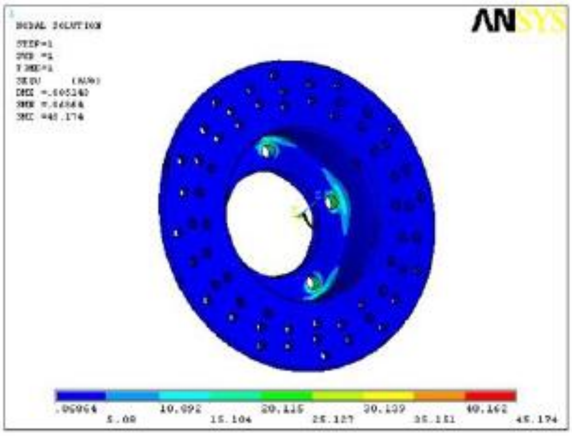

Fig.9 Stress analysis on cast iron with holes

C. Aluminium Alloy analysis

Structural analysis of disc break without cross drilled holes for Aluminium alloy was done and the amount of displacement maximum occurred is 0.006332 mm as shown in Fig.10 and the amount of stress maximum occurred is 43.338N/mm^2 as shown in Fig.12. Structural analysis of disc break with cross drilled holes for aluminium alloy was done and the amount of displacement maximum occurred is 0.006501 mm as shown in Fig 11 and the amount of stress maximum occurred is 41.621 N/mm^2 as shown in Fig.13.

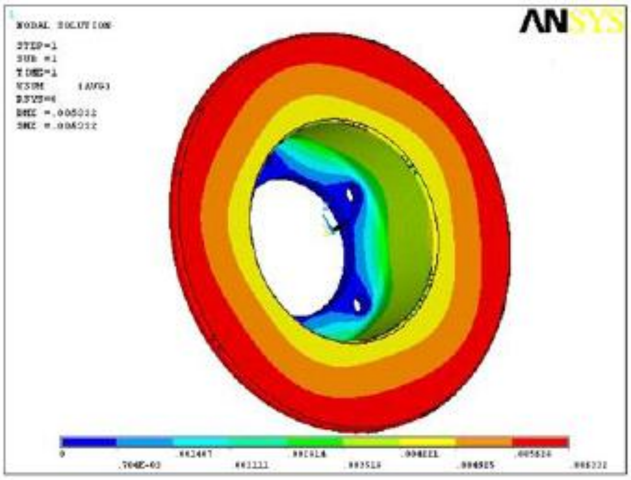

Fig.10 Displacement of aluminium with holes

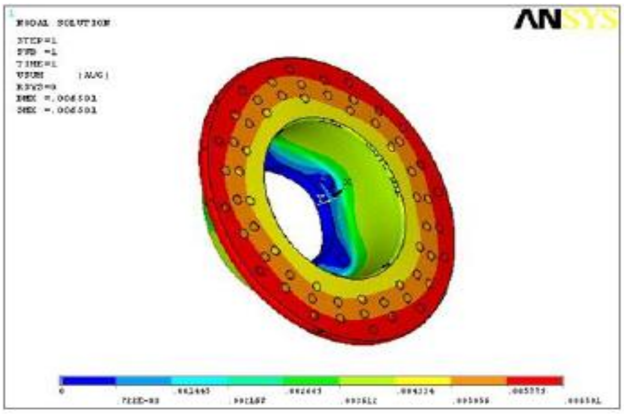

Fig.11 Displacement of aluminium with holes

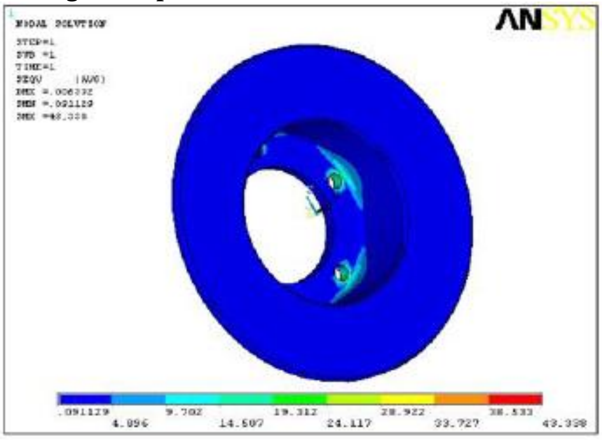

Fig.12 Stress analysis of aluminium without holes

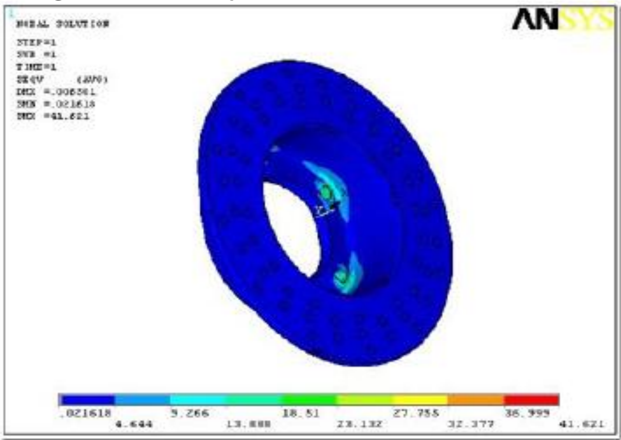

Fig.13 Stress analysis of aluminium with holes

D. Comparison of results

The result of displacement analysis is given in Table 1 for both with cross holed and without cross holed for stainless steel, cast iron and aluminium.

Table1. Comparison of displacement analysis of Disc brake

Material	**Displacement (mm)** without cross drilled holes	**Displacement (mm)** with cross drilled holes
Stainless Steel	0.002556	0.011731
Cast iron	0.005003	0.005143
Aluminum alloy	0.006332	0.006501

The displacement of stainless steel is 0.002556 mm for without cross drilled holes and 0.011731 mm for with cross drilled holes and for cast iron the displacement is 0.005003 mm for without cross drilled holes and 0.005143 mm for with cross holes and for aluminium alloy. The displacement is 0.006332 mm for without cross drilled holes and 0.006501 mm for with cross drilled holes. From the results, it seems that the displacement is low for without cross drilled holes. The results of Von Mises stress analysis is given in Table 2 for both with cross holed and without cross holed for stainless steel, cast iron and aluminium. the Von Mises stress of stainless steel for without cross drilled holes is 44.636 N/mm^2 and for with cross drilled holes 70.022 N/mm^2 and for cast iron the Von Mises stress for without cross drilled holes is 46.254 N/mm^2 and 45.174 N/mm^2 for with cross holes and for aluminium alloy the Von Mises stress is 43.338 N/mm^2 for without cross drilled holes and 41.621 N/mm^2 for with cross drilled holes. From the results, it seems that the displacement is low for without cross drilled holes.

Table 2 Comparison of Von Mises stress of Disc brake

Material	**Von Mises Stress (N/mm^2)** Without cross drilled holes	**Von mises Stress (N/mm^2)** with cross drilled holes
Stainless Steel	44.636	70.022
Cast iron	46.254	45.174
Aluminum alloy	43.338	41.621

V. CONCLUSION

Structural analysis for three different of disc brakes such as stainless steel, cast iron and aluminium alloy is done. Present used materials for disc brake are stainless steel and cast iron. The materials are replaced with Aluminium alloy, since its density is less than that of other two materials thereby reducing the weight of disc brake. The stress values obtained in structural analysis are less than the yield stress value of Aluminium alloy, hence using Aluminium alloy for disc brake is safe. And also by comparing with other two materials, the stress value is less for aluminium alloy. But in aluminium alloy there are two stresses one is without cross drilled 43.338 N/mm^2 and another one is with cross drilled 41.621 N/mm^2. Among this two, aluminium material with cross drilled has minimum Von Mises stress of 41.621 N/mm^2 and displacement of 0.006501 mm. Hence clearly understand that by using aluminium alloy material with cross drilled holes type disc brake will give a greater braking effect comparing with other two materials.

REFERENCES

1. Afzanizam.M.R, Ahmad.R, Nurfaizey. A.H., Radzai M.S., Ridzuan.M.M, and Zaid. M.A. "An investigation of disc brake rotor by finite element analysis", Journal of Advanced Manufacturing Technology, Vol. 3, No. 2, 2009, pp. 37-48.
2. Agbeleye A A , Esezobor D E , Balogun S A , Agunsoye J O , Solis J, Neville A (2017). Tribological Properties of Aluminium-Clay composites for brake disc rotor applications. S1018-3647(17)30834-0.
3. Aleksander Yevtushenko, Michal Kuciej, Ewa Och, Olena Yevtushenko (2018). Frictional heating of the brake disc with essential nonlinearity thermal barrier coating. 95 (2018) 210 – 216.
4. Ali Belhocine, Mostefa Bouchentara (2012). Thermal analysis of a solid brake disc. Applied Thermal Engineering 32 (2012) 5- 67.

5. Barton.D. C, Buckingham.J.T, Crolla.D.A, and Grieve.D.G, "Design of a lightweight automotive brake disc using finite element and Taguchi techniques", Proc. Instn Mech Engrs, Part D: J. Automobile Engineering, Vol. 212, 1998, pp. 245-254.
6. Cho C.D and Cho H.J, "A study of thermal and mechanical behaviour for the optimal design of automotive disc brakes", Proc. IMechE, Part D: J. Automobile Engineering, Vol. 222, 2008, pp. 895-915.
7. Cuevaa G , Sinatorab A , Guesserc W L , Tschiptschina A P , (2003). Wear resistance of cast irons used in brake disc rotors. Wear 255 (2003) 1256–1260.
8. Kharatea N K , Chaudhari S S (2017), "Effect of material properties on disc brake squeal and performance using FEM and EMA approach", Materials Today: Proceedings 5 (2018) 4986–4994.
9. Purusothaman M ,Valarmathi T N,Dada Mohammad S K, Computational Fluid Dynamic Analysis of Enhancing Passenger Cabin Comfort Using PCM, IOP Conf. Series: Materials Science and Engineering 149 (2016) 012197, doi:10.1088/1757-899X/149/1/012197.
10. Purusothaman M, Mohan Krishna J, Jitendra siva prasad T, Manoj kumar K, " Design and development of Tractor Tubular Tow Pin using Ahss", International journal of Recent Technology and Engineering, Vol.8, Issue.1,2019,pp.2656-2660.
11. Purusothaman M, Sunil Kumar M, Praveen kumar V, Suraj kumar, Senthamizh Selvan S, Design And Thermal Validation Of Four Wheeler Disc Brake Using Different Material, International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Vol.8 Issue-8, 2019, pp.1739-1764.
12. Purusothaman M, Yogesh M, Vengatesan E, Vignesh B, Ramkumar A, "Design Modification and Improvement on Automobile Suspension System", International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-8 Issue-11, September 2019, pp.277-281.
13. Purusothaman, M., and Valarmathi, T. N. (2018). Computational fluid dynamics analysis of greenhouse solar dryer. International Journal of Ambient Energy, *17*. doi:10.1080/01430750.2018.1437567.
14. Senthilkumar, G., Ramachandran, S., & Purusothaman, M. (2010). *Indigenous development of automobile radiator using CFD. Frontiers in Automobile and Mechanical Engineering - 2010*.doi:10.1109/fame.2010.5714862.

ATHUORS PROFILE

M.Purusothaman was born at Madurai, Tamil Nadu on 10.04.1984 and author has completed his Master of Engineering in Refrigeration and Air condition with **Distinction and GOLD Medal** from College of Engineering Guindy, Chennai and Bachelor of Engineering in Mechanical from RVS college of Engineering and Technology, Dindigul. Author's major field of interest is Greenhouse solar Dryer, Refrigeration and Air Conditioning, Computational Fluid Dynamics, and IC Engines. He has 10 years of Teaching and 1 year of Industry experiences and currently working as an Assistant professor in Sathyabama Institute of Science and Technology, Chennai. He has published **16 Scopus indexed journals** in various international and national journals. Mr.M.Purusothaman becomes members in various Professional bodies like Indian Society of Heating and Refrigeration and Air-conditioning Engineers (ISHRAE), Society of Automobile Engineers (SAE), International Association of Engineers (IAENG), Hong kong society of Mechanical Engineers (HKSME).

T Jitendra Siva Prasad was born at Andhra Pradesh on 11.12.1999 and pursuing B.E (Mechanical) from Sathyabama Institute of Science and Technology. Author's major field of interest is Thermal Engineering Refrigeration and Air Conditioning and IC Engines.

J Mohan Krishna was born at Andhra Pradesh on 07.01.1999 and pursuing B.E (Mechanical) from Sathyabama Institute of Science and Technology. Author's major field of interest is Heat and mass Transfer, Refrigeration and Air Conditioning, and IC Engines.

K Manoj kumar was born at Telangana on 05.10.1999 and pursuing B.E (Mechanical) from Sathyabama Institute of Science and Technology. Author's major field of interest is Thermal Engineering, Refrigeration and Air Conditioning and Design.