iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VIII **Month of publication:** August 2021

DOI: https://doi.org/10.22214/ijraset.2021.37642

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VIII Aug 2021- Available at www.ijraset.com

Transient Thermal Analysis of Disk Brake System under Varying Velocities and Pad Material Properties

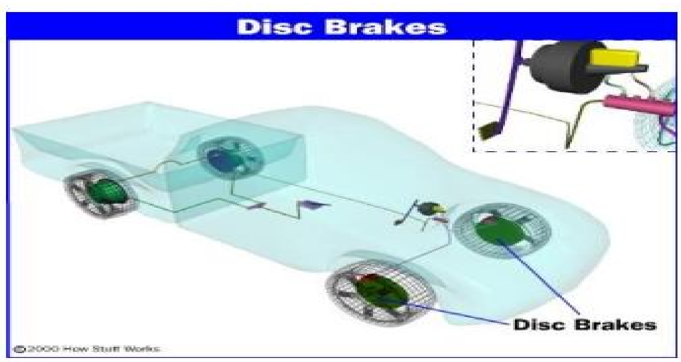
Rahul Gund[1], Pradnya Kosbe[2]
[1, 2]Department of Mechanical Engineering, JSPM's Jayawantrao Sawant College of Engineering

Abstract: The Enormous progressions in the field of automobiles have led their car engines to have enriched brake power in vehicles. The braking system's efficiency should be at par with the engine to decelerate the car from a given speed within a less braking distance. The disc rotor and brake pads design and material while counting other impacting factors contribute to braking efficiency. The disc rotor will be exposed to large stresses which result in surface cracking, overheating of brake fluid, seals and other components. Many factors are affecting it as coefficient of friction between brake pad and disk rotor surface, thermal conductivity of pad material. Hence to reduce thermal stresses we can choose right pad material. In this project, thermal analysis for vented disc brake rotor of Mahindra Bolero's done, for providing an efficient material for disc brake rotor and brake pads with 0 to 12 % of steel powder as filler materials are used which can dissipate heat generated during braking at faster rate and also being structurally safe

Keywords: Braking system, Disc Brake Rotor, Thermal, Structural Analysis, CATIA V5, ANSYS WORKBENCH, Pad Material properties

I. INTRODUCTION

The disc brake is a wheel brake which slows the rotation of the wheel by the friction caused by the pushing brake pads against a brake disc with a set of calipers. The brake rotor is connected to the wheel and axle. To stop the wheel, the friction material mounted on a brake caliper, is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and wheel to slow down. The function of brakes is based on the law of conservation of energy. In this process, the brakes absorb either kinetic energy of the moving member or the potential energy given up by objects being lowered by hoists, elevators, etc. If vehicle is at faster speed, it is difficult for it to stop. Due to increased kinetic energy, there is increased heat energy on brake system.



Location of disc brake

II. RESEARCH BACKGROUND

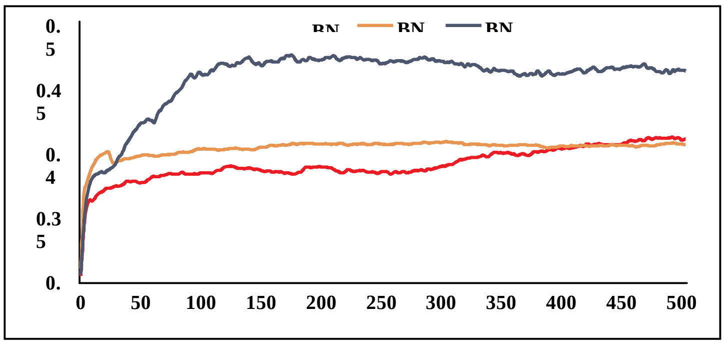
Temperature and Thermal Stresses of Vehicles Gray Cast Brake by A.Belhocine, M. Bouchetara[1]-In this publication, they presented the analysis of the thermo mechanical behavior of the dry contact between the brake disc and pads during the braking process; the modelling was based on the ANSYS 11.0.The modelling of transient temperature in the disc is actually used to identify the factor of geometric design of the disc to install the ventilation system in vehicles. The thermo-structural analysis is then used with coupling to determine the deformation established and the Von Mises stresses in the disc, the contact pressure distribution in pads. The results are satisfactory when compared to those found in previous studies.

Design and Analysis of Vented Disc Brake Rotor by Praharsha Gurram1 , Shravan Anand Komakula1 , G. Vinod Kumar[2]- In this paper, from all materials which are taken into consideration, aluminum metal matrix composite has show the desirable results for disc brake rotor (vented with cross-drilled holes) which bares maximum thermal stresses induced due to friction between brake pad and surface of disc rotor and also dissipates the heat generated at a faster rate. So according to them aluminum metal matrix composite material is preferred because of less deformation, high strain and stress along with high heat flux when compared with other materials.

FEA on Different Disc Brake Rotors by S.A.M Da Silva, DVV Kallon[3]- Different types of disc rotors are studied like grooved, cross drilled brake rotors and combination of both. The drilled-grooved brake was also designed with grooves and drilled holes to allow better performance of the brake disc by allowing air to cool the rotor

Effect of hexagonal boron nitride (h-BN) inclusion on thermal characteristics of disc brake friction composites by Pradnya Kosbe, Pradeep Patil , Muthukumar Manickam , Gurunathan Ramamurthy[4]- In this paper, friction composites are studied keeping other ingredieants constants and varying

wt% of hexagonal filler h-BN from 0 to 8 wt% and and decreasing the space filler barite from 35 to 27 wt% in friction composites BN0, BN1, and BN2 respectively. The composite with the highest amount of hBN (BN2) shows the lowest friction fluctuations with a high coefficient of friction. The highest thermal conductivity is observed in the case of friction composite having 8 wt% BN powder.



III.METHODOLOGY

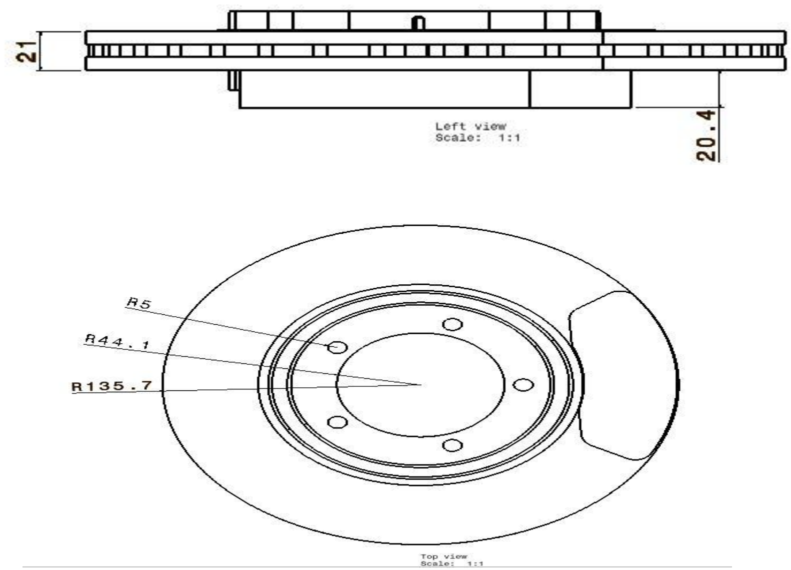
1) Design of disc brake rotor
2) Material selection
3) Analysis of disc brake rotors
4) Evaluating results from the analysis

A. Design of Disc Break Rotor

Designing of vented disc brake rotor using the ISO standard dimensions of Mahindra Bolero car in CATIA V5

Product	Brake disc
Product name	Mahindra Utility, Bolero
Material	Cast Iron
Type	Plain
Dimensions	Outer Diameter: 272.5mm Total Height : 40mm Inner Diameter : 152mm Plate Thickness: 21mm

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VIII Aug 2021- Available at www.ijraset.com



B. *Material Properties of Disc Rotor*

Properties	Grey cast iron
Density, ρ	$7000 Kg/m^3$
Yield tensile strength	142 MPa
Compression-to-Tensile Strength Ratio	4.05
Young modulus, E	100 GPa
Thermal conductivity, K	54W/m.K
Specific heat, C_p	586J/Kg.K
Passion's ratio, υ	0.28
Coefficient of expansion, α	$8.1*10^{-6} m/(m*K)$

C. *Different Pad Materials*

Material Properties	Material 1	Material 2	Material 3	Material 4
Density (gm/cc)	2.29m/cc	2.25gm/cc	2.30gm/cc	2.34gm/cc
Thermal Conductivity (W/mk)	0.93	1.06	1.258	1.35
Coefficient of Friction	0.33	0.34	0.36	0.42
Percent Of Steel powder	0%	4%	8%	12%

D. Different Vehicle Parameters

Parameter Name	Parameter Value (units)
Mass of the vehicle (M)	1735kg
Top speed	100 km/hr or 27.77 m/s
Wheel diameter	381mm
Piston diameter	57mm

E. Calculation For Heat Flux

1) For Pad Material 1

For Velocity $=80\frac{km}{hr}$

Kinetic Energy of Vehicle

$$K.E = \frac{mv^2}{2}$$

$$= \frac{1735 \times 22.22 \times 22.22}{2}$$

$$\therefore K.E = 428309 \text{ Joule}$$

Where, K. E − kinetic Energy (J)

M − Mass of vehicle (Kg)

V − Linear velocity of vehicle $\left(\frac{m}{s}\right)$

The total kinetic energy = The heat generated

Stopping distance of vehicle

Braking distance of vehicle refers to the distance a vehicle will travel from the point when its brakes are fully applied to when it comes to a complete stop.

The maximum friction force,

$$F = \mu mg = 0.330 \times 1735 \times 9.81$$

$$\therefore F = 5616.715 \text{ N}$$

$$a = \frac{F}{m}$$

$$= \frac{5616.715}{1735}$$

$$\therefore a = 3.2373 \frac{m}{s^2}$$

Time taken to stop the vehicle,

$$t = \frac{v}{a} = \frac{22.22}{3.2373}$$

$$= 6.85$$

$$\therefore t \cong 7 \text{ sec}$$

$$\text{Heat Flux} = \frac{\frac{\text{Heat generated}}{\text{time}}}{\text{Contact area}}$$

Where, Contact area = 2×contact area of piston of caliper

$$= 2\times\frac{\pi}{4}\times[(\text{diameter of rotor})^2 - (\text{diameter of rotor} - \text{diameter of piston})^2]$$

$$= 2\times\frac{\pi}{4}\times[(0.2725)^2 - (0.2725 - 0.057)^2]$$

$$= 0.04369\ m^2$$

$$\therefore \text{Heat Flux} = \frac{\frac{428309}{7}}{0.04369}$$

$$\therefore \text{Heat Flux} = 1.40e^6\frac{W}{m^2}$$

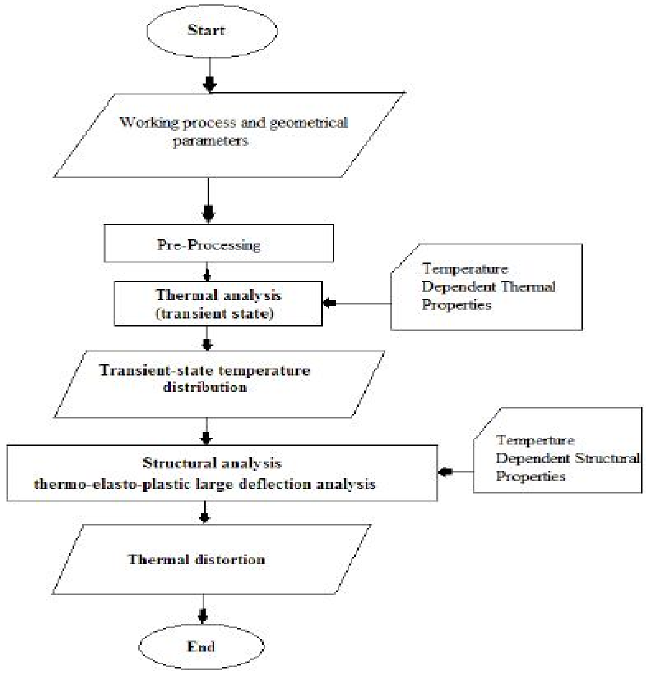
Similarly,

Velocity (Km/hr)	KineticEnergy (Joule)	Time (Seconds)	Heat Flux $(\frac{W}{m^2})$
$80\frac{km}{hr}$	428309 J	7 sec	$1.40e^6\frac{W}{m^2}$
$90\frac{km}{hr}$	542187 J	8 sec	$1.637e^6\frac{W}{m^2}$
$100\frac{km}{hr}$	668992 J	9 sec	$1.70e^6\frac{W}{m^2}$

IV. FEA ANALYSIS

1) *Introduction to ANSYS Program:* Dr. John Swanson founded ANSYS. Inc in 1970 with a vision to commercialize the concept of computer simulated engineering, establishing himself as one of the pioneers of Finite Element Analysis (FEA). ANSYS inc. supports the ongoing development of innovative technology and delivers flexible, enterprise wide engineering systems that enable companies to solve the full range of analysis problem, maximizing their existing investments in software and hardware. ANSYS Inc. continues its role as a technical innovator. It also supports a process-centric approach to design and manufacturing, allowing the users to avoid expensive and time-consuming “built and break” cycles. ANSYS analysis and simulation tools give customers ease-of- use, data compatibility, multi platform support and coupled field multi-physics capabilities.

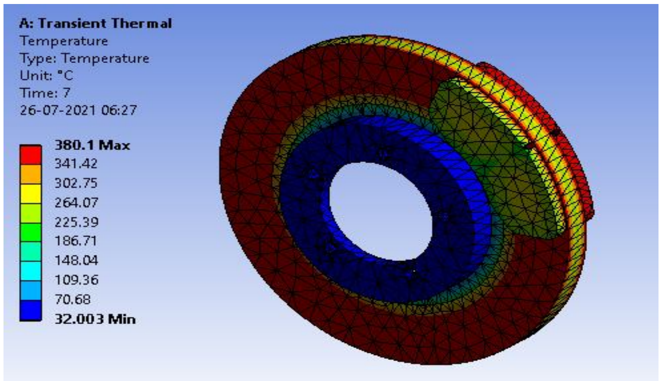
2) Procedure for ANSYS Analysis



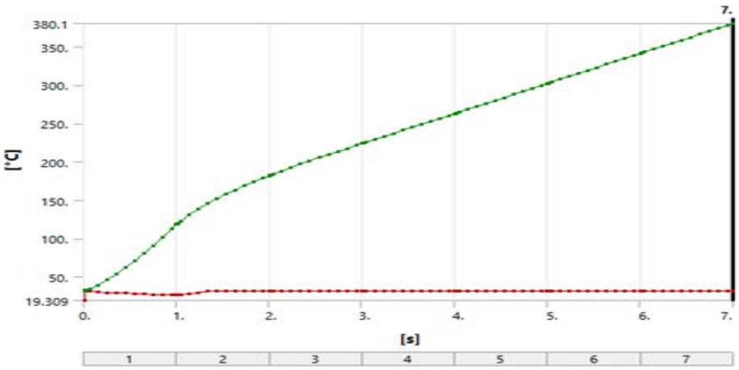
V. RESULTS

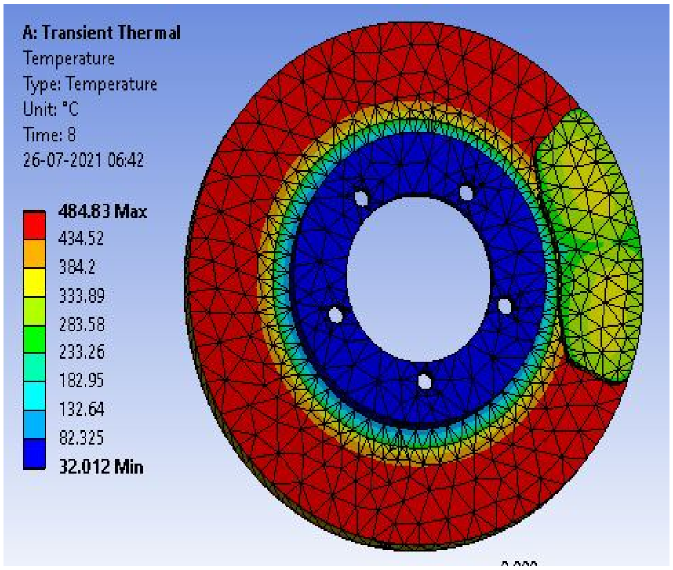
A. Analysis Results for Pad Material 1

1) Transient Thermal

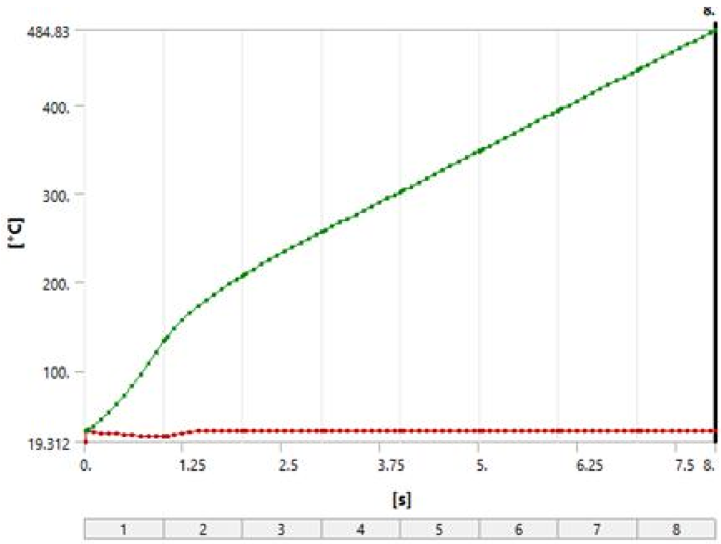


Temperature Distribution for 80km/hr

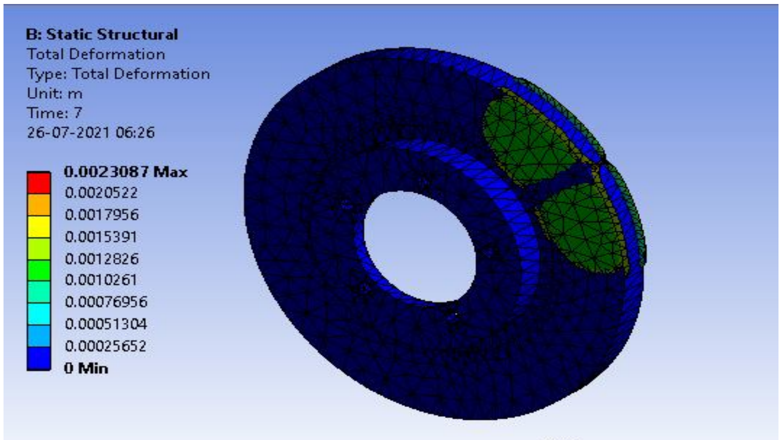




Temperature Distribution for 90km/hr

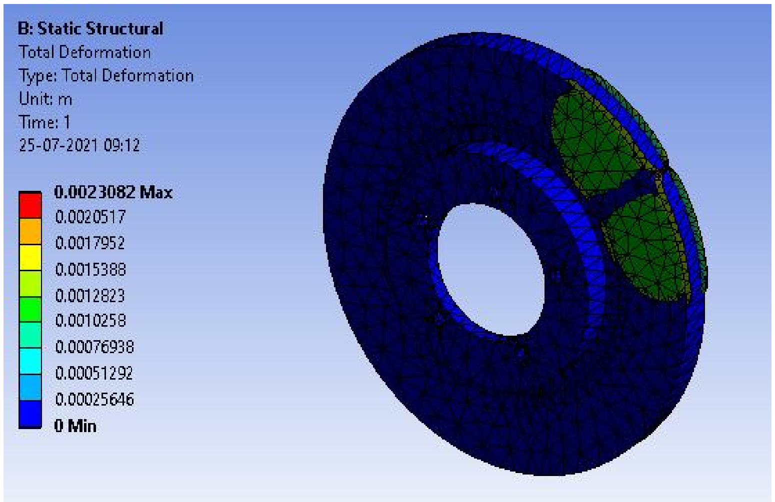


2) *Static Structural*

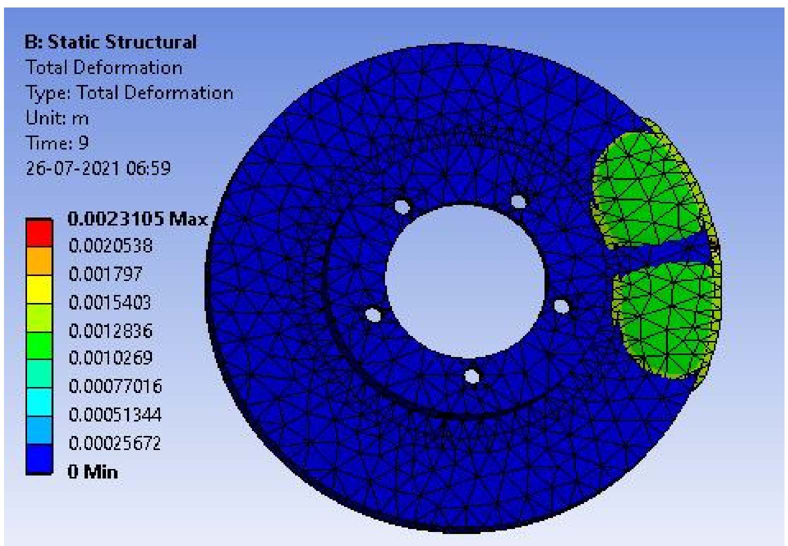


Total Deformation for 80 km/hr

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VIII Aug 2021- Available at www.ijraset.com



Total Deformation for 90 km/hr



Total Deformation for 100 km/hr

Velocity	Static Structural Analysis				Transient Thermal Analysis			
	Total Deformation(m)		Equivalent Stress (Pa)		Temperature (°C)		Total Heat flux(W/m^2)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
80 km/hr	0.m	0.0023087 m	568.91 Pa	2.1586e+006 Pa	32 °C	380.1 °C	1.0963 W/m^2	2.2224e+006 W/m^2
90 km/hr	0.m	0.0023095 m	1123.8 Pa	2.156e+006 Pa	32 °C	484.83 °C	7.3763 W/m^2	2.6654e+006 W/m^2
100 km/hr	0.m	0.0023105 m	1453.4 Pa	2.1533e+006 Pa	32 °C	556.41 °C	9.2259 W/m^2	2.8402e+006 W/m^2

VI. CONCLUSION

A. As per FEA results, we observed that pad material having higher percentage of steel powder undergone maximum temperature of 573.65 °C.

B. Pad material having higher coefficient of friction shows highest temperature. So we can say, higher the coefficient of friction higher is the temperature.

C. From the results obtained we can conclude that pad material with the least coefficient of friction will help to reduce the temperature rise in the disc rotor.

REFERENCES

[1] Praharsha Gurram, Shravan Anand Komakula, "Design of Disc Brake Rotor using Static Structural and Thermal Performance Analysis", JETIR (Journal of Emerging Technologies and Innovative Research) | Volume 6, Issue 4, April 2019 | ISSN: 2349-5162.

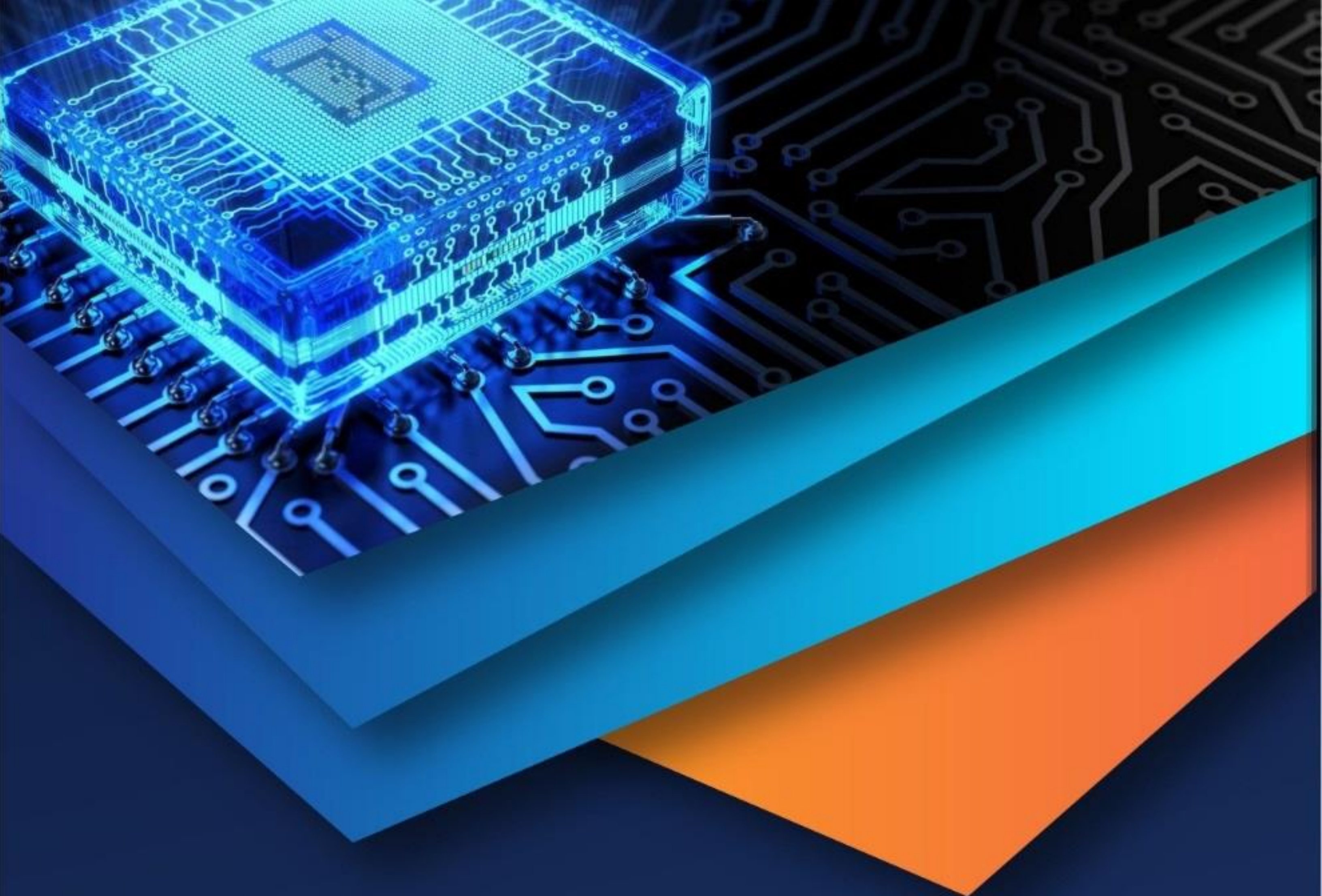
[2] Mit Patel, Mansi Raval, Jenish Patel, "Design of disc brake rotor", IJEDR (International Journal of Engineering Development and Research) | Volume 4, Issue 4, 2016 | ISSN: 2321-9939. [

[3] Sainath chary, Anoop Kumar, "Design and analysis of disc brake using structural steel", IJETSR (International Journal of Engineering Technology Science and Research) | Volume 4, Issue 12, 2017 | ISSN: 2394-3386

[4] J. Bijwe, Composites as friction materials: recent developments in non-asbestos fiber reinforced friction materials – a review, Polym. Compos. 18 (1997) 378–396, https://doi.org/10.1002/pc.10289.

[5] K. Hee, P. Filip, Performance of ceramic enhanced phenolic matrix brake lining materials for automotive brake linings, Wear 259 (2005) 1088–1096, https://doi. org/10.1016/j.wear.2005.02.083. [

[6] M.H. Cho, S.J. Kim, D. Kim, H. Jang, Effects of ingredients on tribological characteristics of a brake lining: an experimental case study, Wear 258 (2005) 1682–1687, https://doi.org/10.1016/j.wear.2004.11.021.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY