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Failure Analysis and Design of Disc in Two Wheeler

Ranjan Kumar[1], Manoj Narwariya[2]
[1, 2] Mechanical Engineering Department, IPS-CTM Gwalior

Abstract: Failure of brakes in vehicles has been one of the major causes of many accidents. As far as two wheelers are concern it is the major reason for accident by collision or slipping. When we apply force (brake) to stop the vehicle then the force transfer to the disc rotor due to force on disc it sometimes damages the disc and eventually it may fail also. This shows that no proper material has been chosen while selecting the disc at different conditions. So, the main motive of this work is to moderate the crash by replacing a matter which could surmount the properties of existing material used in a disc rotor then Analysis in static condition is performed on the disc rotor of disc brake assembly to confirm the endurance of mechanical properties on the disc rotor. Results of two commonly used materials which are Cast Iron (CI) and Stainless Steel (SS) is compared with the result of Vanadium Steel. The analysis results represent that the Vanadium Steel has better performance than the other materials. The factors which were selected to verify the result was maximum deformation, stress and strain. The disc brake is modeled and the analysis is done on ANSYS Workbench 15.0.
Keywords: Disc brake, Static Analysis, Total deformation, Stress, Strain, ANSYS 15.0

I. INTRODUCTION

A brake is a mechanical arrangement by which artificial resistance of friction is applied to slow down the rotational motion of wheel in vehicle. When we apply brake to the vehicle brake pads comes in contact with the disc rotor and tangential frictional force is applied due to this kinetic energy of brake is absorbed and gets converted into heat and is librated to the surrounding atmosphere by means of holes on disc brake. Now a day, disk brakes system is taking revolution place in light vehicles. The rotor of disc brake is generally made up of stainless steel and cast iron or there composites or by using some ceramics also, and rotor of disc brake is placed in parallel with wheel or at axle of vehicle. To retard the motion of the wheel a frictional pad is in build in the assembly of the disc brake which is connected hydraulically. Or electrically to the driver of the vehicle. When brake is applied then frictional; pad comes in contact with disc rotor at both area of the rotor which retard the motion of the wheel.

The braking arrangement in 2-wheelers must possess following characteristics.

1) The rotor of disc brake should rapidly liberate heat to the near atmosphere.
2) The rotor of the brake must wear less to increase disc rotor life.
3) On applying brake vehicle must not slip.
4) The brake arrangement should be capable of retarding the motion of vehicle.

Depends on the working mode disc brakes are categorized in three ways:

a) Hydraulic brakes.
b) Electric brakes.
c) Mechanical brakes

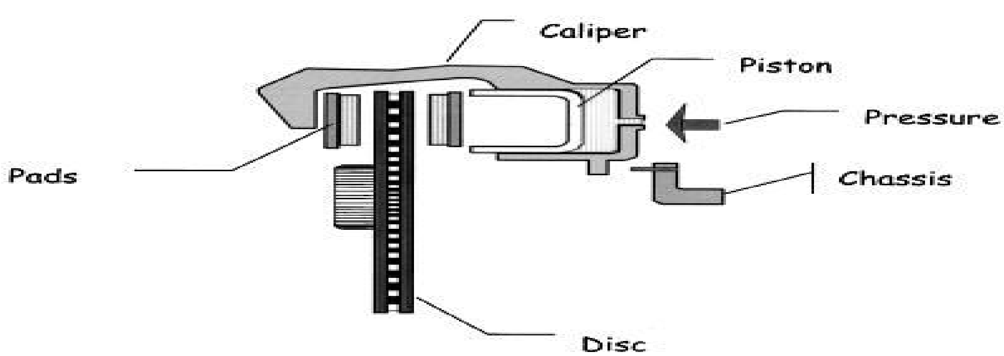

Fig-1 Schematic of Disc brake and component

A. Classification of Brakes

1) *Radial Brakes:* In those brakes the pressure performing on the brake drum is in radial course. The radial brake can be subdivided into outside brakes and internal brakes.
2) *Axial Brakes:* In those brakes the force appearing on the brake drum is best within the axial course. e.g. Disc brakes, Cone brakes

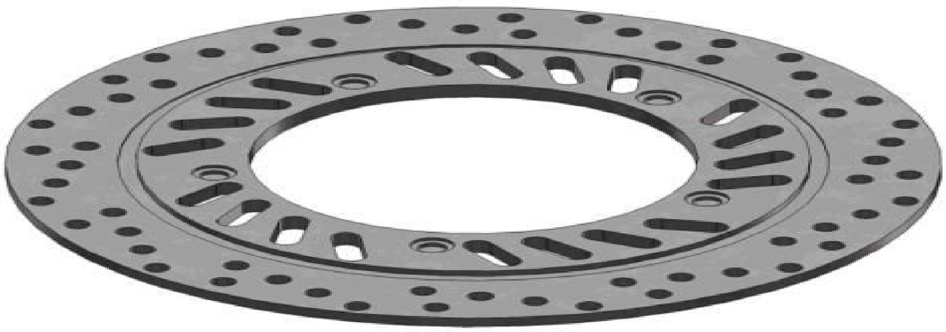

Fig-2 Rotor of Disc brake

B. Problem Statement and Objective

When force is applied on the brake pedal then it causes the brake pads to stick with disc brake which creates artificial friction due to this friction rusting of rotors and pads takes place and responsible for deformation and various thermal stresses due to high increase in temperature and friction takes place. Due to these unsuitable conditions forms consequences like microscopic cracks, permanent failures, thermal deformation due to frictional heating and various elastic after effect produces on the friction surfaces of disc. Due to localized high temperature contact regions created which are called "hot spots". These Hot spots can cause material damage and thermal crack, and induce an undesirable frictional vibrations.

C. Objective

1) Design of the disc for a disc brake system using load analysis, stress analysis and thermal analysis system approach.
2) The rotor of disc brake should hold enough rigidness.
3) Life of rotor and pad must increase.
4) Absorption and dispersion of heat must be rapid.

II. LITRATURE REVIEW

A. M. L. Agarwal at el. This work reviews the design and FEA model of disc brake assembly in which deformation and deflections in all three direction of rotor can be found out and in inclusion Von mises assessment of rotor is analyzed by putting boundary conditions. The analysis result of FEA are associated with performed data.when results are compared then designed set is safe under practical loading condition.

B. Ameer Fareed at el. This work reviews the study of disc rotor of Honda Civic. In this paper mechanical & Thermal analysis was conducted on the brake rotor. After altering the designing condition of disc rotor brake examination was performed. The material selected as Cast Iron (CI). Actual disc brake does not hold holes on its surface, by improving the design of the disc brake rotor of brake assembly by creating certain holes for more heat indulgence. Model of disc was designed on Catia and then Analysis of rotor is performed on ANSYS workbench. The created designed brake rotor was then analyzed at various high nodal temperature conditions. Then results were used as to carry out the distortion and deformation on rotor at elevated temperatures. We observe some increase in displacement with comparison to the earlier condition.

C. Daniel Das. at el. The motive of this research work was to find out the hot spots and structural area of the rotor of disk brake when emergency braking is done. This analysis was carried out with four different materials. The fractionalization of the temperature on the disc rotor depends on the prescribed factors like friction, surface irregularity and swiftness. The outcome of the sharp velocity and the induced pressure tends to rise of temperature of rotor of disc brake. The FEA for 2D model was set on priority due to the ratio of heat librated per unit area constantly distributed in peripheral direction. And then the value of temperature and distortion for different load condition using analysis software with chosen four materials.

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D. N. Balasubramanyan at el. In this research manuscript, 3-D modeling of thermal & Structural analysis by simulation on ANSYS workbench were performed. The outcomes have greater flexibility and accuracy. There were 3 dissimilar materials of disc brake rotor bearing invariable hydraulic pressure of 1 N/mm2 in dynamic condition & analysis. On observing the result and analysis they concluded that grey Cast Iron is the appropriate material for disc brake rotor.

III. DESIGN PARAMETERS OF DISC BRAKE

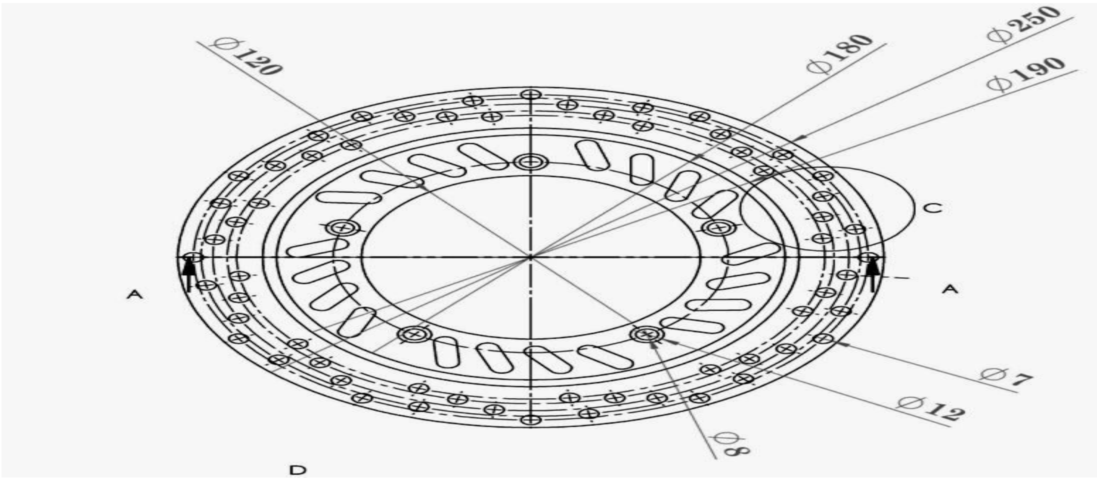

Fig-3 Geometric consideration of disc brake

IV. MATERIAL AND METHODS

First we design the rotor of disc brake assembly and then we select the appropriate material by which its mechanical properties can be put down while analyzing the rotor model. when all the aspect of design and analysis are fulfilled then manufacturing of the component takes place. This whole process is performed to decrease the production costs, rapid time-to-market, a reduction in-service failures, etc., to realize these benefits; engineers have to cope up with extremely complex matrices. There are numberless material which can be taken in use to fulfill the requirement of the problem in terms of design, manufacturing, cost, market and working life. But when any material is selected there must be optimum set of all the conditions, so a comprehensive study is required before finalizing any material.

A. Factors Affecting Selection Of Material

Selection of material for manufacturing is also a very complex and important aspect. While selecting materials various factors can be taken into consideration. These considerations depend upon many criteria in which some of them are.

1) Properties of material
2) Cost and Availability
3) Manufacturing aspect
4) External factor (Environment)

a) Mechanical Properties Of Material

Table 1 Properties of selected material

Properties	Stainless Steel	Cast Iron	Vanadium steel
Density	7800	7150	6150
Young’s modulus	200	130	128
Poison’s Ratio	0.3	0.25	0.35
Thermal Conductivity	28	55	32
Specific Heat	500	580	487
Coefficient of friction	0.23	0.3	0.25

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b) Model Of Disc Brake

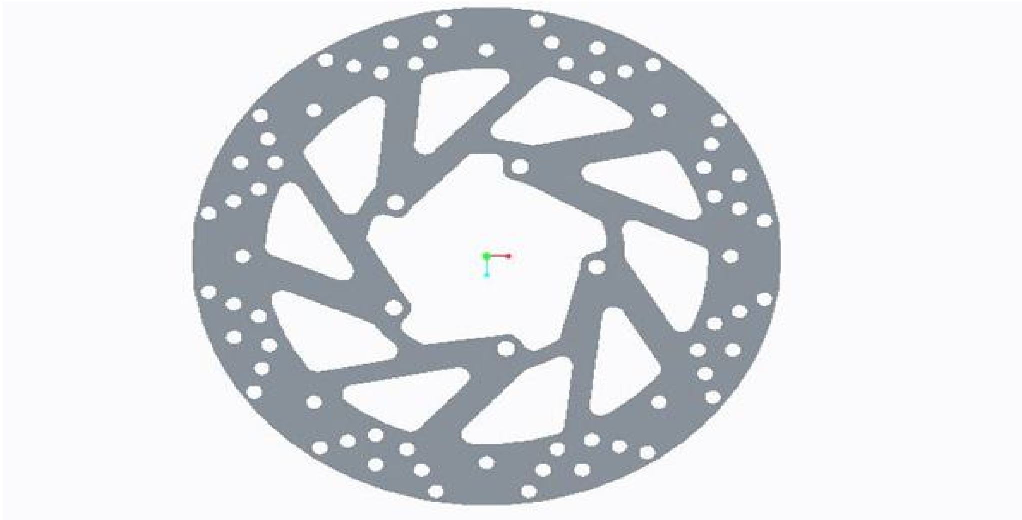


Fig-4 Top view of disc

The 2-dimensional disc is designed with all standard geometrical considerations. The diameter of disc is 240 mm and the thickness of the disc is 3mm.

V. RESULTS AND DISCUSSIONS OF DISC ROTOR

1) *Stainless Steel:* The analytical result of static structure of disc of Total deformation, longitudinal Stress and Normal Elastic Strain of used material Stainless Steel after analysis on ANSYS workbench 15.0 with cited load condition.

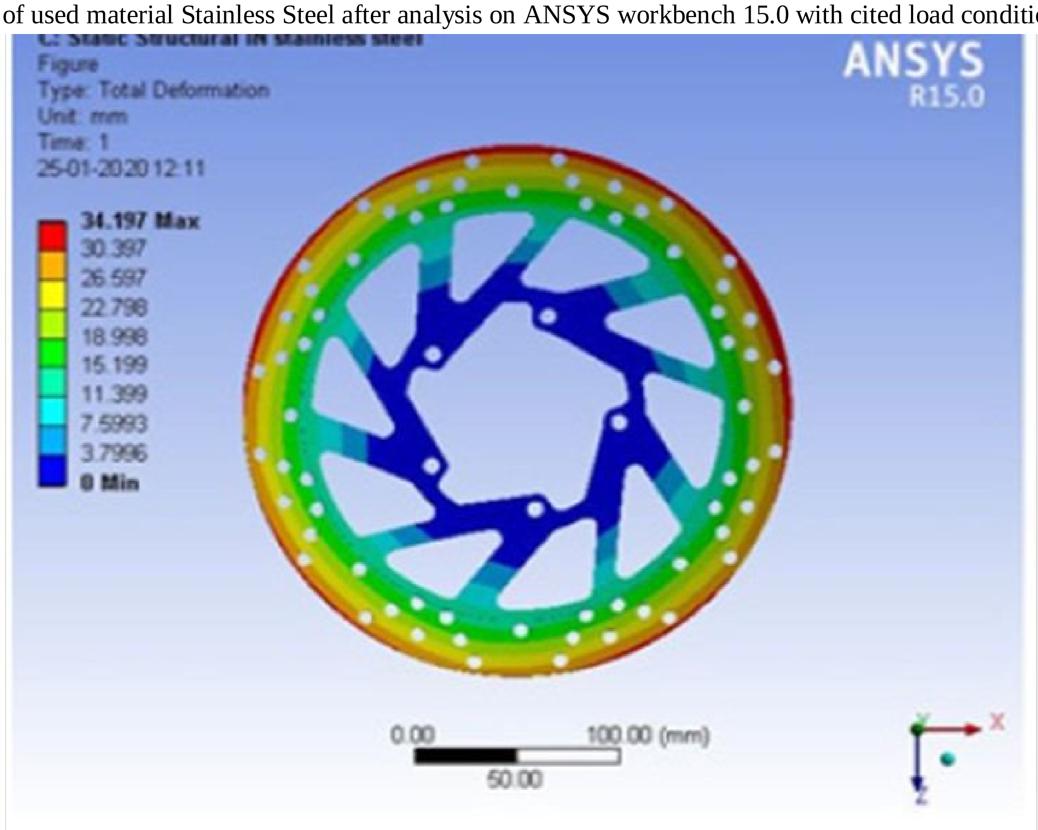


Fig-5 Total deformation

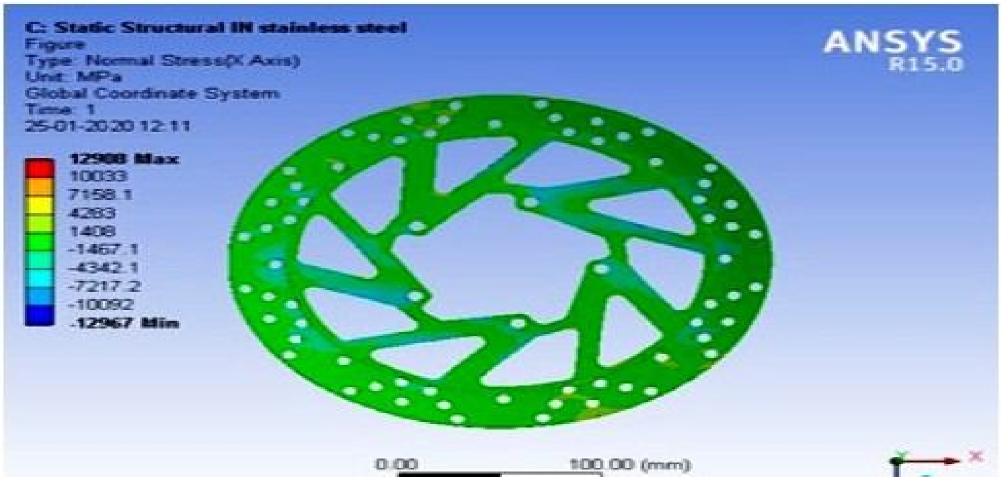


Fig-6 Total stress

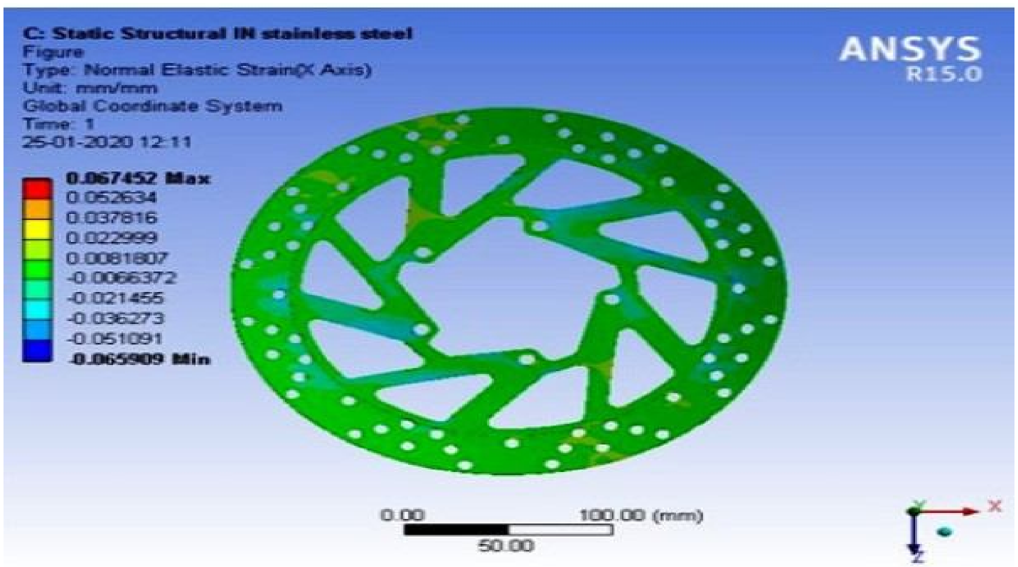


Fig-7 Total strain

2) *Cast Iron:* The result of Total deformation, Normal Stress, Normal Elastic Strain of used material Cast Iron after analysis on ANSYS workbench 15.0 with cited load condition.

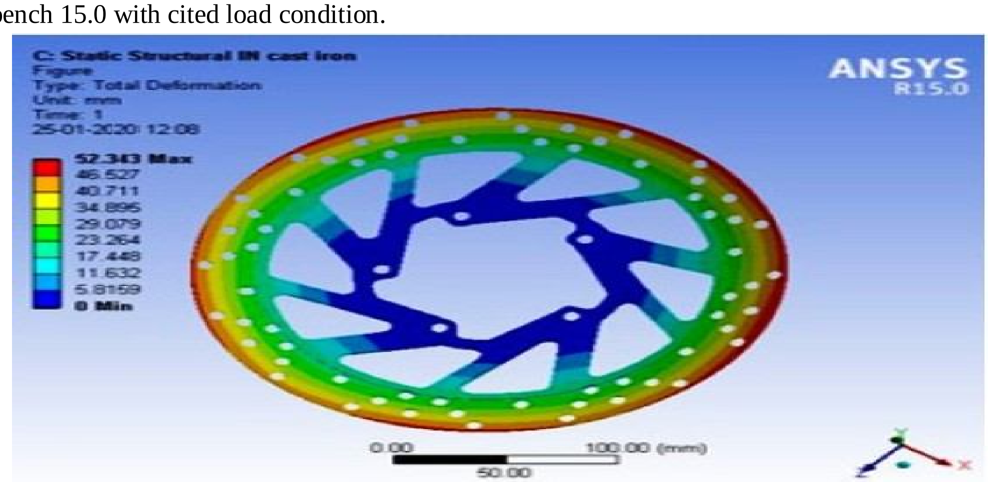


Fig-8 Total deformation

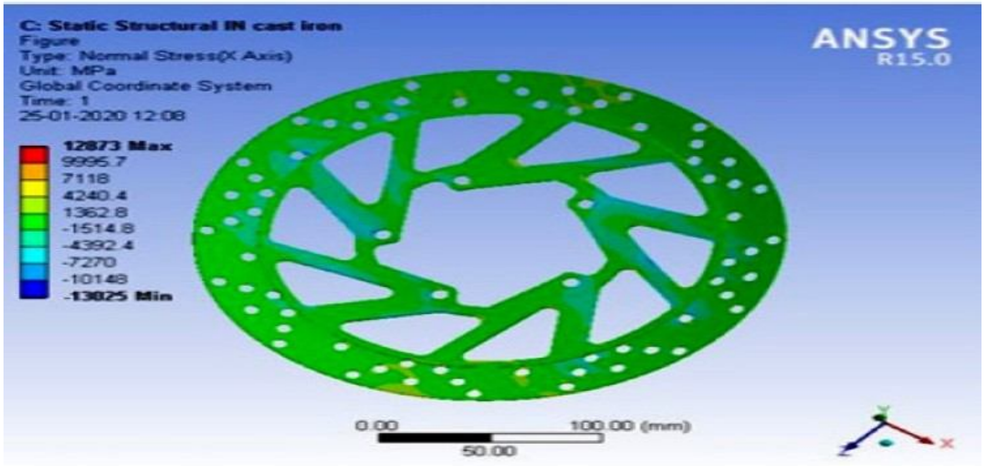


Fig-9 Total stress

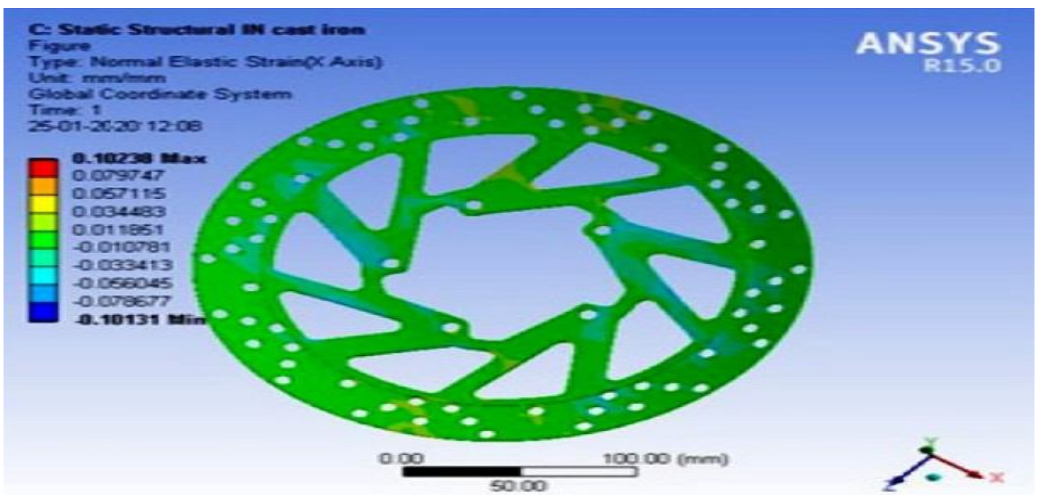


Fig-10 Total strain

3) *Vanadium Steel:* The result of Total deformation, Normal Stress, Normal Elastic Strain of selected material for analysis Vanadium Steel after analysis on ANSYS workbench 15.0.

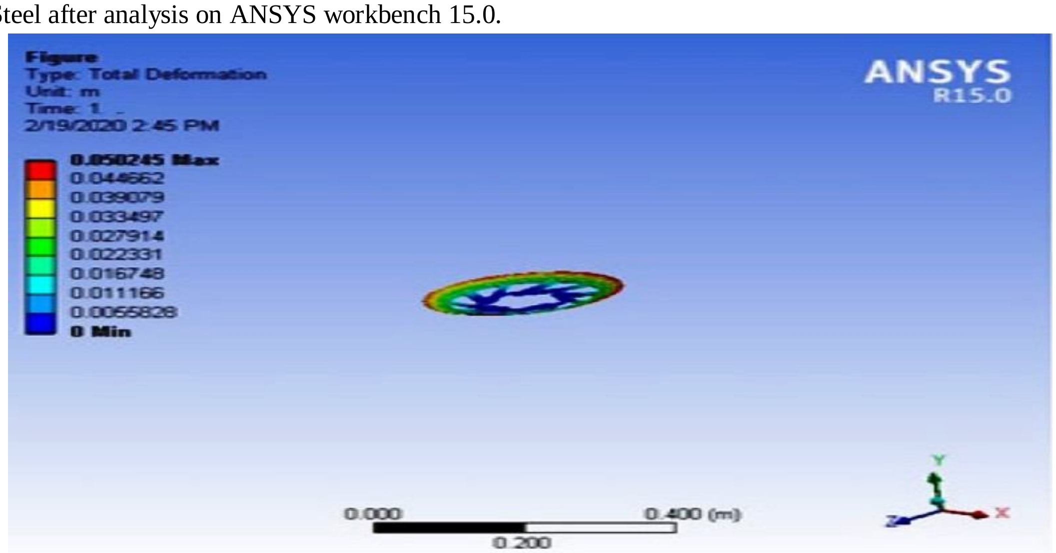


Fig-11 Total deformation

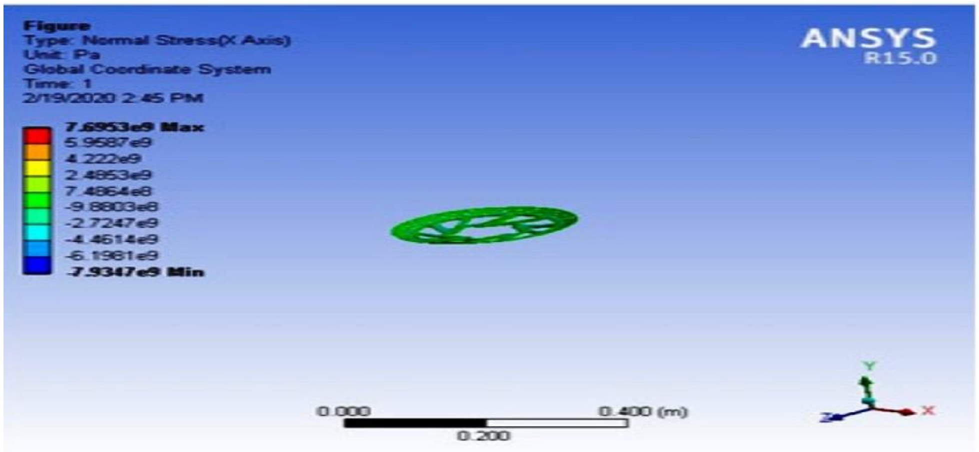


Fig-12 Total stress

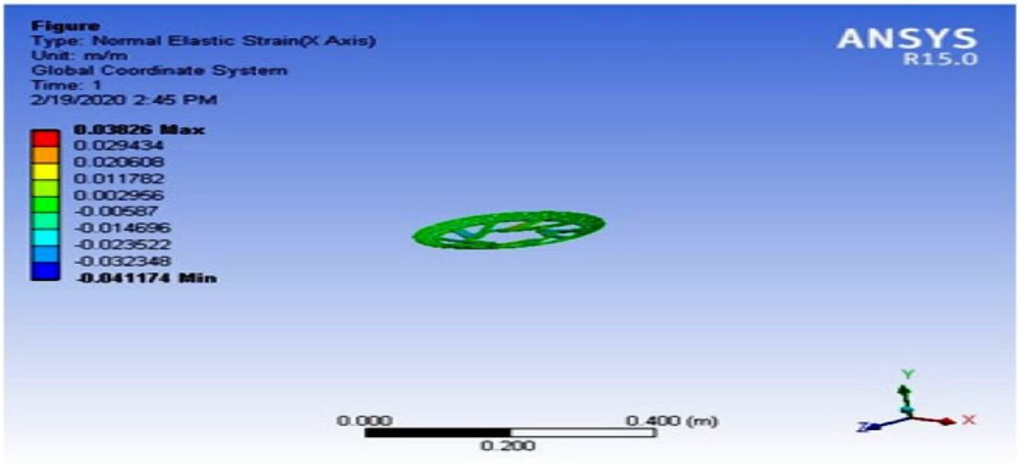
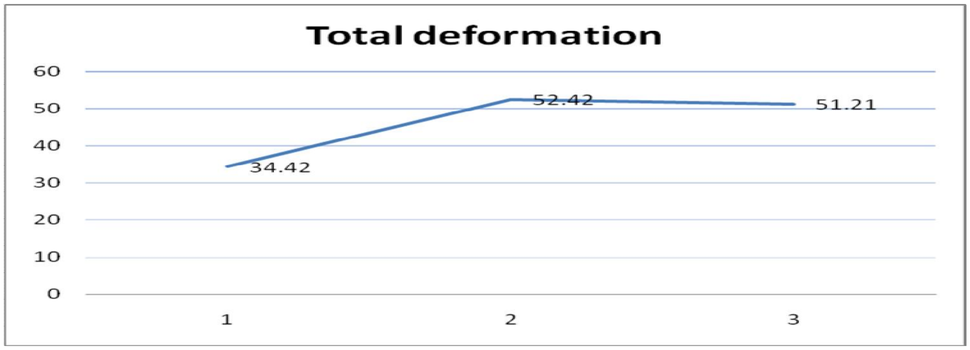


Fig-13 Total strain

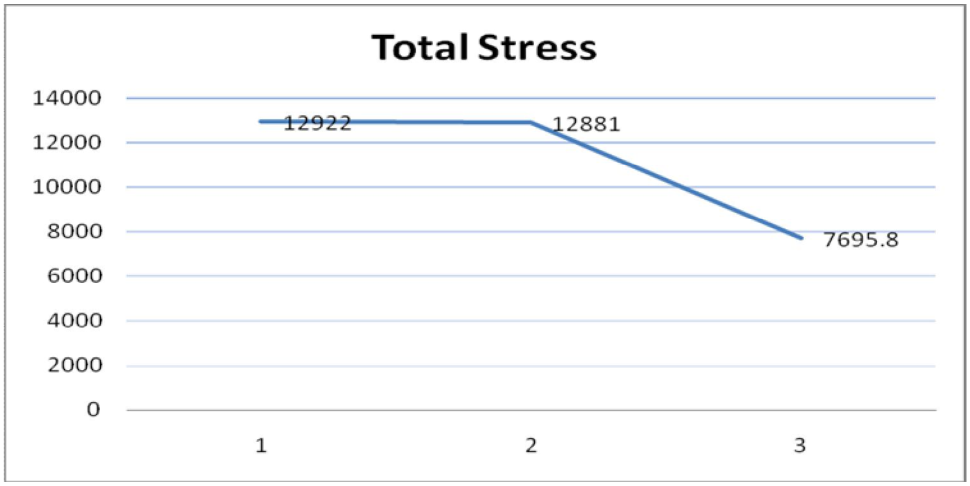
Table 2 Result of Different Materials

Result	(1)Stainless steel		(2)Cast Iron		(3)Vanadium steel	
	Max	Min	Max	Min	Max	Min
Total Deformation	34.42	0	52.42	0	51.21	0
Normal stress	12922	-12867	12881	-13027	7695.8	-7934.7
Normal strain	0.0674	-0.0659	0.102	-0.101	0.038	-0.0411

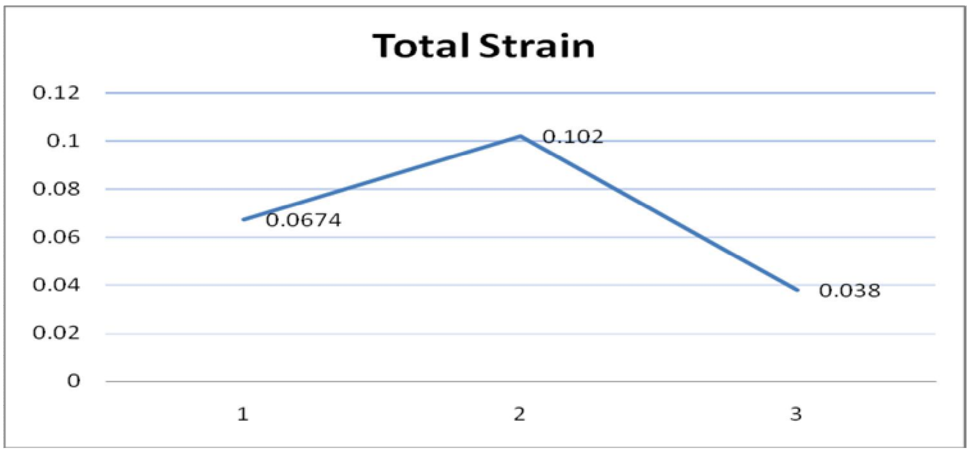
Comparison Graph Of Analysis On Different Materials



Graph-1 Graph for total deformation of materials



Graph-2 Graph for Total stress of materials



Graph-3 Graph for Total strain of materials

VII. CONCLUSION

Thus the mechanical load analysis was performed on the rotor of Disc Brake made up of vanadium steel and on comparing their outcomes with Stainless Steel and Cast Iron and from results we found that vanadium Steel has better results for all strength conditions than other materials as it can endure stresses thereby conforming that the deformation occurring on the disc rotor will be less. The analytical values that we observed from analysis are mitigated. Hence the design of the Disc Brake Rotor of vanadium steel is safe.

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