IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

FINITE ELEMENT ANALYSIS OF AUTOMOTIVE DISC BRAKE USING ANSYS

[1]Vineshkumar S Prajapati, [2]Krunal B Prajapati,

[1]Lecturer, [2]Lecturer

[1]Department of Mechanical Engineering,

[1]Swami Sachchidanand Polytechnic College, Visnagar, Gujarat, India

Abstract: Considering for optimization aspects in automobile is very important and necessary as there is large number of vehicles on road today, so that part or product will be durable, safe and affordable to the users. The brake is important aspect to fulfill the braking functions. The disc brake is a braking mechanism which stops or retards the moving vehicle by applying the frictional resistance. This paper presents the thermal-structural analysis to determine the thermal stress and deformation for six second of braking. The heat-flux, braking force, braking torque has been calculated for disc brake and FE analysis has been done on the disc brake. In this present work disc brake is modelled in Creo Parametric 2.0 and analyzed using ANSYS workbench.

***Index Terms* - FEA; Automotive Disc Brake; Disc Design; Braking Force; Ansys.**

I. INTRODUCTION

The brake is a mechanical contact device for changing over the momentum or kinetic energy of the moving vehicle into heat by the method of rubbing. Vehicle deceleration is dependent on the static function that manifests between the tyres and the road surface. The criteria for how brakes stop a car would be that "kinetic energy due to the vehicle's motion is scattered as heat energy due to contact between the wheel and brake shoes." The air is utilized to dissipate the heat energy produced.

Classification of brakes (based on transformation of energy) [2]:

- Hydraulic brakes.
- Electric brakes.
- Mechanical brakes.

The mechanical brakes are distributed based on the direction of the force acting into two groups:

- Radial brakes
- Axial brakes

Mainly three types of mechanical stresses are subjected on disc brake.

- Traction force caused by centrifugal effect and it occurs when wheel is rotating and no brake force is applied to the disc.
- Compressive force, when the brake is applied due to action of the force exerted by pressing the pad perpendicular onto the surface of the disc.
- Due to braking action caused by rubbing on the brake pad against the surface of the disc. It acts in opposite direction of the disc rotation.

Thus, the main objective of the project is to analyze alto 800 LXI disc brake made up of Grey cast iron material.

II. LITERATURE REVIEW

Thermal and Structural optimization using Finite Element Analysis (FEA) and other computational tools has become a major part in research and development process in recent years. The method has wide application and enjoys extensive utilization in the structural and thermal areas. **Manjunath et al.** (2013) proposed coupled thermal-structural analysis during braking condition to define the Equivalent stress and deformation in solid and ventilated type disc brake. It has been showed that ventilated disc brake was best suitable than solid disc brake [3]. **Tiwari et al.** (2014) presented the transient structural analysis of structural steel in ANSYS 14.0. The 10 node tetragonal elements were used in mesh generation to create the geometrical parts of a complicated mechanical component so to gain more authentic results based on the high techniques of fatigue life calculation [5]. **Patel et al.** (2015) performed the Finite element modelling (FEM) and structural analysis of chassis frame using modelling software i.e. Creo Perametric 3.0, ANSYS Workbench [6]. **Kulkarni et al.** (2016) investigated thermal and structural analysis of disc brake made with AMMC material to check the validity of disc brake under baking condition. The disc brake was modelled in Creo Parametric 2.0 and analysed in ANSYS Workbench [7]. **Shinde et al. (2016)** performed transient thermal analysis for four second of braking condition in ANSYS Workbench to predict failure of the disc brake. The variation of pressure and angular velocity of disc brake was taken with time [8].

III. BASIC CALCULATION FOR DISC BRAKE

The disc brakes specifications are used in the calculation are as follows:

Table 1 Disc Brake Specification

Disc Brake diameter	215 mm
Vehicle Mass	1140 kg
Velocity of the vehicle	34.05 m/s
Coefficient of friction	0.7
Weight of disc	2.8 kg

3.1Heat-flux Calculation

Maximum frictional force $F = \mu . M . g$

$= 0.7 \times 1140 \times 9.81$

$= 7828.38\ N$

Hence deceleration of the vehicle $a = F/M$

$= 6.86\ m/s^2$

Time taken to stop the vehicle $t = V/a$

$= 6\ sec$

Kinetic energy $= 0.5\ \times M \times V^2$

$= 0.5\ \times 1140 \times 38^2$

$= 825247\ J$

Kinetic energy = heat generated

Kinetic energy per wheel $= Heat\ generated/4$

$= 203286.63\ Joule$

Heat power $= Hg/t$

$= 203286.63/6$

$= 34.385\ kW$

Heat flux is defined as heat power per unit time and per unit rubbing area

Hence, Heat flux $= Heat\ power/(2\ \times rubbing\ area\ of\ disc)$

$= 845263.23\ Watt/m^2$

Only 70% of the mass of the vehicle will be front

Hence, heat flux is $= 0.7\ \times 845263.23$

$= 591684.26\ W/m^2$

3.2 Braking Torque and Force Calculation

Stopping distance $d = \frac{V^2}{2 \times \mu \times g}$

$$= \frac{38^2}{2 * 0.7 * 9.81}$$

$d = 105\ m$

Tangential braking force: f_t = K.E/S

= 206311.85/105

f_t = 7859.5 N

Tangential force on each Disc $F_t = f_t/4$

= 7859.5/4

F_t = 2000 N

Therefore consider $F_t = 2000\ N$

Braking torque $T_w = F_t * R$

$= 2000 \times 0.089$

$$= 178 \text{ N. m}$$

Where, R_e – effective radius (m)

$$\text{Effective rotor radius} \quad R_e = \left(\frac{\text{rotor diameter}}{2}\right) - \left(\frac{\text{calliper piston diameter}}{2}\right)$$

$$= 89 \text{ mm}$$

Here, caliper piston diameter is 42 mm.

$$\text{Clamping force} \quad C = \frac{T_b}{2 \times \mu \times R_e}$$

$$= \frac{178}{2 \times 0.5 \times 0.089}$$

$$C = 2000 \text{ N}$$

IV. FINITE ELEMENT ANALYSIS

A computational method called finite element analysis (FEA) is used in engineering to provide approximate solutions to boundary value problems. A boundary value problem can be defined as a mathematics problem where one or more dependent variables must fulfill a differential equation everywhere inside a known domain of independent variables and satisfy particular requirements on the domain boundary [6].

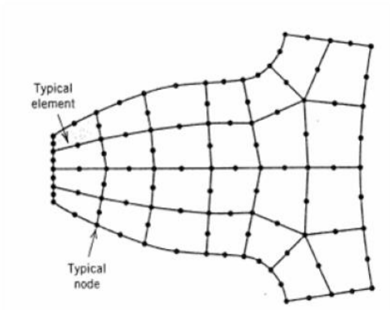

Fig. 1: Discretization of model [6]

The FE technique can be simply described as breaking a structure into numerous elements (pieces of structure), simply specifying each element's behaviour, and then connecting the elements at nodes as if the nodes were pins or droplets of glue holding the elements together (Fig. 1). A group of simultaneous algebraic equations are produced by this technique. These equations are node equilibrium equations used in stress analysis. Such equations could number in the hundreds or thousands, making computer implementation necessary [1].

V. MODELING AND ANALYSIS OF EXISTING DISC BRAKE

The model of existing Disc Brake as per the dimension is created in Parametric Creo 2.0 as shown on Figure 2. The model is then saved in *.x_t (Parasolid) format which can be directly imported into ANSYS workbench. Figure 3 shows the imported model in ANSYS workbench.

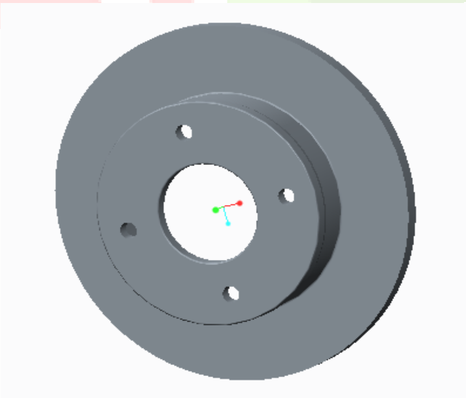

Fig. 2: CAD model of disc brake in PTC Creo 2.0

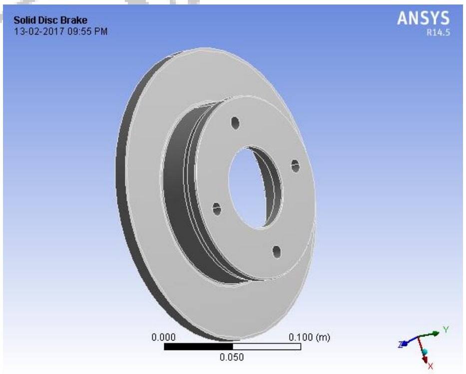

Fig. 3: Geometry of disc brake in Ansys

5.1 Material of Model

For the Disc brake generally grey cast iron, Aluminum Metal Metrix are used. In the present study, Grey cast iron is used and its properties are as given below

Table 2 Material Properties of Grey Cast Iron [4]

Density	7100 kg/m^3
Young modulus	125 GPa
Thermal conductivity	54 W/m. K
Specific heat	586 J/kg. K
Poisson's ratio	0.25

5.2 Meshing of Disc Brake

For the meshing, 10 node-tetrahedral elements were chosen to model the Disc brake. Study by previous researcher found that 10 node-tetrahedral elements gave a closer dynamic behaviour to the experimental results [5]. Figure 4 shows meshing of model of solid and drilled rotor.

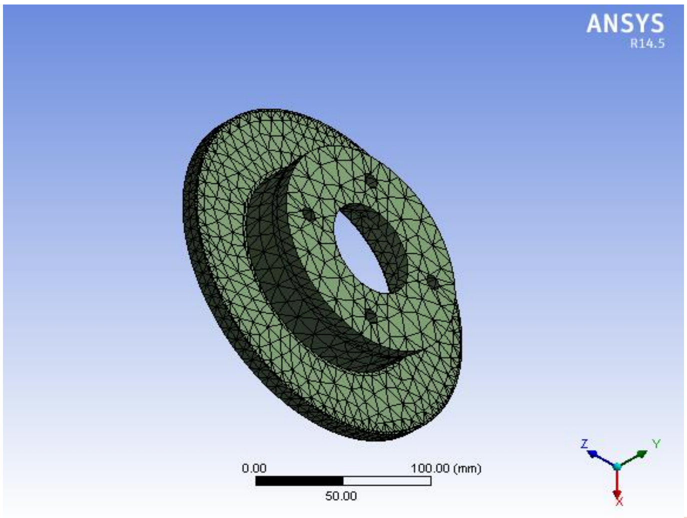

Fig. 4: Meshing of solid Disc Brake

5.3 Thermal loading and boundary conditions

The thermal loading is characterized by the heat flux entering the disc through two sides of the disc as shown in Figure 5. The initial and boundary condition are introduced into module ANSYS workbench. The thermal calculation will be carried out by choosing the transient state.

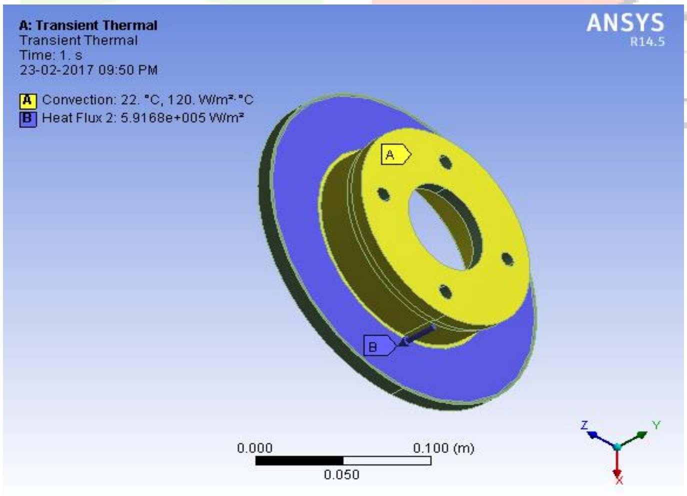

Fig. 5: Thermal Boundary condition of Solid Disc Brake

The initial temperature is taken as 22 ºC and the convective coefficient is 120 W/m^2 ºC. The convection is provided on the non-touching area of disc and brake pad. The radiation between the disc and air is ignored.

5.4 Structural loading and boundary conditions

The fixed support is provided on the four hole of the disc brake as shown in Fig. 7. The calculated clamping force acting on both side of the disc brake. The rotational velocity of 142 rad/sec is provided on the disc brake model. The temperature of transient thermal analysis is imposed on the static structural analysis for thermal stress prediction. The magnitude of force on the two side of the disc brake is 2000 N as shown in figure 6.

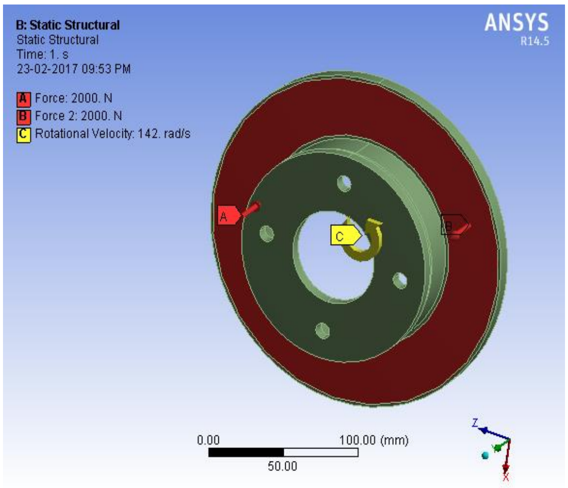

Fig. 6: Structural boundary condition of disc brake

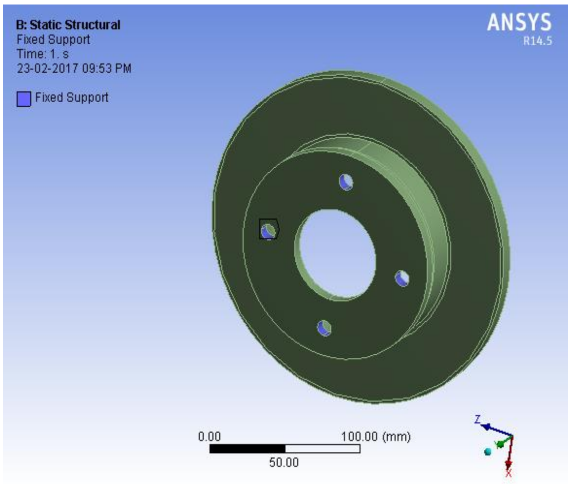

Fig. 7: Fixed support of Disc brake

I.RESULTS OF ANALYSIS

The generated equivalent stress is less than the permissible value so design is safe based on strength and rigidity criteria. The temperature, deformation and equivalent stress are as shown in Figure 8, 9, 10.

Figure 8 shows the temperature distribution on the disc brake at the end of 6 s. The maximum temperature generation occurred in the middle of disc and pad contact.

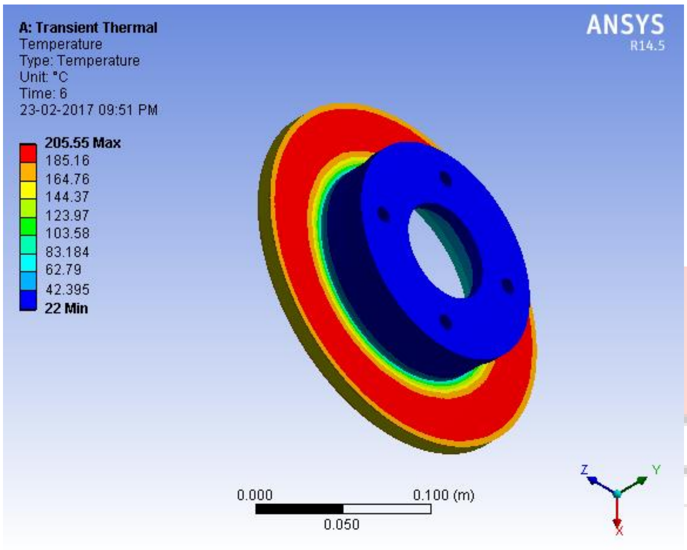

Fig. 8: Temperature on disc brake

Figure 9 shows the defamation distribution on the disc brake in structural analysis. The maximum deformation is occurred in the outer edge of the disc brake. The thermal stress distribution is shown in figure 10. The thermal condition is imported into structural analysis to predict thermal stress. The equivalent stress generated in disc brake is less than the permissible value.

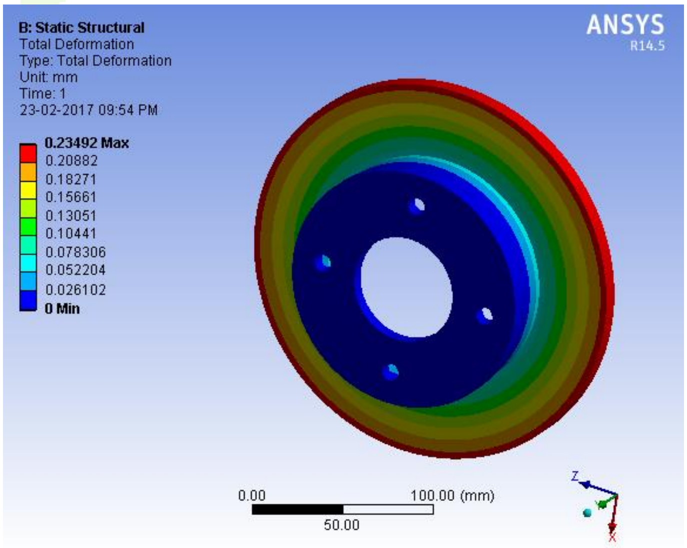

Fig. 9: Deformation on disc brake

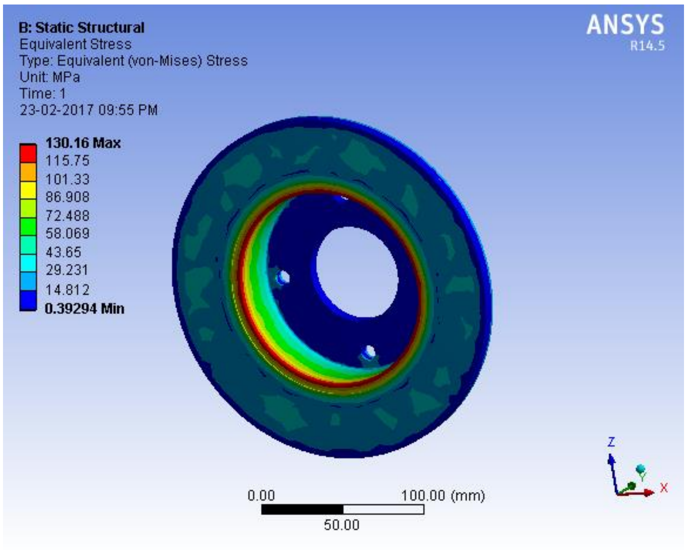

Fig. 10: Equivalent stress on disc brake

REFERENCES

[1] Dubey, A., & Dwivedi, V. (2012). Vehicle Chassis Analysis: Load Cases and Boundary Conditions for Stress Analysis. In Proceedings 11th National Conference on Machines and Mechanics (p. 395).

[2] Nathi, G. M., Charyulu, T. N., Gowtham, K., & Reddy, P. S. (2012). COUPLED STRUCTUAL THERMAL ANALYSIS OF DISC BRAKE, 539–553.

[3] Manjunath T V, Dr. Suresh P M (2013). "Structural and Thermal Analysis of Rotor Disc of Disc Brake", International Journal of Innovative Research in Science Engineering and Technology, 2(12), 7741–7749.

[4] Narayana, K. S., Rao, G. U., Simhachalam, D., & Nagaraju, B. (2014). Finite Element Analysis of Solid and Ventilated Disc Brake, 3(9), 875–882.

[5] Tiwari, A. K., Yadav, P., Yadav, H. S., & Lal, S. B. (2014). Finite Element Analysis of Disc Brake by ANSYS Workbench, 2(2), 1–6.

[6] Patel, T. M. (2015). Finite Element Analysis of Automobile Structural Member using. Gitjet, 8, 1–10.

[7] Kulkarni, A. S., Hegade, K. C., Karale, O. V, & Joshi B E Students, P. S. (2016). Coupled Thermal and Structural Analysis of Brake Disc Rotor Manufactured from Aluminum Metal Matrix Composite (AMMC) reinforced with Silicon Carbide. Imperial Journal of Interdisciplinary Research, 2(6), 2454–1362.

[8] Shinde, A., Dagale, K., Deshmukh, K., & Scholar, P. G. (2016). Thermo Structural Analysis of Disc Brake Rotor, 3(1), 174–178.

[9] Singh, D. K. Automobile Engineering, Vol. 1, 2008.