DESIGNING OF BRAKE SHOE: STUDY AND METHODOLOGY

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***Abstract*: Brake is a device which applies resistance to moving machine member, in order to retard the motion or stop the machine. A drum brake is a brake that uses friction caused by a set of shoes that press outward against a rotating cylinder-shaped part called a brake drum. The brake shoes are also the carrier of the friction material. During braking, there is natural wear of the friction material. So Brake shoe should possess certain characteristics for handling wear and tear. In this paper we discussed the methodology for redesigning for Brake shoe.**

Keywords: Brake Shoe, Ansys, CATIA-Computer Aided Three-dimensional Interactive Application

I. Introduction

Brakes are mechanical devices which absorb the kinetic energy of the system & convert it into any other form of energy (generally heat) in order to stop a moving system[1].They are not only used to stop a moving system but also to prevent motion of any part of a particular system. Brakes restrains the motion of moving system by absorbing its. It slow down or stops the moving vehicle, wheel, axle, or to prevent its motion, most often accomplished by means of friction. Brake is a device which applies frictional resistance to moving machine member, in order to retard or stop the motion of machine. In performing this function, the brake either absorbs kinetic energy of moving member or potential energy given up by objects being lowered by hoist , elevator etc. The energy absorbed by brakes is dissipated in the form of heat.

Friction brakes on automobiles store braking heat in the drum brake or disc brake while braking then conduct it to the air gradually. When traveling downhill some vehicles can use their engines to brake.

Types of brakes-Drum Brakes and Disc Brakes are two types of Mechanical Brakes. A drum brake is a brake that uses friction caused by a set of shoes or pads that press outward against a rotating cylinder-shaped part called a brake drum. The drum brake has a metal brake drum that encloses the brake assembly at each wheel. The drum brake has a metal brake drum that encloses the brake assembly at each wheel. Two curved brake shoes expand outward to slow or stop the drum which rotates with the wheel. The term *drum brake* usually means a brake in which shoes press on the inner surface of the drum. The shoes are pulled away from the drum by the springs when the brakes are released. Drum brakes generally can be found on older car and truck models. However, because of their low production cost, drum brake setups are also installed on the rear of some low-cost newer vehicles.

The disc brake is a device for slowing or stopping the rotation of a road wheel. A brake disc, usually made of cast iron or ceramic, is connected to the wheel or the axle. To stop the wheel, friction material in the form of brake pads (mounted in a device called a brake caliper) is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop. In a disc brake, the fluid from the master cylinder is forced into a caliper where it presses against a piston. The piston in turn squeezes two brake pads against the disc (rotor), which is attached to wheel, forcing it to slow down or stop. Compared to modern disc brakes, drum brakes wear out faster due to their tendency to overheat. But cost of installation and maintenance for disc brake is more the Drum Brakes

There is a qualitative difference between the two and some of it centers on friction. The disc brake dissipates the heat more effectively. Brake fad**e** occurs when the brakes begin to lose their effectiveness and this can happen on steep downhill inclines for the drum brake design. It takes longer for the disc brake achieve brake fade, and these perform better on steep descends. The drum brake has the potential of collecting water inside during rain or driving over puddles. That can result in the drum brakes not performing as well in wet conditions. Still, however, many cars have rear drum brakes.

It is quite possible that your car may have disc brakes in the front end with drum brakes handling the rear tires. The reason is pure economics. Because **a** car weight is going to shift with braking, over two thirds of the braking effort occurs in the front of the car. There is not quite the need to have disc brakes, which are more expensive than drum brakes, on all four wheels. The maintenance of a drum brake is also cheaper. The brake drum has an all-in-one design that is very easy to replace when repair work is needed. In fact, the brake shoes can be replaced in less than ten minutes when the drum has been taken off. This means that both parts and labor costs are dramatically reduced when a drum brake is on the car. The drum brake also gets the job done, and both types of brakes will bring the car to a stop.

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material. So Brake shoe should possess certain characteristics for handling wear and tear. In this paper we discussed the methodology for redesigning for Brake shoe.

II. Brake Shoe

Brake shoes are a very important component of a drum brake. Essentially, they comprise the brake drum, the brake shoes, the wheel brake cylinder and the adjustment mechanism. The brake drum is fixed to the wheel and turns with it. When the brakes are applied, the wheel brake cylinder forces apart the fixed brake shoes and presses them against the brake drum, inducing braking. The brake shoes are also the carrier of the friction material. During braking, there is natural wear of the friction material. The decreasing thickness of the friction material is compensated by a mechanical adjustment mechanism.

CHARACTERISTICS OF BRAKE SHOES

During braking, the brake shoe experiences high temperature and thermal stresses. Due to this the brake shoe material should possess a high thermal conductivity, thermal capacity and high strength in order to with stand these stresses. Braking results in uneven Stress, Strain, Deformation, and heat dissipation. For good performance of Braking system in Drum brakes, Brake Shoe should have low deformation, low von mises stress, low strain, high heat flux etc.

What happens when brake shoes wear down? Every time when brakes are applied it causes amounts of wear and tear on brake shoes. For each type of brake pads, ceramic, organic, and metallic, this friction causes small amounts of protective coating to wear away from the brake shoes. With the time, this deterioration gradually increases, as a result brake shoes becomes thinner and thinner, they will eventually get to the point where they should be replaced.

Replacement of brake shoes
Here are some signs to look for to know when to replace brake shoes.
Squealing or screeching noises- When brakes are exposed to wet, damp conditions, such as after a rain storm, a thin layer of dust can form on the brake shoes and cause a very similar screeching sound while braking. If a sound disappears after the first few times you use your brakes, that's a good indicator that it was just a bit of rust built up on the brake shoes and not the brake shoes needs to be replaced.
Less than a quarter inch of brake shoes-We can also visually inspect our brake shoes to check weather ot time to have them replaced or not .Look through our tire spokes and we should see our brake shoes compressed against your brake rotor. If the shoes is less than ¼ inch thick(about 3 millimeters) we should consider having our brakes inspected, especially if it's been a long time since our last inspection.

Deep metallic grinding and growling-If we hear a deep, low noise that sounds like metal grinding or a rumbling growl, that can be a sign that not only are our brake shoes worn away, but that our brake discs and calipers are making contact. Since this metal on metal contact can very quickly cause even further damage in our braking system.

III. Literature Survey

G. Gopinath , P. Murali - In his Analysis he used The Finite Element Method (FEM) is a numerical technique to obtain approximate solutions to a wide variety of engineering problems where the variables are related by means of algebraic, differential and integral equations The three dimensional model of the brake shoe has been modeled using Pro/E Wildfire modeling software. The developed model is exported to Ansys 10.0 analysis package. [1]

Abhishek Patel , AK jain-His research emphasizing on the substitution of cast iron by any other lightweight materials. A model iscreated with the help of software CATIA V5 and structural and thermal analysis is performed in ANSYS 16.0 work bench. Astatic structural and thermal analysis of different materials for a brake shoe lining is done.[2]

DvsrbmSubramanyam, L.Sravani et al (2017) This paper describes that the brake drum is experiencing high temperature and thermal stresses during braking. Brake shoe makes contact with the inner surface of rotation brake drum with high pressure which generates structural stresses in the brake drum as well as brake shoe assembly. Heat is also generated by the action of friction which contributes to increase in thermal stresses and hence the analysis takes into account both the thermal stresses and mechanical stresses together.This project was designed (drum, & pads) in solid works 2016 and structural and thermal analysis are performed in ANSYS work bench software.[3]

Dr. Kodathalapalli Sudheer His paper discuss about characteristics which are required for efficient Brake Shoe, he analysed different materials to be used in Brake Shoe. He emphasizedonthefact that Brake shoe must have less deformation and High Heat flux[4].

J. Kukutschova
A model semi-metallic brake lining was subjected to full-scale automotive brake dynamometer tests. The structural properties and surface topography of brake linings were analyzed at different stages of wear testing and correlated to frictional performance.A combination of abrasive and adhesive wear with oxidative processes dominated the friction process.Formation of a friction layer adhering to the friction surfaces of pads and discs is the major feature responsible for friction performance.[9]

IV. Methodology

A model should be created with the help of computer aided drafting software, CATIA V5. Using CATIA software we can create 3D model of brake shoe as per measurement data .Import of CATIA Model (IGES) in the ANSYS 2020R1 Workbench for pre-processing. Then the structural analysis is done on the brake shoe. The Analysis involves the discretization called meshing, boundary conditions and loading.

SOFTWARE AND TOOLS

CATIA: (an acronym of Computer Aided Three-dimensional Interactive Application), is a C++ programming language software.Developed by the French company Dassault Systems.Offers a solution to shape design, surfacing workflow, styling and visualization to create, modify and validate complex innovative shapes It's a comprehensive software that spans the entire range of physics, providing access to virtually any field of engineering simulation. It delivers the most comprehensive set of physics features

*Ansys 2020 R1:*helps engineering teams combine simulations to optimize products throughout their lifecycle .Other improvements in Ansys 2020 R1 include :Enhancements to the model size and nonlinear capabilities of Ansys Mechanical. A simplified multiphase simulation workflow in Ansys Fluent

BOUNDARY CONDITION AND ASSUMPTIONS

The boundary condition of brakeshoe are given as follows,

- Pressure generated inside the brake shoe: 1.2MPa
- Ambient temperature: 22^0C
- Maximum temperature generated: 90^0C

The following are the assumptions made for the finite element analysis.

- Heat transfer co-efficient remains constant.
- All unexposed surfaces are treated as insulated.
- Heat transfer due to radiation was not considered.
- Distribution of heat flux at lining interface was considered to be uniform.
- Variation of material properties with temperature was not considered.
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MATHEMATICAL ANALYSIS

Consider an elemental area (Figure 1) on the friction lining located at an angle ϕ and subtending an angle $d\phi$. The elemental area will be 'R $d\phi$ w' where 'w' is the width of the friction lining parallel to the axis of the brake drum, R is radius of drum. If 'p' is the intensity of normal pressure on this elemental area, the normal reaction 'dN' is given by

$$dN = p\,R\,w\,d\phi \qquad (a)$$

As mentioned in the first assumption, the normal pressure 'p' is proportional to the vertical distance 'R $\sin\phi$' of the element from the pivot. Therefore, p $\alpha \sin\phi$

$$p = C1\sin\phi \qquad (b)$$

Assuming p = pmax when $\phi = \phi max$ we have

$$pmax = C1\ \sin\phi\ max \qquad (c)$$

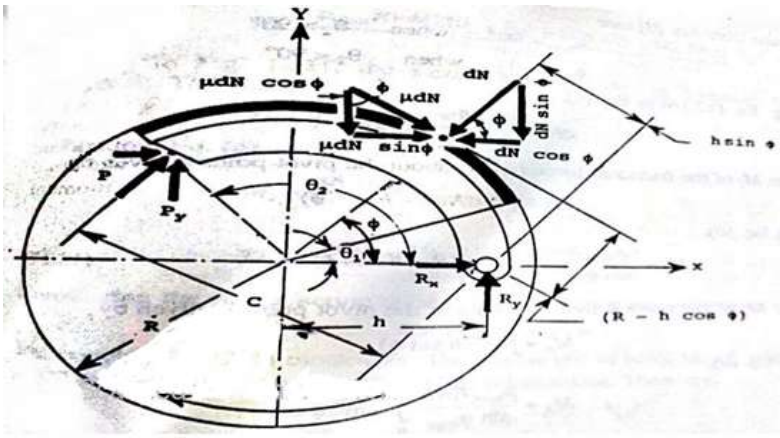

Figure 1: Diagram for mathematical analysis

$$p = \frac{p\max \sin\phi}{\sin\phi\max} \qquad \text{(d)}$$

It can be seen from equation (b) that

$\phi\max = 90^o$ when $\theta_2 > 90^o$
$\phi\max = \theta_2{}^o$ when $\theta_2 < 90^o$

Substituting Eq(d) in Eq(a)

$$dN = Rw\frac{p\max \sin\phi}{\sin\phi\max}d\phi \qquad \text{(e)}$$

The moment M_f of friction force(μdN) about the pivot point is given by

$$M_f = \int \mu dN(R - h\cos\phi)$$

Substituting eq (e)

$$M_f = \frac{pmax}{\sin\phi\max}\int_{\theta 1}^{\theta 2} sin\,\phi(R - h\cos\phi)\,d\phi \qquad \text{(f)}$$

The moment of normal orce (dN) about the pivot Point is Given by

$$M_n = \int dN(h\sin\phi)$$

Substituting eq (e)

$$M_n = Rwh\frac{pmax}{\sin\phi\max}\int_{\theta 1}^{\theta 2} sin\,\phi\,d\phi \qquad \text{(g)}$$

Solving Eq (f)

$$M_f = \frac{p\max\mu Rw[4R(\cos\theta 1 - \cos\theta 2) - h(\cos 2\theta 1 - \cos 2\theta 2)}{4\sin\phi\max} \qquad \text{(h)}$$

Solving Eq (g)

$$M_n = \frac{p\max Rwh[(2\theta 2 - \theta 1) - (\sin 2\theta 2 - \sin 2\theta 1)}{4\sin\phi\max}$$

Considering the forces acting on the Shoe and taking the moments about the pivot ,

$$\mathbf{P \times C + M_f - M_n = 0}$$

Therefore

$$P=\frac{Mf - Mn}{c}$$

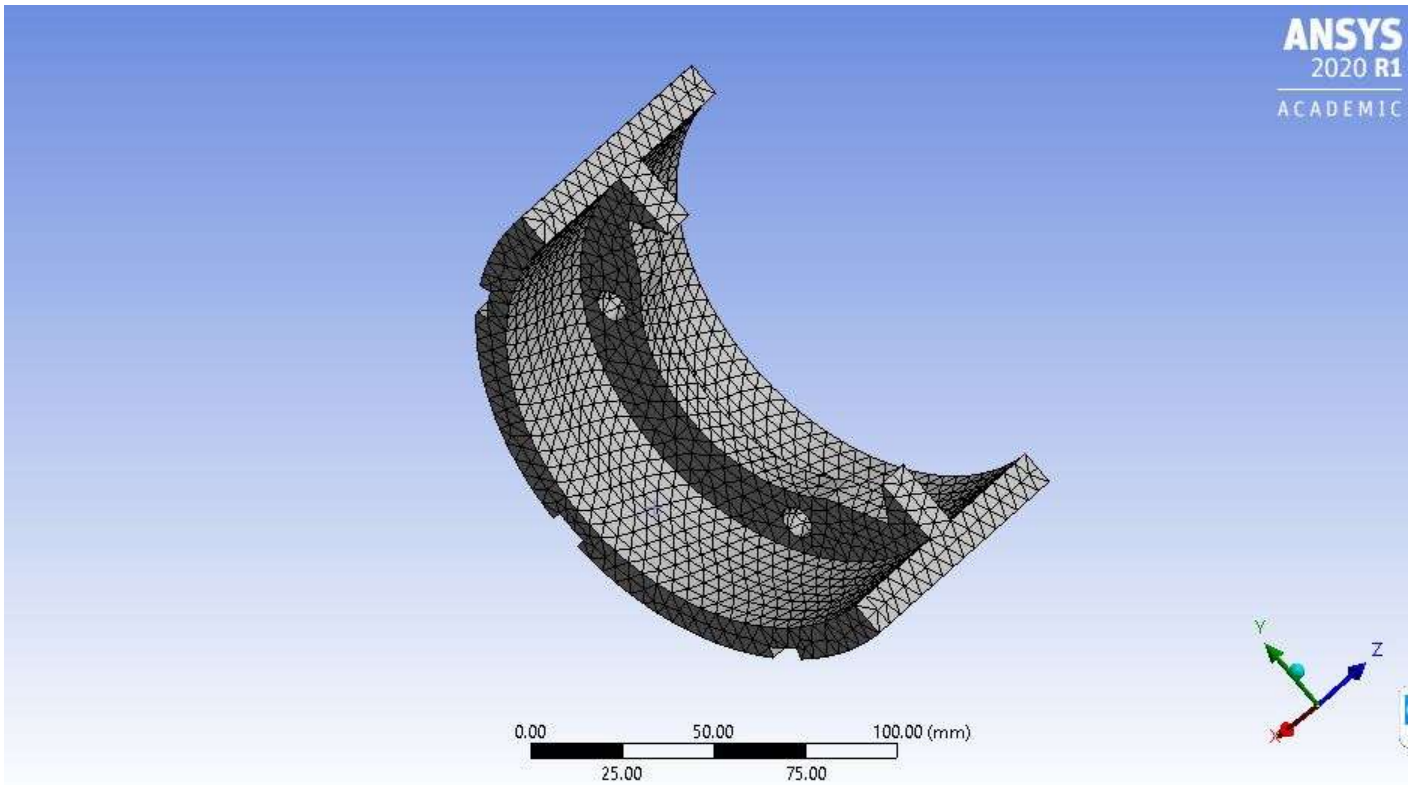

Figure 2 : Meshing Diagram of Brake Shoe

V. Conclusion

From above discussion we can conclude that materials Used for manufacturing brake shoe must have minimum value of deformation as well as maximum von-mises stress, adequate values of heat flux which validates the heat dissipation ability of material. From the above literature survey we find that there are many researchers done analysis on drum brake shoe designing. With the help of software CATIA V5 ANSYS 2020R1 work bench software can proved efficient for creating model and performing Analysis for designing of Brake Shoe

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