Design and Analysis of Internal Expanding Drum Brake with Collet & Wedge Mechanism

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Abstract **— The drum brake uses friction caused by a set of shoes or pads that press outward against a rotating cylinder-shaped part called a brake drum. When shoes press on the inner surface of the drum the braking occurs. In cam operated brake the intensity of pressure acting in the contact area between the drum and the pad is low in the portion that is nearer to the pivot end. This also results in the excessive wear at the portion of a friction pad nearer to the cam end. To overcome this drawback, we have used collet and wedge for equal expansion of brake shoe with more area of frictional contact which provides equal intensity of pressure to the brake drum. This results in the better braking efficiency.**

Keywords **— Brake, drum brake, collet operate**

I. INTRODUCTION

Brake is the most significant part in a vehicle that ensures the safety of motor vehicles. The different types of brakes include block, drum and disc brake. The internal expanding drum brake is the most common one used in the automobiles. The drum brake is used as rear brake and the disc brake is used front wheels of most vehicles. The working of drum brake is based on the principle of conversion of kinetic energy in to the dissipation of heat energy. The drum brake has a caliper assembly in which brake shoes bonded with the frictional pads are pivoted. The brake drum is provided with a liner on its inner surface. When the brake is actuated the pivoted brake shoe expands by contacting with the liner. This makes the retardation of the brake drum due to the friction between the pad and the liner. As the brake drum is attached to the wheel the wheels comes to rest on complete braking. The braking takes place in a very shorter time. It is a challenging job to dissipate the heat produced due to the friction between the frictional pad and the liner in very short span of time.

The research is going on with an objective to increase the braking performance by enlarging the contact area, reducing the brake shoe pad wear, and by changing the design of friction pad and actuating mechanism. This paper shows a new model of brake actuation that gives the better area of contact along with low stress in the braking element. These analytical results would be an added support to the development of braking system. In this paper the simulation is done with the CATIA and the analysis is done using ANSYS Workbench.

II. LITERATURE SURVEY

Na Liua, Zhongcai Zheng [1]. The finite element analysis is done for the drum brake assembly including parts such as brake drum, brake shoe, friction plate. The actuation of the braking process is simulated and analyzed. The load applied on the drum brake shoes was symmetric on both the shoes and the displacement was also symmetric. But the stress obtained in one of the brake shoe is greater than the other one. The stress occurred is maximum on one side of the brake shoe in its internal end face.

Sriram T. Mutalik [2]. In this paper, the author has developed a new automobile braking system and checked for its torque absorbing capcity. It is been found that the disc brake is more efficient than the drum brake. The drum brake with more stopping distance makes the ride more difficult in the city traffic. A solution of disc oriented drum brake has been developed to overcome the above said problems.

M. S. Manikandan, K. V. Nithish Kumar [3] The Braking system in the automobile plays a significant role. Here the braking force control under empty and full load is studied. It is found that the stopping distance is greatly reduced for the higher loaded vehicle than the empty loaded vehicle. This is due to the load on the vehicle increases the contact pressure between the road surface and the tire higher. This shows that the more area of the frictional contact between any two bodies the motion of that body is restricted. By this the stopping distance for the vehicle is reduced.

a. Conventional Internal Expanding Drum Braking System

In a conventional internal expanding drum brake system a cam is used to operate the pivoted brake shoes to expand and contact with the liner. When the brake pedal is actuated the cam in the calliper rotates in a direction that pushes the brake shoe outwards. This cause a portion of the brake with more vertical distance from the pivot end will have more intensity of contact pressure towards the liner.

This frictional contact between the brake pads (frictional pads) and the liner makes brake drum to retard by converting kinetic energy in to heat energy. This heat energy is dissipated by the process of normal or forced convection based on the design. .

b. Disadvantages of conventional Drum and Disk brake systems

1. Lower braking efficiency: The friction material in the brake shoe has its unique properties that may be changed when it is

heated much and the same properties are regained when it is cooled again. Though these properties are regained there is a problem of unequal pressure acting between the pad and the liner due to the cam operation that lowers the brake efficiency.

2. Excessive wear at half portion of the shoe where the intensity of pressure between the shoe pads and the liner is more due to braking.

3. The brake will not be effective if there is any air that remains in the disc brake system. This may cause accident.

4. The Disc brake has more complex and moving parts compared to the drum brake.

5. The Disc brake system needs more maintenance effort such as Brake pad changing.

6. It is claimed that the disc brake fails during wet condition.

7. The stress concentration is more in the disc brake due to lower contact area.

c. Problem Identification

In the existing drum brake, with usage of cam operation in motorcycle causes

- Non- uniform intensity of pressure between the brake shoe and the brake liner attached to the brake drum. This results in low braking efficiency. Hence, the stopping distance is more
- The Brake shoe wears excessively only in either side of the shoe that has more vertical distance from the pivot end.
- Area of frictional contact is low in the cam operated internal expanding brake.
- Braking torque is low when compared to disc brake.
- In a disc brake, if there is any air lock in the hydraulic system the brake will not work effectively and causes accident.
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III. DESIGN OF CAM OPERATED BRAKE SYSTEM

Internal expanding drum brake with cam operating system modelled in SOLIDWORKS

Fig.1 Cam Operated Brake model

Usual drum brake system is created by SOLIDWORKS and the brake model is analysed by the ANSYS Workbench.

a. Analysis of Cam Operated Brake System

The input parameters and the boundary conditions given for the analysis are:

1. The contact analysis is done between the brake shoe and the brake lining.
2. The load applied is 100N.
3. Contact type is frictional.
4. The state of the model and the load applied is fully defined.

Result of pressure intensity between the brake shoe and the lining.

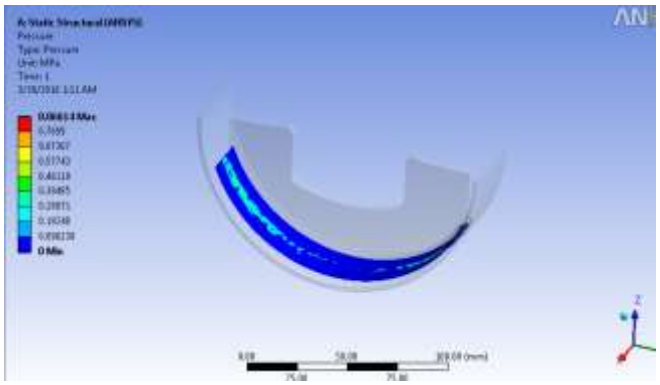


Fig.2 pressure intensity between the brake shoe and the lining

It shows that the intensity of pressure is more at the pitch circle of the shoe along its either sides only. The maximum pressure acting for the given load is 0.86614 MPa.

Result of contact between brake shoe and the lining

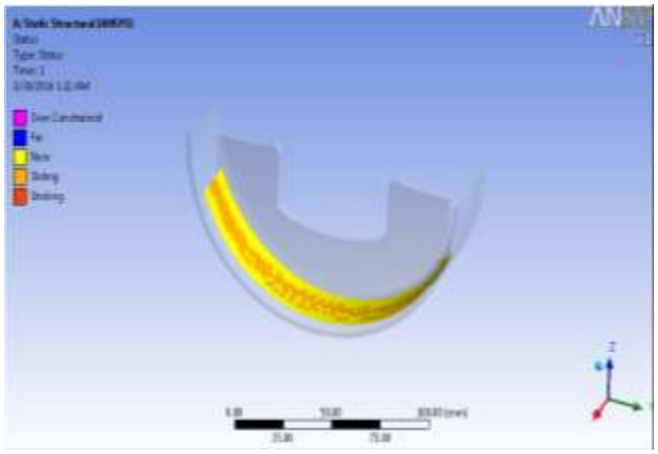


Fig.3 contact between brake shoe and the lining

The above fig. shows the surface contact between the brake shoe and the liner. The yellow colour shows that the contact is more nearer and the orange denotes its sliding.

Result of stress between brake shoe and the lining

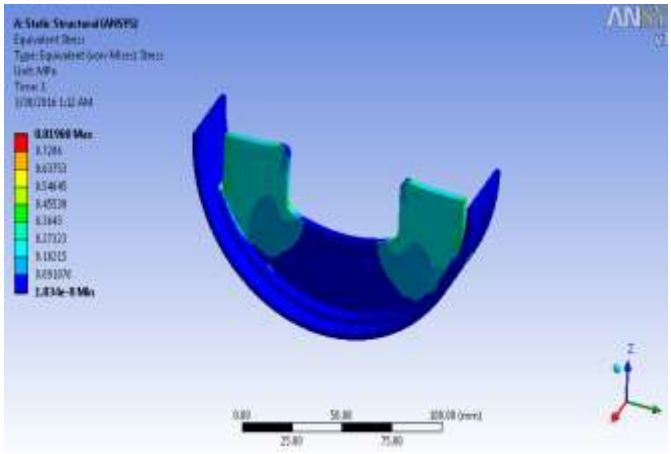


Fig.4 stress between brake shoe and the lining

This result shows that there is more stress induced at both end of brake shoes. (i.e. Pivot and cam end) when compared to the liner and middle part of the shoe.

The min. equivalent stress = 1.834×10^{-8} MPa

The max. Equivalent stress = 0.819×10^{8} MPa

Result of directional deformation between brake shoe and the lining

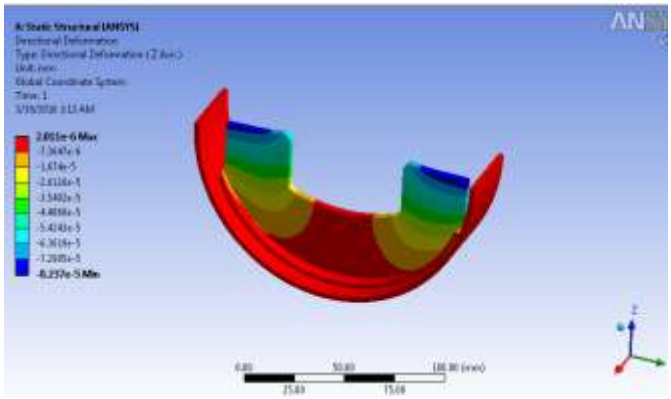


Fig.5 directional deformation

The min. deformation = -8.237×10^{-5} mm

The max. deformation = 2.011×10^{-6} mm

b. Design of Collet and Wedge Operated Brake System

In the newly developed collet and wedge operated internal expanding braking system the cam used in the existing model is replaced with a wedge. The braking element brake shoe or toss is replaced with a collet here. The wedges are welded or connected to the the bush through connecting levers. There are five wedges connected to the bush through five connecting levers. The collet is fixed to the calliper disc whose purpose is to expand and contract. The collet is designed with an elastic material that has more elastic deformation which is able to retain to its original position when its load is removed. The bush is made to rotate in the counter clockwise direction when the brake is applied. This sliding contact between wedge and collet makes the collet element to push outward and create frictional force against the drum. When the brake is released the wedge and collet returns back to the original positon with the help of a retractor spring.

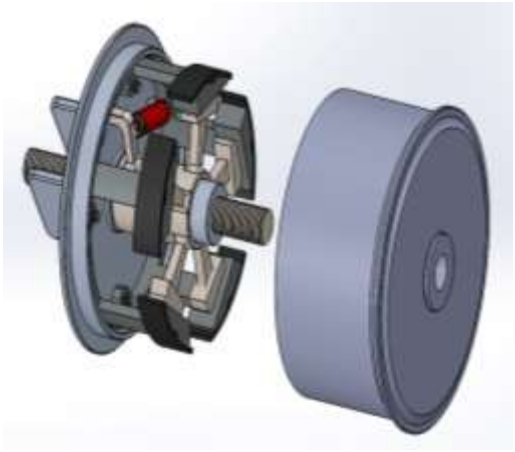


Fig.6 Collet operated Drum brake model by using SOLIDWORKS

The model is created and parts are assembling by using SOLIDWORKS. The model is imported to CATIA software. In CATIA the brake model is perfectly constrained and motion for applying brake is defined. Complete simulation for collet operated braking system is done in the CATIA.

Then structural model is imported in the ANSYS workbench software. Structural and contact analysis is done in the ANSYS workbench. In structural analysis stress, strain for the brake assemble model is determined. Maximum stress and strain areas are concentrated for develop the modelling. Contact analysis is conduct to the brake assemble model. In contact analysis braking torque is determined.

c. Analysis of Collet and Wedge Operated Brake System

Internal expanding drum brake with collet and wedge operating system model by using SOLIDWORKS.

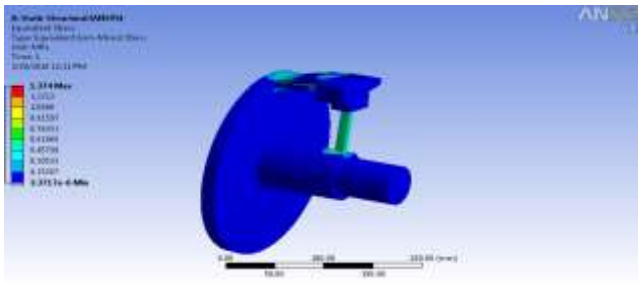


Fig.7 Analysis of Collet and Wedge Operated Brake

The result of Equivalent stress in the collet, when the wedge contacts the collet surface completely.

This shows that the stress is within the yield strength of the material chosen.

The min. Equivalent stress =$3.3717\times10^{\wedge-6}$ MPa

The max.Equivalent stress=1.374 MPa.

Directional deformation of collet and wedge

Directional deformation in X-axis =0.00036932mm

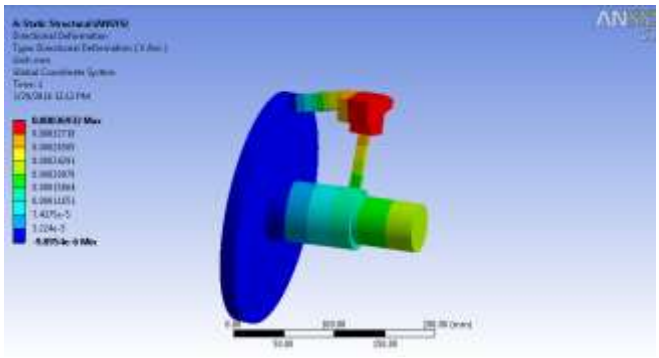


Fig.8 Deformation in collet

This result shows the deformation is more at the collet and wedge surface

Result of pressure intensity between the brake shoe and the lining.

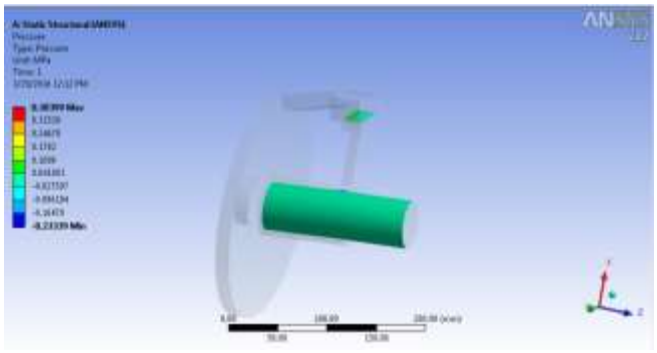


Fig.9 Pressure intensity between the brake shoe and the lining

Intensity of pressure.

The min. Pressure stress =-0.23339 MPa

The max. Pressure stress=0.38399MPa

Result of contact between collet and wedge surface

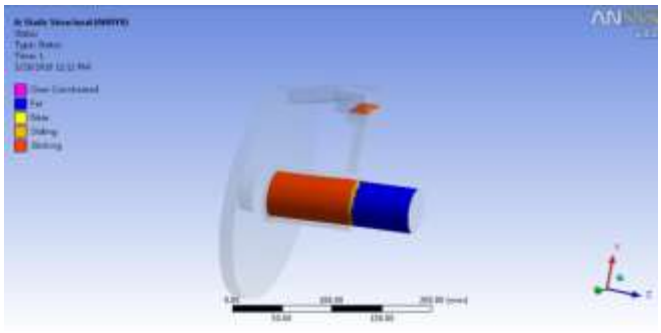


Fig.10 contact between collet and wedge surface

This result shows that the sliding and sticking contact between the wedge and collet surface.

This sticking contact makes the maximum deformation of the collet to obtain the maximum stress results

IV. CALCULATION

a. Stress calculation

1) Internal expanding brake with cam operated mechanism:

Given,

a) Applied load (P_1) = 100 N

b) Area of Brake shoe in existing model (A_1) = 4470 mm^2

Analytical result in ANSYS .Assuming the partial contact at the upper portion of Brake shoe on the drum.

The maximum equivalent stress induced in the brake shoe (σ_e) = 0.8196 MPa

2) Internal expanding brake with collet and wedge operated mechanism:

Given,

a) Applied load (P_2) = 100 N

b) Area of collet Brake shoe in new model (A_1) = 2500 mm^2

Analytical result in ANSYS. Assuming the complete contact at the collet Brake shoe on the drum.

The maximum equivalent stress induced in the brake shoe

(σ_c) = 1.374 MPa

Ratio of Brake shoe area in both the model:

R_A= Area of cam operated brake shoe / Area of collet operated brake shoe

$$R_A = 1.79$$

The area of existing model cam operated brake shoe is 20% more than the newly designed collet brake shoe.

We know that,

$$\text{Stress} \propto 1/\text{Area}$$

Since the area is smaller in the collet operated brake shoe, it is obvious that the stress induced in it will be more than the existing one.

If same area is considered in both the models,

Then induced equivalent stress for the existing model would be,

$(\sigma_e) = 0.8196 \times 1.79$

$(\sigma_e) = 1.467084$ MPa

$(\sigma_c) = 1.374$ MPa.

Therefore,

$$\sigma_e > \sigma_c$$

Hence, the lower stress inducing element collet & wedge have greater strength.

b. Area of contact comparison

1) Area of contact in cam operated brake = 4470 mm^2

For two shoes = 8940 mm^2

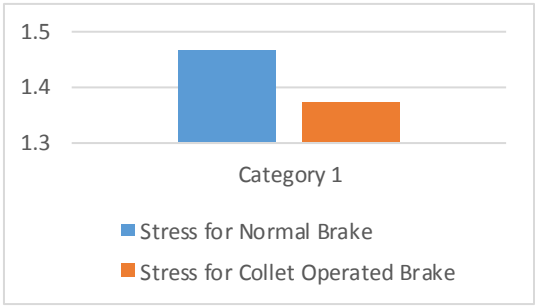
2) Area of contact in collet & wedge operated brake = 2500 mm^2

For five shoes = 12500 mm^2

Due to the more frictional contact area, braking effect will be more.

V. RESULT AND DISCUSSION

From the comparison between the analytical studies of the existing cam operated internal expanding drum brake and the collet wedge operated internal expanding brake; we come to know that the equivalent stress acting in the collet is far lower than the equivalent stress acting in the existing model.



Due to the lowest working stress acting in the collet the ultimate strength of the material need not be higher.

The stress is equally distributed in the collet among the five limbs

The collet operated drum braking system and usual drum brake system results are compared, in comparison collet operated drum brake system braking torque is higher than usual drum brake system.

VI. CONCLUSION

The strength of the collet element is found greater than the pivoted brake shoe element of the existing model. Therefore material failure is avoided in the new collet operated internal expanding brake. The more area of frictional contact in the collet operated model increases the braking effect.

Our future research is to derive the numerical formulae to find the torque absorbing capacity and the actuating force of the newly designed collet and wedge operated internal expanding brake.

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