Study on Brake Shoe

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Abstract- *Brake is a mechanical device used in automobiles, trains, machineries etc., to slow down or stop the vehicle in shortest possible time at the time of need and to control the speed of vehicle at turns and also at the time of driving down on a hill slope. Frictional brakes, commonly referred as drum brake are usedfor the purpose. In traditional method, two shoes are used to stop the vehicle by making them press against the rotating drum, in which area of contact of brake lining with brake drum is less. Arc angle of each of the shoes in contact with the brake drum is high and it leads to only 50% of the brake lining to be in contact with brake drum while applying brake. Increase in the area of contact between brake lining and brake drum, was achieved by splitting the traditional two brake shoes into four brake shoes, thereby reducing the arc angle of each shoe. Therefore area of contact was increased, which leads to the braking time reduced by 25% and correspondingly braking distance also reduced.*

Keywords- Brake Drum, Area of Contact, Four Shoe Brake, Braking Time, Braking Distance.

I. INTRODUCTION

Brakes inhibit slowing or stopping a moving object or preventing its motion, by the action of friction between the sliding contact surfaces.

While braking, the entire kinetic energy of the moving vehicle is converted into heat. Brakes are generally applied to rotating axles or wheels. While braking a vehicle moving at a velocity of 10m/s, kinetic energy increases quadratically with velocity, having 100 times as much energy as one of the same vehicle moving at I m/s. Simultaneously the braking distance also 100 times long at the traction limit. Friction (pad/shoe) brakes are often rotating devices with a stationary pad and a rotating wear surface. Pads that pinch a rotating disc, refers to a disc brake. Brake characteristics includes: Peak force, continuous power dissipation, fade, smoothness, power, pedal feel, drag weight, noise & durability. A significant amount of energy is always lost while braking, even with regenerative braking system. Energy applied for braking, may be mistakenly utilized for unavoidable friction, leads to deceleration of the vehicle. Brakes usage have to be minimized for the efficient usage of fuel. The specific contact surfaces that form during the use render the pads very good friction and wear characteristics [l]. The pad area is divided into numerous contact plateaus (occupying some 20% of the area) surrounded by lowlands. The lowlands are constantly out of

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sliding contact. The area of real contact is concentrated to small spots confined within the plateaus. The plateaus have a relatively long life while the areas of real contact are constantly shifting due to wear and deformation and surface roughness on the disc surface. The size of the nominal contact area has very little influence on the friction level as long as it is very much larger than the real contact area. The only effect of decreasing the nominal contact area will be to bring the areas of real contact correspondingly closer, and in the particular case of brake linings probably collected within fewer contact plateaus. Pin on disc tests conclude Fragments tend either to leave the tribological system or are trapped with debris from the disc in between the mating surfaces and are compacted to form the secondary plateaus. [2] In general, the composition of the friction layers observed at different temperatures and their stability are paramount to infer the composition of the particles and fragments emitted by this sort of tribological systems. [3] The increasing coverage of the disc surface with wear debris is in agreement with the slight reduction in the wear coefficient.

Increase in friction surface has an impact on friction coefficient, thereby affects brake pressure, leads to the reduction of friction at the interface. Further it has been found that disc brakes exhibit gradual decrease of friction coefficient due to the equitable distribution of braking effort while drum brake presents sudden variations in friction coefficient. [4] The highest friction can be accompanied with the lowest detected wear and vice versa.

This is related to specific character of the friction layer, which can protect surface against wear and will have larger adhesive capacity. [5] Friction surface can be divided into several plateaus (red areas), which are elevated above numerous valleys. The effects of using a fixed caliper, different friction coefficients and different speeds of the disc on the stress concentration, structural deformation and contact pressure of brake disc and pads, respectively. [6] The temperature distributions in the pin and the disc were modeled using a finite element analysis by considering perfect contact between the surfaces. The results were then discussed by considering the damaging phenomena occurring at the sliding contact. The approach based on the perfect contact with thermal continuity at the interface was found to better fit the experimental temperature records and to be in substantial agreement with the observed wear phenomena occurring at the pin— disc interface. [7]

II. TRADITIONAL METHOD

Most used wheel brakes are internal expanding brakes, which have the compactible construction and economic too.

Backing plate or brake shield is attached to the axle, acts as a support for brake shoes and operating mechanism. The brake drum behaves as a cover for brake shoes and operating mechanism. It is attached to the rotating wheel and facilitates a frictional surface for the shoes. To produce the braking action, brake shoes are forced against the brake drum outwardly. One extreme end of the shoe is hinged upon the backing plate with an anchor pin arrangement and the other extreme end remains unattached.

By the operating mechanism, the unattached end can be moved in its support. When the braking force is applied at the unattached end of the shoe, the brake shoe expands and stops the wheel. After the braking action was done, the shoes return to its original position by the retracting spring.

The internally expanding brakes, commonly used in cars and heavy vehicles, having two shoes: Sl and S2. The shoes are lined with materials having high coefficient of friction, thereby ensure less friction at the contact surfaces. About the fixed fulcrum 01 & 02 the shoes are pivoted. At the time of piston movement, brake shoes are outwardly pushed against the drum rim. Braking torque produced as a result of friction between the drum and shoe surfaces, hence drum speed reduces. Springs are used to hold the shoes normally in offspring condition. The entire mechanism is encrypted up within a drum arrangement to prevent from moisture and dust.

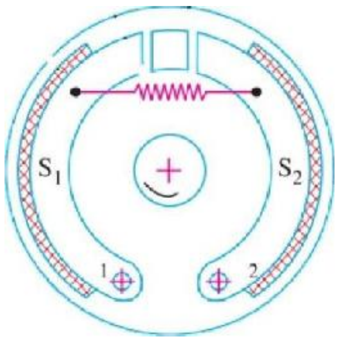


Fig 2. Line diagram of traditional method

Consider the forces acting on such a brake, when the drum rotates in the anticlockwise direction. For anticlockwise direction of rotation, primary shoe is the left hand shoe and secondary shoe is the right hand shoe. Let, r — Internal radius of the wheel rim; b — Width of the brake lining; pl Maximum intensity of pressure; pn — Nominal pressure; F I Force exerted by the cam on the leading shoe; F2 — Force exerted by the cam on the trailing shoe.

III. FOUR SHOE BRAKE SYSTEM

In traditional method (i.e.) brake drum with two shoes, area of contact between brake drum and brake lining is less. Moreover, vehicle stopping distance and braking time are more. Heat dissipating capacity is poor. Wear rate of brake lining is high. To improve the area of contact of brake lining with brake drum and to reduce the braking time of vehicle, four shoe brake system is an efficient way.

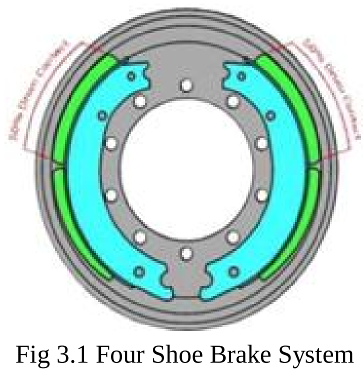


Fig 3.1 Four Shoe Brake System

Fig 3.2 Brake Drum

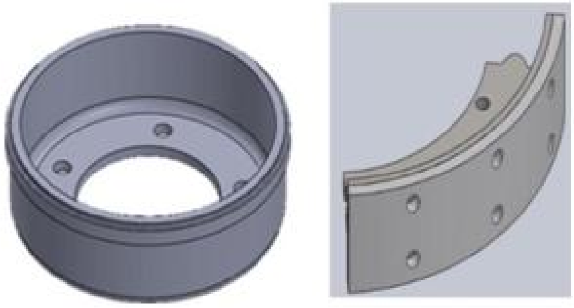


Fig 3.3 CAD model of Brake Drum & Break Shoe

IV. THEORETICAL MOMENT & FORCE CALCULATIONS

Four Shoe Brake System Moment of frictional force (MD

* Pmax * R * w [4R(cos91 — cos92) - h (cos291 —cos292)] 4
sin cp max

=
0.4 * 1.103 * 106* E• * * T(cos 0.210° —cos 70°) —0.775(cos20° —cos 140 °)]
3.7584

=7.3330

Nominal moment (MID

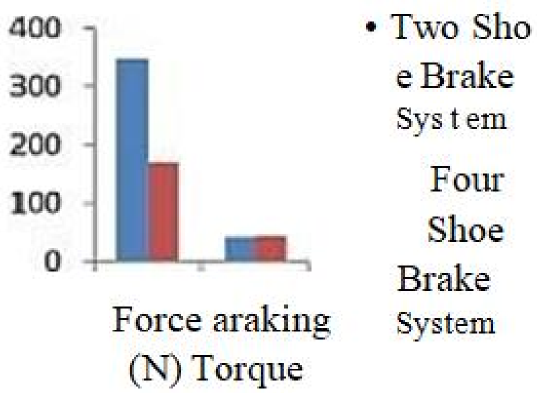
Pmax * R * w *h[2(92 —91) - (sin292 —sin291)]

4 sin cp max

=
1.103 *10 6 * E* 5 * .0−3*0.0775[2(1.22173−0.17453)−(sin 140— sin 20)]
2

3.7584

=20.4Nm



$$= \frac{\mu * Pmax * R * w [4R(\cos\theta 1 - \cos\theta 2) - h(\cos 2\theta 1 - \cos 2\theta 2)]}{4 \sin \varphi max}$$

=

$$\frac{0.4 * 1.103 * 10^6 * \frac{0.2}{2} * 5 * 10^{-3} [4 * \frac{0.2}{2}(\cos 25° - \cos 125°) - 0.775(\cos 50° - \cos 250°)]}{4}$$

M_f = 28.44 Nm

Nominal moment (M_n)

$$= \frac{Pmax * R * w * h[2(\theta 2 - \theta 1) - (\sin 2\theta 2 - \sin 2\theta 1)]}{4 \sin \varphi max}$$

=

$$\frac{1.103 * 10^6 * \frac{0.2}{2} * 5 * 10^{-3} * 0.0775[2(2.1816 - 0.4363) - (\sin 250 - \sin 50)]}{4}$$

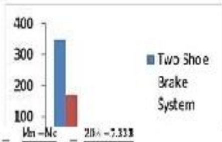
M_n = 55.52 Nm

$$Force = \frac{Mn - Mc}{c} = \frac{55.52 - 28.44}{0.0775} = 349.42 N$$

4.2 Comparison Chart For Braking Force & Braking Torque

Table 4.1 Comparison between Two Shoe & Four Shoe Brake Systems

Parameter	Force (N)	Braking Torque (Nm)
Two Shoe Brake System	349.42	43.31
Four Shoe Brake System	168.60	44.40



$$Force = \frac{Mn - Mc}{c} = \frac{20.4 - 7.333}{0.0775} = 168.60 N$$

Solid model of brake shoe system was crafted by using solid works software. The model was further meshed and analysed using Ansys 14.0. Maximum displacement, stress and strain induced in the brake shoe system were found out. Maximum displacement = 0.04912 mm; Maximum stress = 1.083 * 109 N/mm2; Maximum strain = 0. 001779.

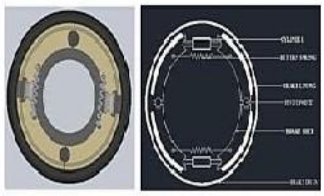


Fig 5.1 Solid Model of Four Shoe Brake System

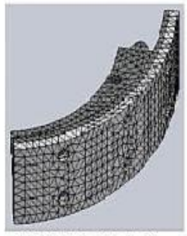
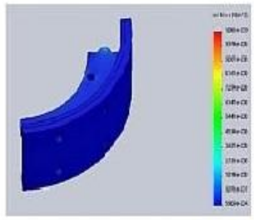


Fig 5.2 Meshed Brake Shoe



reduced, thereby improving the life of the brake

S. SOLIDMODELANALYSISOF BRAKESHOE

Two Shoe Brake System
Motnem of Frictional Force (ME)

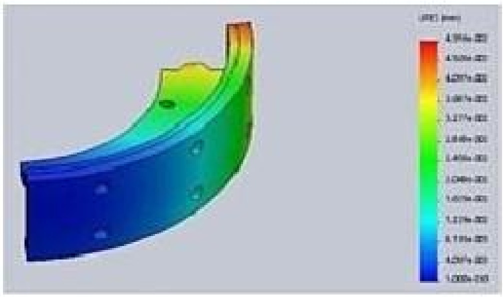


Fig 4.1 Comparison between Two Shoe & Four Shoe Brake Systems

Tun shoc brake system and four shoe brake System was con.pared based on force applied on brakes and braking torque induced on the brake drum. Comparing to the traditional model, rour shoe trwke syslcm requires less amount of force for making the brake shoe to expand. And regarding braking torque, both systems induces the same value for both braking systems, Reduction of force is onc of the advantages, to be considered for four shoe brake System. Sinæ the force is reduced. wear rate occurring at the sliding surface between shoe and the brake drum also Fig 5.3 Stress Plot of Brake Shoe of shoes to expand against the rotating brake drum.

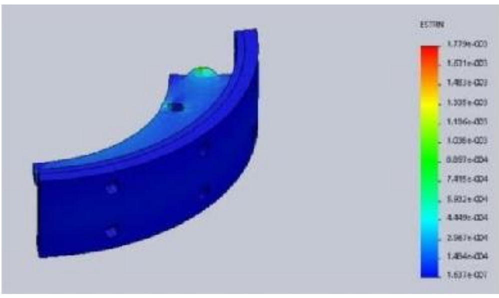


Fig 5.4 Displacement plot Of Brake

Fig 5.5 Strain Plot of Brake Shoe

Fig 6. Fabricated Four Shoe Brake System

VI. FABRICATION OF FOUR SHOE BRAKE SYSTEM

In four shoe brake system, instead of two shoes, four shoes were placed. Additionally two pivot points are provided about which a pair of shoes can rotate and two cylinders are also provided to actuate the brake shoes. Each pair of shoes moves about a single fixed pivot point. Cylinder contains two pistons moving in two different directions and it gets actuated by hydraulic fluid. So, each cylinder can make a pair tested will be place in this setup. Brake pedal will be connected to inlet port of brake drum. Motor provides power. Disengaging mechanism disengages motor and gear box when necessary. Gear is used to vary the speed. Brake pedal is used apply pressure on brake drum. It will be connected in the following order (i.e.) Motor - Disengaging clutch - Gear box - Brake drum - Brake pedal.

VII. EXPERIMENTATION

Brake testing machine is similar to an automobile vehicle. It contains motor, disengaging mechanism, speed reduction box, bearing, base, etc., Here, motor acts as an engine, disengaging mechanism as clutch and speed reduction box as gear box. Brake to be

Braking Force & Braking Time Reduction by using Four Shoe Brake System

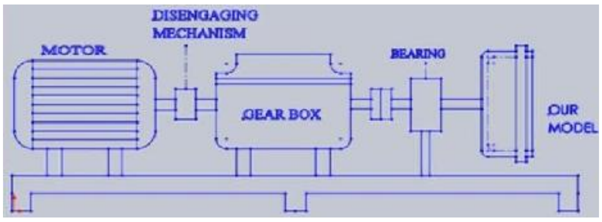


Fig 7.1 Layout of Brake Testing Machine
Fig 7.2 Fabricated Brake Testing Machine

Fig 7.3 Brake Pedal Set

Four Shoe Systems

When the motor is switched on, it rotates and transmits power to the disengaging clutch. The gearbox will be in neutral gear (by default); the power will not be transmitted to brake. So, to transmit power, Gear should be changed. To change the gear, motor and gear box should be disengaged by using clutch. Thus gear will get changed and power will be transmitted to brake drum.

Results & Discussion

Motor Speed (rpm)	Gear	Speed (rpm)	Braking Time (ms)	
			Two Shoe Brake System	Four Shoe Brake System
1420	1st	540	58	42
	2nd	950	84	65
	3rd	1100	223	175
	Reverse	400	30	20

Table 7.1 Comparison of Braking Time for Two Shoe & Four Shoe Systems

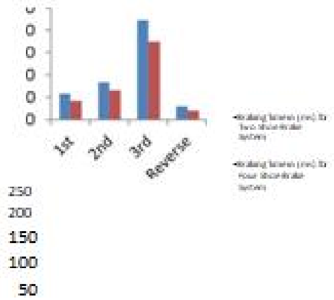


Fig 7.4 Comparison of Braking Time for Two Shoe &

Four Shoe Systems

The approximate timing consumed by a vehicle to come to rest position from the time of application of brake is meant to be the Braking time. Braking time was calculated with the modified brake drum assembly & Brake pedal set as shown in Fig. 7.2 & Fig. 7.3. Braking time was calculated using stop watch for each and every gear. Similarly, braking time is calculated for two shoe brake system too for each and every gear and the results were compared as shown in Table 7.1 & Fig. 7.4. It was observed that, when comparing the two shoe brake system with four shoe brake system, four shoe brake system possess 16 ms reduction during first gear, 21 ms reduction during second gear, 52 ms reduction during third gear and 10 ms reduction during reverse gears of operation. Corresponding due to the braking time reduction, braking distance also reduced. Four shoe braking system provides effective braking in terms of speed, braking time & braking distance.

VIII. CONCLUSION

The traditional brake shoe system (two brake shoe system) was replaced with the four shoe braking system. Brake testing machine was fabricated and brake timing was found and comparison has been made out with the two shoe and four shoe brake systems in the present experimental study and the following observations were made.

- Theoretically, it was found out that, the force required to be applied at the brake drum was reduced to 50% and the braking torque induced remains same. (i.e.) Less force requires to be applied to the brake system.
- By modifying the traditional brake system into four shoe brake system, area of contact between brake lining and brake drum is increased.
- Increase in contact area, leads to the reduction of braking time and braking distance will also get reduced simultaneously.
- Reduction in braking time, improves the life of brake lining.

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