Survey of the Causes of Brake Failure in Commercial Mini-buses in Kumasi

1Prince Owusu-Ansah, 1Timothy Alhassan, 1Alex Frimpong and 2A. Agyei Agyemang
1Department of Mechanical Engineering, Kumasi Polytechnic, P.O. Box 854, Kumasi, Ghana
2Department of Mechanical Engineering, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana

Abstract: This paper studies the causes of brake failure in commercial mini-buses in Kumasi, Ghana. A structured questionnaire was administered at (20) bus terminals, (65) automotive workshops and (25) government institutions. The researcher met the personnel in charge of these institutions and explained the objectives of the research. The questionnaire was left with the authorities overseeing these institutions and the response was collected at a later date. In all a total of (485) people were surveyed. The results and responses suggested that the main causes of brake failure in mini-buses are: Overheating of the brake assembly due to prolong application of the brakes, low brake fluid level as a result of defective rubber seals in the master cylinder and air trapped in the braking system resulting in spongy brakes and reducing braking efficiency. The survey results showed that brake failure in commercial mini-buses is caused mainly by Overheating of the brake assembly due to prolong application of the brakes. The survey responses suggest that the braking system should be inspected and serviced periodically in order to minimize the rate of brake failure in mini-buses.

Keywords: Brake failure, brakes, braking efficiency, master cylinder

INTRODUCTION

When a vehicle is accelerated, energy supplied by the engine causes the vehicle’s speed to increase. Part of this energy is instantly used up in overcoming frictional and tractive resistance but a large amount of it remains stored in the vehicle. This energy of motion is called the kinetic energy (Hillier, 1991). The existence of kinetic energy is observed when a vehicle is moving and neutral gear is selected. The vehicle does not immediately come to rest, instead it travels for a considerable distance before it becomes stationary. In this case the stored energy is used to drive the vehicle against the resistances that oppose the vehicle’s motion.

Relying on these resistances to slow down a vehicle could cause many problems, so an additional resistance called a brake is needed to convert the kinetic energy to heat energy at a faster rate in order to reduce the speed of the vehicle. This reduces the speed of the vehicle at a faster rate and brings the vehicle to rest within the shortest possible time when the brakes are applied.

To bring a vehicle to a stop, the brakes have to absorb all the energy given to the vehicle by the engine and that due to the momentum of the vehicle. This energy must then be dissipated. In most vehicle brakes, the energy is absorbed by friction, converted into heat and the heat dissipated to the surrounding air. As the energy is absorbed, the vehicle is slowed down; in other words, its motion is retarded. The brakes must also pull up the vehicle smoothly and in a straight line. The road wheels of the vehicle may be retarded or braked by means of drum or disc friction brakes, or by a friction brake which is applied to some part of the transmission system.

Types of braking systems: There are two main types of braking systems used in motor vehicles. These are:

- The Drum brake assembly
- The Disc brake assembly

Drum brake assembly: The drum brake is an internally expanding type of brake that uses two shoes attached to a back-plate, which is fixed to a stub axle or axle tube. Each shoe has a ‘T’ section and a friction lining riveted or bonded to its outer face. At one end of the shoe is a device for expanding the shoe when the brake pedal is depressed. In a simple brake, such as that shown in Fig. 1, a cam is used as a shoe expander, but modern layouts fitted to cars are hydraulically operated pistons for this purpose.

All shoe-type brakes must have some arrangement to prevent the shoes rotating with the drum. The shoe anchor, which must be rigidly attached to the back-plate, takes the form of a large pin that passes through the shoes, or a housing, against which the shoes butt.
Springs pull the brake shoes on to the back-plate and also return the shoes to the ‘off’ position after the brake has been applied. In some cases separate springs are used to perform the retention and return functions. The inner cylindrical surface of the cast iron drum is ground to give a smooth surface on to which the brake linings can rub. The drum is generally attached to the hub flange by small counter-sunk screws and retained securely by the wheel nuts. If possible, the drums should be exposed so that a good flow of air over the drum is achieved to dissipate the heat and prevent loss of brake efficiency that occurs when the unit gets very hot. Some form of adjuster is provided for each brake to take up excessive clearance due to wear of the friction facing. Since a large leverage is needed between the brake pedal and shoe, a large movement of the shoe would mean that the brake is fully applied. This dangerous condition is avoided by either manually adjusting the brakes periodically, or having an automatic adjuster that continually sets the shoes so that they are always positioned very close to the drum (Heisler, 1989).

The drum brake assembly consists of the following components:

- Wheel cylinder
- Master cylinder
- Back plate
- Brake shoes
- Brake drum
- Springs

Advantages and disadvantages: The main advantages of the drum brake are:

- The same braking power is available in reverse as well as when moving forward.
- Drum brakes give a greater stopping force for a given size of brake drum.
- Drum brakes have self servo action which gives effective braking.

The main disadvantages of the drum brake are:

- Loss of braking power is more evident during prolong braking which results in overheating of the system.
- The system is more complicated in design.
- Uneven wearing of the braking lining results in vehicle pulling to one side during braking period.
- One problem with drum brakes is fade (This is a condition where the brake performance falls drastically when a brake, especially the friction linings, reaches a given temperature).

Disc brakes assembly: The disc brake consists of an exposed disc which is attached to the hub flange; the two friction pads are pressed on to this disc to give a braking action. Figure 2 shows a disc brake assembly. The pads are moved by hydraulic pistons working in cylinders formed in a caliper that is secured to a fixed part of the axle. When the hydraulic pressure is applied to the two cylinders held in the fixed caliper, the pistons move; this action forces the friction pads into contact with the rotating cast iron disc. The sandwiching action of the pads on the disc gives a retarding action and heat generated from the energy of motion is conducted to the disc.

Greater part of the disc is exposed to the air, therefore heat is easily radiated, with the result that the brake can be used continuously for long periods before serious fade occurs. Since the friction pads move at a right angle to the disc, any drop in the friction value does not affect the force applied to the pad. As a result this type of brake is not very sensitive to heat (Mudd, 1972a, b). The disc brake was developed to minimize the fade problems. When fading occurs, the driver has to apply a much larger effort and in extreme cases it becomes impossible to bring the vehicle to rest. The problem arises when a drum brake is continually operated for long periods, as when a vehicle descends a long mountain road. The friction between the lining and drum and the effect of this friction on the application of the shoes, govern the maximum braking torque that a drum brake can produce. Although friction materials having good anti-fade qualities are produced, there is still the chance of fade with a drum brake.

No assistance is obtained from the rotating disc to aid the driver in the application of a disc brake to
achieve a given retardation. A disc brake requires a
greater pedal pressure than that needed for a drum
brake. Adjustment to take up pad wear is automatic on
a disc brake, therefore minimum attention is required. A
merit of this type is the ease with which the pads can be
inspected. If corrosion is not present, the pads can be
easily renewed.

The disc brake assembly consists of the following
components:

- Master cylinder
- Brake pads
- Brake discs
- Rotor

Advantages of the disc brakes: Disc brakes have the
following advantages over drum brakes.

Greater heat dissipation: This is because only small
part of the disc is heated by contact with the pads, the
greater part always being in contact with the stream of
cooling air. Brake fade is therefore greatly reduced and
pedal travel remains fairly constant.

Cleaner braking surfaces: Centrifugal force throws
water, dirt and oil off the discs, which therefore retain
their efficiency and are worn less. The discs are more
substantial and so less liable to distortion than drums.

Lighter in weight: The disc brake assembly is about
20% less in weight than the equivalent drum type.

Simpler construction: Pads are visible and wear is
easy to observe or see.

Easier maintenance: Brake pads can be changed much
quicker than brake shoes.

Disadvantages of disc brakes:

- The disc brake has no self servo action, therefore
  higher operating forces and pressures are required.
  In-spite of this feature the disc brake, particularly
  when used with a hydraulic servo unit, provides a
  braking effort which is directly proportional to the
  applied pedal force.
- The higher operating forces required complicate
  the design of the hand-brake mechanism. For this
  reason many cars are fitted with disc brakes at the
  front wheels only.

Brake fluid: The fluid used in the hydraulic brake
systems is a vegetable oil with certain additives. The
main requirements of a good brake fluid include low
viscosity, high boiling point, compatibility with rubber
components, lubricating properties, resistance to
chemical ageing and compatibility with other fluids
according to Nunney et al. (1998). However, most
Ghanaian drivers use other fluid such as dirty brake
fluid, less dirty fluid and even soapy water as substitute
to the original brake fluid.

Fluid contamination: It is even more important that
engine oil, shock absorber oil, petrol and paraffin never
be introduced into a fluid brake system-nor should they
ever be used to clean brake parts. The use of these
mineral-based oils results in the rapid weakening or
destruction of all the rubber components and possibly in
the injury or death of the vehicle users as a result of
brake failure. Cleaning should always be done with
industrial methylated spirit, followed by washing in
clean brake fluid and/or application of the correct
rubber grease. A system contaminated by mineral oils
or wrong fluids must be thoroughly flushed out with
methylated spirit, have the contaminated fluid
destroyed at once and all rubber parts replaced.

Flushing is similar to normal bleeding except that
the fluid is replaced by methylated spirit and at least a
litre of spirit passed through each bleed valve. Flushing
should be carried out once every 3 years of normal
service and whenever the fluid appears thick and dirty
(Reed and Reid, 2000).

Anti-lock Braking System (ABS): There is an
increasing need for systems that provide better safety,
as the number of vehicles that use the road. A braking
system that incorporates an arrangement that prevents
the road wheels from locking up and skidding should
contribute to this extra safety required if used correctly.

A driver finds it difficult to assess the force that
should be applied to the brake pedal to make an
emergency stop and bring the vehicle to rest in the
shortest possible distance. This is because it is an
impossible task to take into account the many varying
factors such as type and roughness of the road and tyre
and the condition of the surfaces; e.g., wet, dry, greasy
or icy. This generally means that the driver applies
either too much or too little pressure on the pedal. The
effects of such actions are:

- Pedal pressure too high: One or more of the
  wheels may skid over the surface with the result
  that:
    o Stopping distance is increased because the
      adhesion between a skidding wheel and the road is
      less than that given by a wheel that is held on the
      verge of skidding.
    o Directional control is jeopardized: In the case of
      a rear-wheel skid, the vehicle turns from front to
      rear.
- Pedal pressure too low: Stopping distance is
  increased, which can result in impact with an
  object.

The adhesion between the road wheel and road
surface is governed by the coefficient of friction. This
varies considerably when the condition of the road surface is changed. For example, the friction value of a dry asphalt road falls by about 0.8 to 0.15 when it is covered with black ice.

On a dry surface the adhesion varies as the percentage of wheel slip changes from 0 to 100%. Retention of steer ability in maximum braking situations and avoidance of skid danger under all road conditions are the basic requirements of a good anti-locking system. The system should be fail-safe, low in weight and the initial cost should be reasonable.

The systems in use differ in the method that is used to sense wheel slip. The systems of ABS available are:

- Mechanic
- Electronic

The layout of the main components of a four-wheel regulated system is similar to that produced by Association of Technical Engineers ('ATE'). The system may be divided into two sub-systems: Hydraulic and Electronic.

**MATERIALS AND METHODS**

**Survey:** A structured questionnaire was administered at (20) bus terminals, (65) automotive workshops and (25) government institutions. The researcher met the personnel in charge of these institutions and explained the objectives of the research. The questionnaire was left with the authorities overseeing these institutions and the response was collected at a later date.

Bus terminals, automotive workshops and government institutions fall into several categories. Due to the different categories, random sampling was used to select the sampling units. Stratified random sampling was used to select samples in situation where population is heterogeneous but has definite strata or classes which are homogeneous (Kalton and Moses, 1989). Kejetia bus terminal and Suame magazine were investigated and the sample units taken.

**RESULTS AND DISCUSSION**

**Survey responses:** Out of a total number of four hundred and (485) people interviewed, (132) representing 27.2% indicated that the brake failure they experienced was as a result of low brake fluid level in the master cylinder. One hundred and nine representing 22.5% attributed the cause of brake failure to overheating of the brake assembly, while (65), representing 13.4% said the cause of brake failure was air being trapped in the pipeline.

The results from the survey show that out of the various causes that are attributed to brake failure, low brake fluid, overheating of the brake assembly and air trapped in the pipeline which amounted to 63.1% indicates that they are the most often causes of brake failure in mini-commercial buses.

The rest of the results were: twenty nine representing 5.9%, stating that grease or brake fluid on lining was the cause, (17) representing 3.5% said incorrect shoe adjustment, while (10) people representing 2.1% attributed uneven tyre pressure and brake shoe adjustment as the cause of brake failure. Automatic shoe adjuster not functioning, poor or wrong lining fitted into the brake assembly and master cylinder or wheel cap being soft and sticky had (16), (20) and (26) representing 3.3, 4.1 and 5.4%, respectively in commercial mini buses, while (28) people representing 5.7% attributed brake failure to causes different from what was stated in the questionnaire.

Table 1 gives the causes of brake failure in commercial mini-buses. Figure 3 shows a bar chart of the results in Table 1.

**Servicing periods:** The servicing period gives the number of times the people who answered the questionnaire service their brakes. With reference to the
Fig. 3: Causes of brake failure in commercial mini-buses

Table 1: Causes of brake failure in commercial mini-buses

<table>
<thead>
<tr>
<th>Causes of brake failure</th>
<th>Total</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air in system</td>
<td>65</td>
<td>13.4</td>
</tr>
<tr>
<td>Low fluid level in the master cylinder</td>
<td>132</td>
<td>27.2</td>
</tr>
<tr>
<td>Cracked brake drum</td>
<td>11</td>
<td>2.3</td>
</tr>
<tr>
<td>Grease or brake fluid on lining</td>
<td>29</td>
<td>5.9</td>
</tr>
<tr>
<td>Incorrect shoe adjustment</td>
<td>17</td>
<td>3.5</td>
</tr>
<tr>
<td>Uneven tyre pressure</td>
<td>10</td>
<td>2.1</td>
</tr>
<tr>
<td>Overheating of the brakes</td>
<td>109</td>
<td>22.5</td>
</tr>
<tr>
<td>Brake shoe distortion</td>
<td>10</td>
<td>2.1</td>
</tr>
<tr>
<td>Automatic shoe adjuster not functioning</td>
<td>16</td>
<td>3.3</td>
</tr>
<tr>
<td>Poor or wrong lining</td>
<td>20</td>
<td>4.1</td>
</tr>
<tr>
<td>Master cylinder or wheel caps being soft and sticky</td>
<td>26</td>
<td>5.4</td>
</tr>
<tr>
<td>Others</td>
<td>28</td>
<td>5.7</td>
</tr>
<tr>
<td>1 and 2</td>
<td>12</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Table 2: Servicing periods

<table>
<thead>
<tr>
<th>Periods</th>
<th>Total</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>One month</td>
<td>29</td>
<td>6</td>
</tr>
<tr>
<td>Three months</td>
<td>41</td>
<td>8</td>
</tr>
<tr>
<td>Six months</td>
<td>104</td>
<td>22</td>
</tr>
<tr>
<td>One year</td>
<td>310</td>
<td>64</td>
</tr>
</tbody>
</table>

graph, it clearly reveals that (310) people repair their brakes yearly, which could be attributed to the various causes of brake failure. If out of (485), 310 representing 64% people service their brakes yearly, then the conclusion can be drawn that people do not service their brakes regularly. This may be the cause of the frequent brake failure.

Out of the 485, 104 representing 22% stated that they service their brakes every 6 months. Twenty nine and 41 people representing 6 and 8%, respectively service their brakes every month and every three months, respectively. A critical analysis shows that few people could afford to have their brakes checked on monthly bases. This may be the cause of the numerous brake failures in commercial mini buses.

Table 2 gives the results of the survey as far as servicing periods was concerned. Figure 4 shows the periods within which the respondents service their brakes.

Brake failure results in accident: Figure 5 shows the survey results of brake failure cases that resulted in accidents. It was observed that out of a total number of (485), (392) representing 81% did results in road accident. Clearly the survey reveals that most accidents
Fig. 5: Brake failures that resulted in accident on our road associated with commercial mini-buses is as a result of brake failure and as a result all effort must be made to reduce it or if possible avoid brake failure completely.

CONCLUSION

The survey results showed that brake failure in commercial mini-buses is caused mainly by Overheating of the brake assembly due to prolong application of the brakes. The survey responses suggest that the braking system should be inspected and serviced periodically in order to minimize the rate of brake failure in mini-buses.

REFERENCES


