International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 6 Issue 2, February-2017

Experimental Study of Brake System in Light Vehicles

Timur Choban Khidir[1], Abbas Mohammed Ismael[2]

[1,2]Kirkuk University / College of Engineering - Mechanical Dept.

ABSTRACT

In this experimental study, effect of increasing in brake disc temperature on braking performance was investigated. For this purpose, braking distance tests which the criteria of braking performance were carried out. The tests were conducted on a small-size commercial vehicle for different disc temperatures, pedal forces, the vehicle loads and for initial vehicle speeds. Test results of stopping (braking) distance were analyzed for the variation of disc temperatures. The results showed that the stopping distance is considerable increased when the disc temperature is increased for different vehicle speed and pedal forces. Typically, at the vehicle speed of 80 km/h and maximum pedal force for 63 ºC disc temperature, 44.90 m stopping distance was measured. When the temperature is increased as 298 ºC, stopping distance is increased as 52.71 m with the rate of 17.4% at road test.

Keywords: Brake system, pedal force, heating brake discs, commercial vehicle.

1. INTRODUCTION

The researches on traffic accidents generally refer to the driver faults beside that the vehicle and road defects have low proportion. The accidents caused by vehicles brake imperfections come immediately after tire puncture. [1].

The most important equipment for active safety in vehicles is brake systems. Along with developing technology the comfort and speed in today's vehicles with the load capacity of commercial vehicles are increasing continuously, so this case leads to need for effective and powerful braking systems. In order to provide direct stop for the moving vehicle, the brakes are effecting to the road safety directly. [2-3].

Braking efficiency and braking performance with the vehicle's stopping distance shows an important expression. The factors that effect on stopping performance are as follows: vehicle's weight, design of brake system, the hydraulic and mechanic parts state, the factors of environmental conditions, road conditions, tire state and the coefficient of friction between wheel and the road surface. [4-5].

The other factor that effects directly to the braking system performance is the temperature increasing of the braking system elements**.** Increasing temperature during brake, between the drum-lining (or disc-lining) may cause sudden friction (fading), premature wear, brakes liquid evaporation, thermal cracks and vibration. [6].

The brake of drum and disc temperature is a critical value for vehicles. This is a factor that directly affects the braking efficiency. Temperature effect is more important in overheating, and repeating this continuously causes reducing the friction coefficient between disc-lining (or drum-lining) and leads to dangerous results. This phenomenon, reducing brake effectiveness is defined as fading. [7-8].

In this research, road tests are studied during brake supply on a light vehicle and the effects of stopping distance with the change of disc temperature. In these tests; disc temperatures as well as vehicle speed, vehicle weight and applied pedal force variables were taken into consideration.

2. (MATERIALS AND METHOD)

Kia bongo light vehicle was used as a test vehicle. The purpose of this selection is to show that this problem (losing affectivity of brake by increasing temperature), is not happens only in heavy vehicles but also happens in light vehicles. Brake affectivity tests were carried out at a length of 1500 meters and 30 meter wide on dry asphalt road. Coefficient Friction of the road surface is assumed to be 0.6. [9]. During the tests, in order to check and control the disc temperatures whether reached the wanted temperature or not, infrared principle and remote non-contact temperature measurement (laser thermometer) is used. (Figure 1)

Fig. 1: Laser thermometer

To observe different pedaling force in brake activation test values that affect the stopping distance, a pedal force limiting apparatus has been developed (Figure 2-a, b). This apparatus being rigidly connected to the pedal holder, sliding holes on the mechanism and a pin to do tests at different stages (Figure 2-c).

(a) (b) (c)

Fig. 2: Apparatus of the pedal force limiter and installation to the brake pedal

Three different stages of the apparatus are used. Calibrating apparatus achieved with drum brake made with the aid of a test device and the supplied force values on the pedal are determined. These values are, 120 N in the first stage of the limiting apparatus, second stage 260 N and 450 N at the third force were applied.

To measure the force applied to the pedal, digital display with pedal force sensor (Figure 3-a), as well data collector unit (Figure 3-b) are used, to pick up the vehicle data such as speed, stopping distance, acceleration and time, which is collected and sent by optical sensors. Sensors that perceived vehicle speed, acceleration, stopping distance, pedal force etc. collected in electronic form and allows transferring these data to a computer (Figure 3-c).

To achieve different load conditions, each of 25 kg load materials are used. Although the path of the research has necessity to study in heavy conditions, this study aimed to review and examine the behavior in different load conditions.

According to the international safety conditions we chose three speed options for our vehicle 40, 60 and 80 km / h, with load (3220 kg) and without load (1745 kg), on three different pedal force levels 450 N, 260 N and 120 N consequently three different disc temperatures taken from the disc. A total of 60 stopping distances were tested.

Disc temperature values measured during tests and the data such as acceleration, speed, stop distance, etc. simultaneously recorded by the collection unit electronically.

The tests started with load options. According to the constructions of brake type approval tests if the disc temperatures below 100ºC are referred to "Cold Brake" and if the temperatures above 100ºC is called as "Hot Brake". Firstly beginning with cold brake; stopping distance tests were conducted for vehicle speeds 40-60 and 80 km/h at 3 different pedaling forces. Then carrying the brake discs were heated to an average of 180 ° C and tests were repeated. At last step, brakes discs heated to an average temperature of 300ºC and stop distance tests were repeated again. Heating operation of brake discs, achieved by heavy stop-start of vehicle with maneuvers.

The vehicle's conditions are loaded and unloaded. The above sequence was followed and stopping distance tests have been completed.

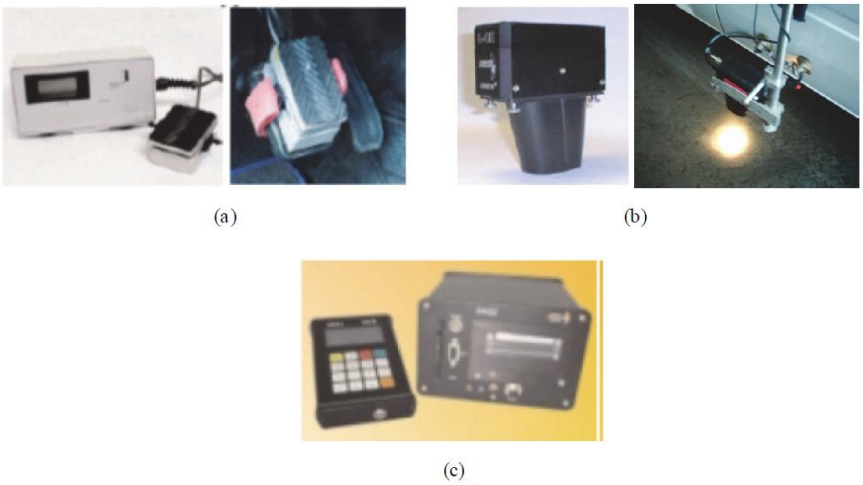

Fig. 3: Sensors and data acquisition unit

3. RESULTS AND DISCUSSION

One of the main objectives of brake effectiveness tests depending on brake disc temperature is to analyze the changes seen in stopping distance. In the tests we saw that the stopping distance of the vehicle is extended with increasing the disc temperature.

In figure 4 it is seen that the speed of vehicle before braking is 80 km/h and laden and as it is seen the stopping distance changing depends on brake disc temperature variation according to three pedal forces. Accordingly, applying brake with the a maximum pedal force (450 N) of the vehicle with an initial speed of 80 km/h the stopping distance value was 52.71 m at disc temperature is 298 ºC (hot braking) while we obtained 44.90 m when the discs temperature was 63 ºC (cold braking), this means that the stopping distance with hot brake is 17.4% more than the cold brake. So, changing the pedal force to (260 N), the stopping distance with hot brake is 82.8% more than cold brake and repeating the same operation with minimum pedal force (120 N) this rate was 71.9%.

The reason for the increase in stopping distance is overheat on disc surface which leads to decreasing the coefficient of friction between the disc and brake pad. By increasing the temperature of the molecules of lining brake material causes expanding bonds between these molecules and this leads to decreasing in the resistance strength. So the wear increases and coefficient friction decreases. This phenomenon, known as fading, and in very high values of disc temperature leads to lose effect of brake completely.

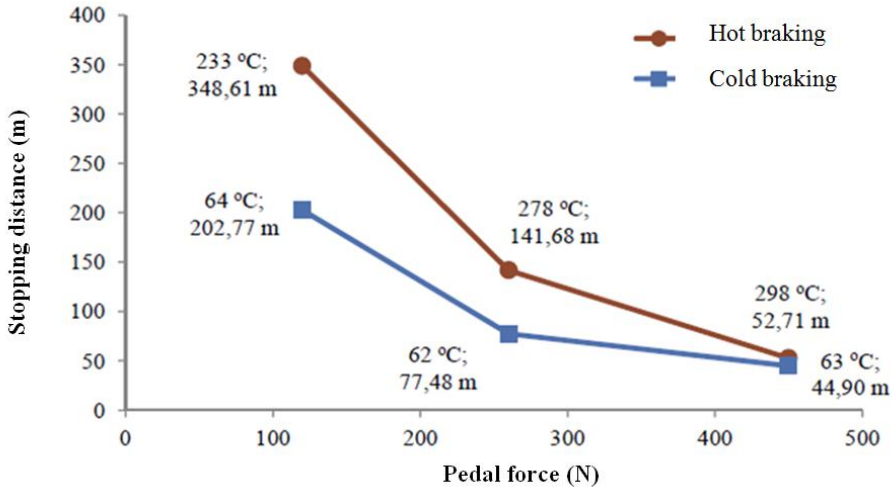

Fig. 4: The effect of brake disc temperature on Stopping distance, 80 km / h and laden

In addition to the increasing brake disc temperature, as we saw in the tests the applied force to the pedal is a distinguish factor. In Figure 5, we changed only the speed of our vehicle to 60 km/h. then we repeated all operations, beginning with braking in a maximum pedal force (450 N) of the vehicle, as we see from the figure the stopping distance values are increasing parallel to the first test.

When the pedal force is lower, the stopping distance value is longer because the moment of inertia of vehicle is effective; but when the pedal force is higher, the stopping distance is shorter than before because of the applying high pedal force to the discs.

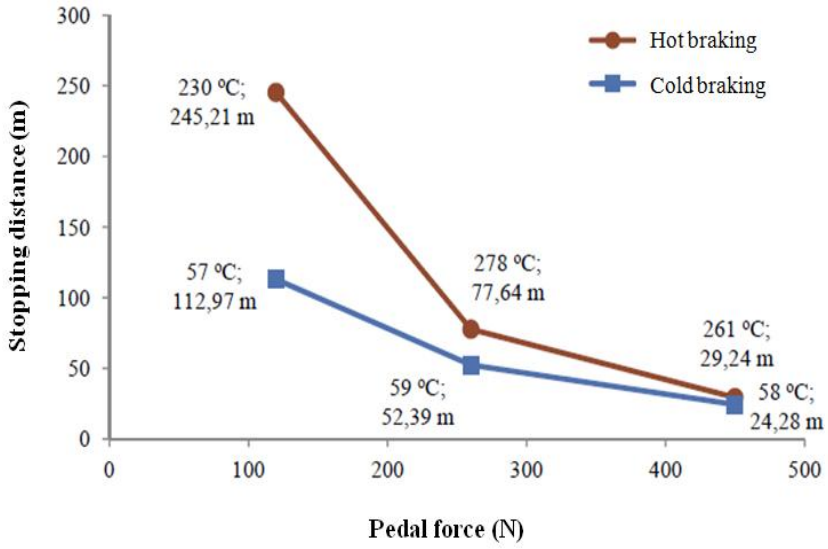

Fig. 5: The effect of brake disc temperature on Stopping distance, 60 km / h and laden

In Figure 6, it is assumed that the vehicle in the loaded condition has a speed of 40 km/h. It is showed the relation of stopping distance according to the disc temperature values. Here also as the disc temperature increases, the stopping distance increases furthermore, in addition reducing pedal force causing further increase in the stopping distance.
The optimum values of braking force between wheel and road is related to the grip-slip relationship. After reaching to a certain slip value between wheel and the road we can reach to the grip or coefficient of adhesive friction. At low pedal forces this optimization cannot be achieved.

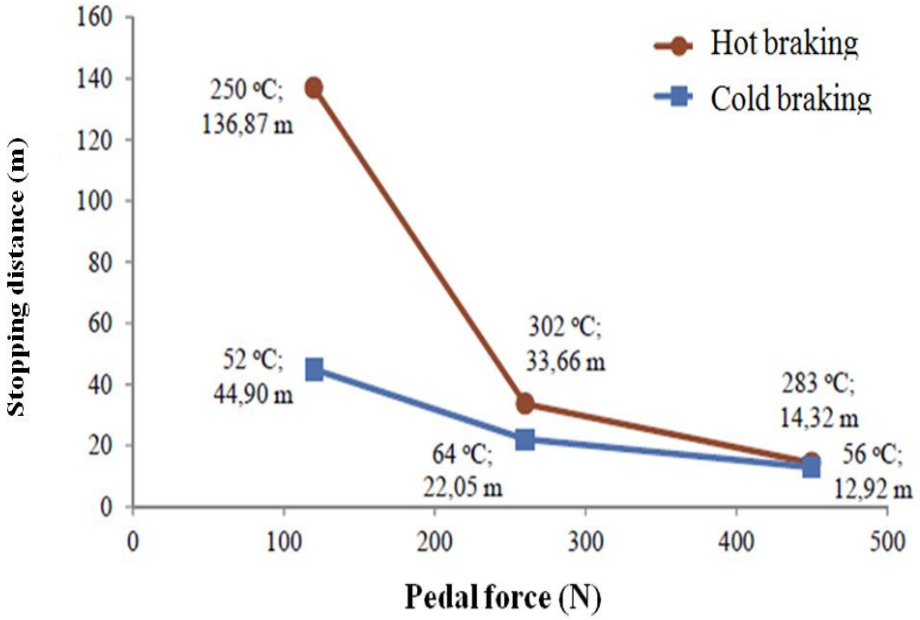

Fig. 6: The effect of brake disc temperature on Stopping distance, 40 km / h and laden

In Figure 7, vehicle speed is 80 km/h with unloaded (unladen), the test is carried out at the braking start with the maximum pedal force, the stopping distance value was 38.11 m when the disc temperature is 71 ºC while this distance was 40.64 m when the discs temperature is 255 ºC, this means that the stopping distance with hot braking is more than the cold braking by a rate 6.64%. So, by changing the pedal force to (260 N), the stopping distance rate is 17.5% with the heat increase of the discs while this rate is 44.2% in minimum pedal force. Which these results characteristically is look like parallel to the tests that carried out when the vehicle was laden.

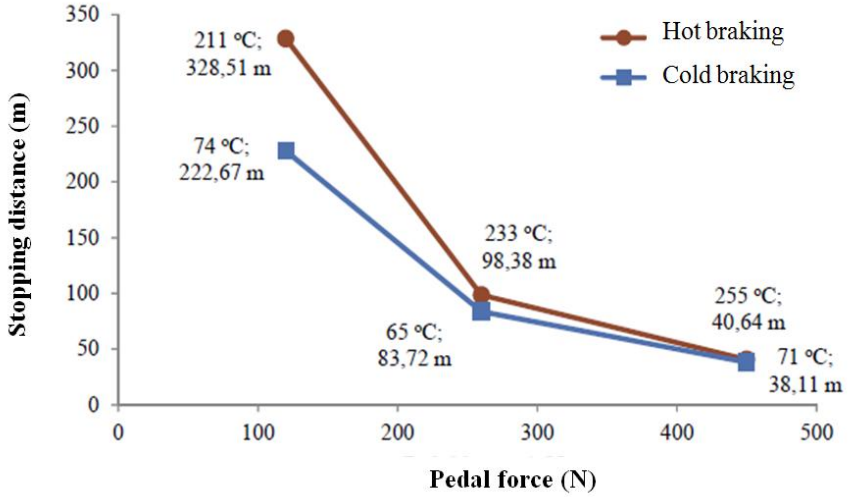

Fig. 7: The effect of brake disc temperature on stopping distance, 80 km / h and unladen

Then we changed vehicle speed is to 60 km/h and unladen and repeated the test with the maximum pedal force at disc temperatures (247ºC) and (66ºC), hot and cold brake consequently, we see about 1 m difference. The reason for this is that the brake discs speed passes to thermal cooling because the vehicle is unloaded and so the kinetic energy value is less comparing to loaded vehicle.

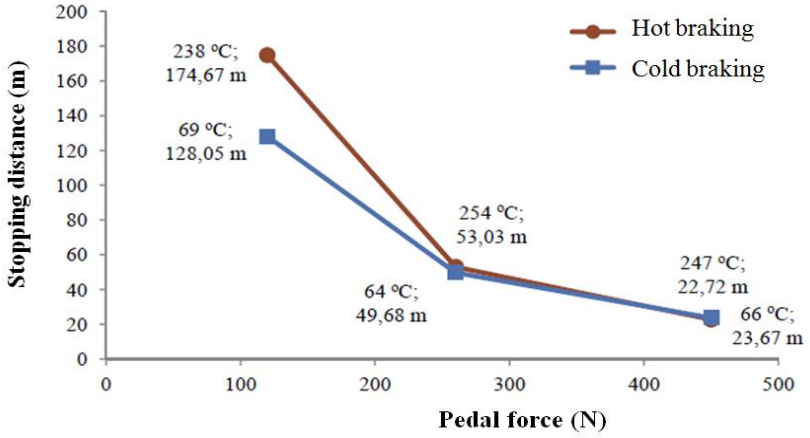

Fig. 8: The effect of brake disc temperature on Stopping distance, 60 km / h and unladen

In Figure 9, under unloaded conditions and starting with vehicle speed test 40 km/h we can examine stopping distances, we see here the similar results as the others.

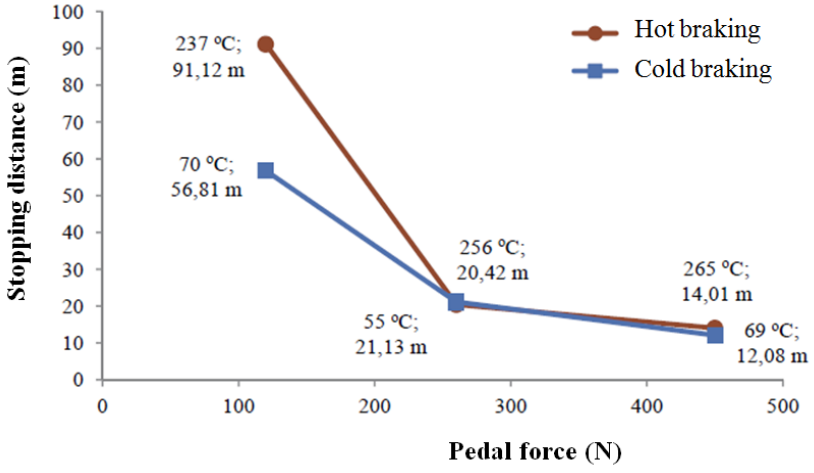

Fig. 9: The effect of brake disc temperature on Stopping distance, 40km / h and unladen

CONCLUSION

In this experimental study was conducted to investigate the effects of heated brake discs. The braking performance of the vehicle is negatively affected.

The most important reason of the loss in braking performance is increasing the temperature of the brake discs. The speed of the vehicle especially downhill, controlled by service brake (continuous brake), increase brake energy of disc/drum which is the most important factor that triggers temperature increasing. In order to prevent this, we must use a device which is absorbs a large portion of kinetic energy of the vehicle and keeps the service brakes continuously cold that slows and makes the brake ready for operation, this devise is (Retarder) that is most important solution source for this problem.

ACKNOWLEDGEMENTS

The authors would like to thank the TECH EQUIPMENTS in Kirkuk/Iraq and Eng. Salah Shokat for their corporation and continuous support with us to complete our research. Wishing them succeed and all the best.

REFERENCES

[1]. Federal Motor Vehicle Safety Standards 116, U. S. Dept. of Transportation, National Highway Traffic Safety Administration, 1991.
[2]. Salaani, M.K, Heydinger G. J, Grygier, P. A., Schwarz, C., Brown T., Heavy Truck Air Disc Brake Study Using NADS, US DOT report in progress.
[3]. Yilmaz, E.H. & Warren, W.H.: Visual control of braking: A test of the tau hypothesis, Journal of Experimental Psychology: Human Perception and Performance, 21, 1995.
[4]. Padmanaban J, Lau E: Accident experience of passenger vehicles with four-wheel antilock braking systems. Annu Proc Assoc Adv Automot Med 1996, 40:111–125.
[5]. Limpert, R., Brake design and safety: 2nd Edition, Warrendale, Pennsylvania: Society of Automotive Engineering Inc., 1999, pp. 137–144.
[6]. Komanduri, R., Hou, Z. B., Analysis of heat partition and temperature distribution in sliding systems, Wear 251 (1–12) (2001) 925–938.
[7]. Wonchai, B. 2008. Stress Analysis in Disc Brake by Finite Element Method. Proceedings of the 22th ME-NETT, Thammasat University, Patumthani, Thailand, October15-17, 2008, 65-71.
[8]. Rao, D. M. M.,Dr.Prasad,C. L. V. R. S. V., Ramakrishna, T. Experimental and Simulated Studies on Temperature Distribution For Various Disc Brakes", International journal of Research in Mechanical Engineering and Technology, 3(1), Nov-April 2013.
[9]. http://hyperphysics.phy-astr.gsu.edu/hbase/Mechanics/frictire.html.