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Short Article

Variability of Data When Testing the Handbrake Parking System *vs* The Electronic Park Brake with Three Maha Testers at Ministry of Transport Facilities

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Abstract

This research is focused on the test of the traditional handbrake parking brake *vs* the electronic parking brake (EPB) systems at Ministry of transport facilities. Different results are obtained when testing on three different roller bed testers from the Maha brand. Data variation results when braking with both systems are the same due to the MOT brake tester characteristics.

Keywords: Electronic Parking Brake; Handbrake Parking; Parking Brake; Ministry of Transport; Roller Bed Testers

Introduction

The present work is aimed to deal with the test of one of the most important parts of the vehicle, the brake system. The hand parking brake, see (Figure 1), is tested when the vehicle is driven to any Ministry of Transport (MOT) facilities. This test is performed on a bank of rollers. The procedure for the brake tests is indicated in the "MOT procedure manual" [1-2] from Ministry of Industry, Tourism and trade of Spain (2006) [3-4].The test is carried out by placing the vehicle on rollers of the brake tester at the MOT station [5-7]. The emergency brake should not be actuated. Rollers rotate around 3-5km/h of speed. The parking brake is actuated until 100% of slippage is obtained [8]. In previous researches it has been demonstrated by the authors that the brake measurements vary depending on extrinsic factors of the brake system such as: tire pressure, weight on the wheel, tire radius, tire tread, tire angles, but also characteristics of MOT brake testers such as: distance between rollers, roller diameter, and roller roughness. This is the first time that it has been studied how influences the MOT brake tester characteristics in the hand brake parking-brake measurements.

Figure (1): Hand parking brake

Furthermore, both types of parking-brake system are used for the analysis: the traditional handbrake parking system *vs* Electronic Parking Brake (EPB) in order to analyse if MOT brake tester characteristic produces the same variability on measurements in both systems.

Figure (2): Electronic Parking Brake (EPB)

Materials and Methods

When parking the car and braking with a traditional handbrake it is only needed to pull the lever up and then two cables pulled which run to rear brakes. See (Figure 1). Thus, it is added tension to these cables, and then the brake pads or shoes squeeze against the discs (or drums) to hold the rear wheels. Some cars with disc brakes have separate handbrake drum-brake shoes or even a separate disc-brake caliper for the handbrake [9,10]. On the other hand, an Electronic Parking Brake (EPB) works by pressing a switch, see (Figure 2), then, motors on each brake caliper squeeze the pads into the disc. A reassuring whirring of the motors will be heart as the button is pressed (or pulled), meaning that you know that the car is held safely, which isn't always a guarantee with a regular handbrake [9,10].

Three different Maha Mot testers were used for the experimentation [5-7]. The three testers had different characteristics, see (Table 1) and (Figures 3-5).

Table (1): MAHA MOT Brake testers used

Model	Roller Diameter	Distance Between Rollers
MAHA RS2 MBT 4000	202 mm	430 mm
MAHA IW7 MBT 7000	265 mm	475 mm
MAHA IW2 RS5	202 mm	400 mm

The rouges of the rollers surface on three MOT testers was 45µm.During all the tests the vehicle characteristics will not vary. Vehicle characteristic specially controlled to be the same during experiments will be: The tyre pressure, weight on wheel and effective radius. Previous studies of the authors have demonstrated that these parameters can vary the brake measurements at Mot stations. Therefore, if there are variations of data between tests it will be due to: separation of the rollers, roller diameter, adhesion of the wheels on the rollers and the rolling resistance.

Brake force values are measured by sensor and during the tests. The imbalance between the left and right brake forces of rear axle is also calculated by the MOT tester software, as well as the service brake efficiency of the parking brake. To calculate the efficiency of the parking brake of the vehicle the weight has to be obtained with a sensor. Previous

studies carried out by the authors established that brake force data obtained with different MOT testers are different. But this is the first time that a comparative analysis of parking brake data measured on MOT brake tester is done.

Experimentation

The measurements obtained from all tests were the "Parking brake force" measured from each rear wheel and the total efficiency [6,7,11]. Thus, a comparative analysis of the parking braking measurements was done for the same test carried out with three different Maha MOT testers, to see differences. The three brake testers have different characteristics such as: distance between rollers, roller diameter, but the same roller roughness. The important point is that all MOT parking brake testers have the same rejection threshold established by the MOT directive the directive 96/96 CEE [11], this is the minimum efficiency for all MOT brake testers that is 16%.

The minimum efficiency or rejection threshold

As stated in and the manual of MOT inspection of vehicles the minimum efficiency to pass the MOT parking brake test is 16% for vehicles [11].

The efficiency is:

$$E = \frac{F_{total}}{m * g} 100 \qquad (1)$$

Where:
E% of efficiency, Minimum to pass the test =16%
m: Maximum permissible vehicle mass in kg, it is:
For the Audi A3= 1340kg of vehicle weight + 75 kg of driver=1.415 kg.
For the Volkswagen= 1452kg of vehicle weight + 75 kg of driver=1527kg.
60% of weight is in the front axle and 40% on the rear axle [10,12-14]
F_{total}: Sum of parking braking forces of both wheels of the rear axle (the parking system only actuate in the rear axle).
G: Gravity acceleration.
The minimum brake force on each front wheel to pass the test has to be:
On rear wheels:

$$F_{total}=E\%*(m*g*0,4/2)/100= \qquad (2)$$

Testing a vehicle with handbrake parking system

To see if this variability could be due to the type of parking brake, it has been measured parking brake data of other vehicle, an AUDI A3, with 225/45 R17 V 91 tyres, with the traditional parking brake system. This is a hand brake or emergency brake, also called e-brake, this is a latching brake that keep the vehicle stationary or even to prevent a vehicle from rolling. This is an automobile hand brakes, and it has a cable directly connected to the brake mechanism that is actuated by a lever that driver can pull handle. Therefore this mechanism is hand-operated. It is placed on the floor on right side of the driver. Parking brake measures were also obtained with the same three MOT testers, see figure below:

Figure (3): IW2 RS2 MBT 4000 MAHA

Figure (4): MAHA IW7 Series MBT 7000

Figure (5): IW2 RS5

In this case the minimum brake force on each front wheel to pass the test, for a vehicle has to be:

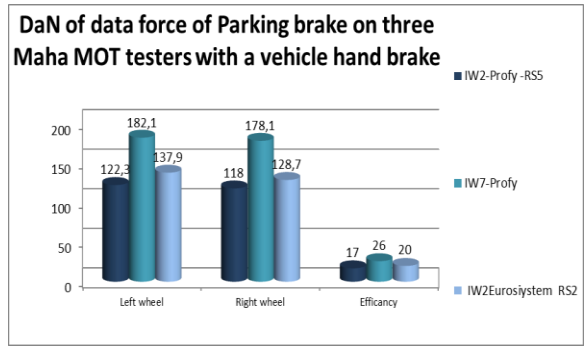
On rear wheels:

m= [1340kg (mass of vehicle) + 75kg (Driver weight)]*0.4 (mas on the rear axle) =566 kg (3)

F_{total}=E%*m*g/100=16*(566kgrearaxle/2)/100= 45,28 DaN (4)

In the following figure it can be seen different results of Parking brake data on three Maha MOT testers with an Audi A3 vehicle hand brake.

Figure (6): DaN of Parking brake data force on three Maha MOT testers with a vehicle hand brake



As it happened in the previous study, higher Parking brake data measured were provided by Maha IW7 MBT 7000 tester. Differences of Brake measurements at MOT-brake testers are 32,8% for left wheel and 33,7 for right wheel. All tyres had 2.2 bar tyre pressure. The difference between the highest value (182,1 daN) and the lowest value (118daN) were 35,2%.

Testing a vehicle with ESP

During the test the vehicle used was a Volkswagen Passat equipped with advanced Electronic Stabilization Program (ESP) that detects critical situations and acts fast to stop skidding before it begins, see (Figures 3-5). And also with anti-lock braking system (ABS) that stops wheels locking. All experiments were carried out with the same type: Hankook Ventus V12 evo2, 235/45ZR17 97Y and also with the same tyre pressure in the 4 tyres. In previous researches, the braking required to stop the wheel varied when the tyre pressure varied. Therefore, it was checked that tyres pressure was the same during all experiments [6-7].

Parking brake measures were also obtained with the same three MOT testers, see figure below:

In this case the minimum brake force on each front wheel to pass the test, for a vehicle has to be:

Figure (7): RS2 MBT 4000 MAHA

Figure (8): MAHA IW7 Series MBT 7000

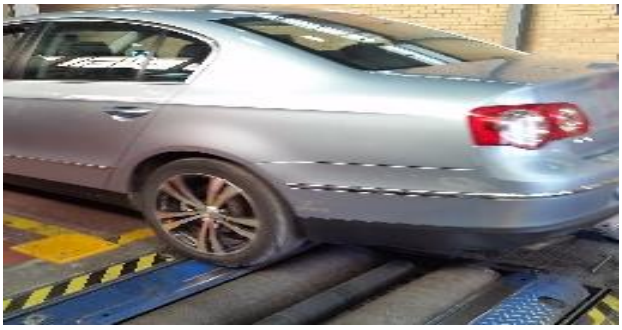


Figure (9): IW2 RS5

On rear wheels:

m= [1527kg (mass of vehicle) + 75kg (driver weigh)] * 0.4 (mas on the rear axle) = 610,8 kg (5)

F_{total}=E%*m*g/100=16*(610,8kgrear-axle/2)/100 = 48,86 daN (6)

Tests have been performed using the three Maha roller bed MOT brake testers, see (Figures 3-5), with different roller diameter and different distance between rollers. The influence of Mot characteristic has been analyzed in parking brake data obtained. In this first case, using a Volkswagen Passat, it was measured daN of force for each tire on three Maha MOT testers. Results can be seen in the following Figure: Higher Parking brake data measured were provided by Maha IW7 MBT 7000 tester.

Differences of Brake measurements at MOT-brake testers are 21,7% for left wheel and 20,8 for right wheel. All tires had 1.7 bar tire pressure.

The difference between the highest value (168 daN) and the lowest value (119 daN) were 29,2%.

Figure (10): DaN of EPB parking bake data on three Maha testers

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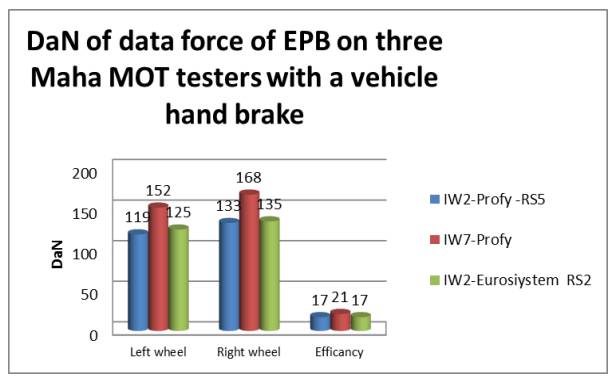
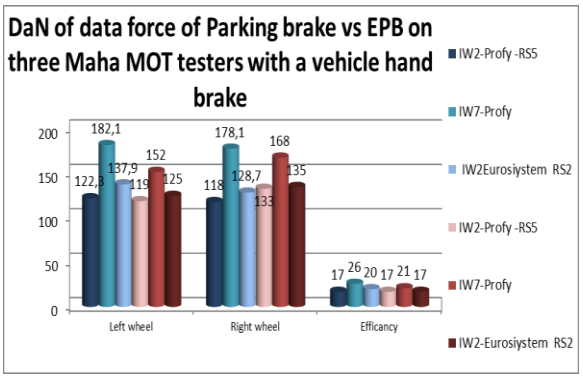


Figure (11): DaN of parking bake data *vs* EPB on three Maha testers.



Conclusions

Comparing data obtained from both experiments: firstly it can be said that the same tendency of results has happened in both experiments.Better results in both experiments the brake tester Maha IW7, secondly with the tester IW2-RS2 and finally with IW2-RS5. Sequel we order the testers according to the results obtained:

1. MAHA IW7 Series MBT 7000

   Roller diameter 265 mm

   Distance between rollers: 475 mm

2. MAHA IW2 RS2

   Roller diameter 202 mm

   Distance between rollers: 430 mm

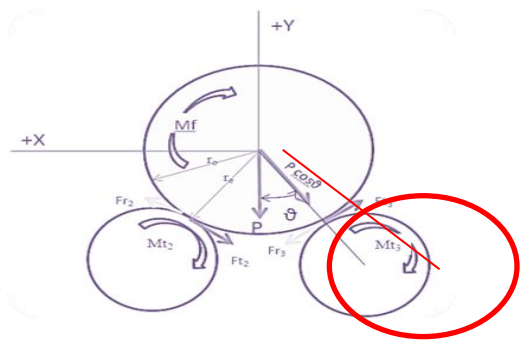
3. MAHA RS5 MBT 4000

   Roller diameter 202 mm

   Distance between rollers: 400 mm

It can be seen that better results are obtained when the roller diameter and the distance between rollers are higher. Best results are obtained with MAHA IW7 Series MBT 7000 because it has the bigger roller diameter and bigger distance between rollers. Although, there are two MOT brake testers with the same roller diameter, 202mm, the first one, RS5 MBT 4000, has 400 mm of distance between rollers and the second one, IW2 RS2, 430mm, and higher parking brake data are obtained with the second one. In other words, it could be said, that the Audi A3 vehicle will have 33% less probability to pass the parking brake test on a Maha IW2 RS5 MOT brake tester and 24% less probability to pass the exam on a Maha IW2 RS2 MOT brake tester, compared with the MAHA IW7. To understand this phenomenon, the influence of roller diameter and distance between rollers should be studied. We should start by paying attention to the mathematical demonstration of equation 4 about (figure 12).

Figure (12): Mathematical demonstration



$$\Sigma M = Mt - Mf - Mr = I\alpha \quad (7)$$

When:

ΣM= Summations of torques

Mf = Braking torque applied to the vehicle wheel

Mt= Tractor torque of rollers. Mt is constant

Mr= friction torque

I= Inertia

α= acceleration

Because there is not acceleration during the tests:

$\Sigma M = Mf - Mt = 0$

And then:

$$Mf = 2Ft * r_r - 2\mu P\cos\vartheta\, re \quad (8)$$

When:

r_e= Effective radius of the wheel on rollers

$r_r = r_2 = r_3$= radius of rollers.

$F_2 = F_3$ = Roller tractor force,

F_r= Frictional force, $Fr_2 = Fr_3$

μ = Rouges of rollers

P = Weight on the wheel

Cos θ = Angle between the symmetry axis and the line between wheel-roller centers. If, θ angle= arcsine ((distance between rollers/2)/(radius of tyre + radius of roller))

Analyzing the equation 6 it can be concluded that increasing distance between rollers the angle ϑ increases and $\cos\vartheta$ decreases then the value of Mf increases. Moreover, if the distance between rollers is higher the wheel will be in a lower position and 100% of slippage of wheel between rollers will be produced earlier. The same happens when the diameter of rollers increases. A bigger roller diameter provides a bigger contact surface between the tyre and the roller. Then, the slippage of the wheel on the roller will be lower, and the MOT brake tester will be able to measure higher values of brake torque from the wheel. In this experiment all rollers had the same roughness. In previous researches, the same conclusions where obtained by the authors when studying the variability of data when testing the brake system (when braking with the pedal) [15].

In conclusion, when the vehicle is tested at MOT stations, it is only need to know if vehicle parking brakes are in good condition or not, but the fact is that parking brake test is influenced by the MOT brake tester characteristics. In other words, if you see the graphics provided it can be concluded that different parking brake results can be obtained depending on the characteristic of the MOT tester used due to the variation of distance between rollers and roller diameter. Finally, it can be said that a car could pass or not the parking brake test due to the brake tester used. Therefore, with this knowledge, drivers could choose the MOT brake tester that offer higher probability to pass the brake exam. But on the other hand, some vehicles with the brake system in poor conditions could pass the parking MOT test just choosing a tester that offer higher probability to pass the exam.

It is concluded that to minimize the variability of parking brake measurements at any MOT station:

1. It would be better to use other type of brake tester verification system without any dragging of wheels the slippage between rollers and wheels would disappear.

2. It would be better that all MOT stations should have the same characteristics.

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