A STUDY OF PRESSURES IN PNEUMATIC TYRE INFLUENCE ON VEHICLES BRAKING DECELERATION

ИЗСЛЕДВАНЕ НА ВЛИЯНИЕТО НА НАЛЯГАНЕТО В ПНЕВМАТИЧНИТЕ ГУМИ ВЪРХУ СПИРАЧНОТО ЗАКЪСНЕНИЕ НА АВТОМОБИЛИ

Eng. Kadikyanov G.P., PhD[1], Eng. Lyubenov D.L., PhD[2], Assoc. Prof. Evtimov I. I., PhD[1], Eng. Ivanov Y.I.[1]

1. Department of Engines & Transport Engineering, Faculty of Transport – University of Ruse, Bulgaria,

e-mail: gkadikyanov@uni-ruse.bg

2. Department of Transport, Faculty of Transport – University of Ruse, Bulgaria, e-mail: dliubenov@uni-ruse.bg

Abstract: *In this article has been considered the influence of various pressures in pneumatic tires of passenger cars with anti-lock braking system and without it on chosen parameter of braking process - braking deceleration. The experiments under snow road conditions are carried out. Used tires for the experiments are for winter conditions.*

Keywords: PRESSURES IN PNEUMATIC TYRE, BRAKING DECELERATION, SNOW ROAD CONDITIONS.

1. Introduction

Maintaining correct inflation pressure in tires helps to keep vehicle handling and braking at its best, as well as improving fuel efficiency and tyre life. In addition it can prevent such events as tread separations and tyre blowouts which may cause loss of control of a vehicle and severe crashes such as rollovers.

Under-inflated tires can potentially result in:

- reduced vehicle handling;
- increased braking distance;
- increased likelihood of blowouts;
- increased tyre wear;
- increased fuel consumption.

Tyre pressure affects the handling of a vehicle particularly during an emergency maneuver. For loss of control crashes, inappropriate speed is usually the most critical factor. Excessive speed alone can cause a loss of control in a curve or in a lane change maneuver. Tread depth, inflation pressure of the tires, and road surface condition are the most notable of a long list of factors including vehicle steering characteristics and tyre cornering capabilities that affect the vehicle/tyre interface with the road [3, 4, 5, 6, 8].

Tires are designed to maximize their performance capabilities at a specific inflation pressure [1, 2]. The relationship of tyre inflation to stopping distance is influenced by the road conditions (wet versus dry), as well as by the road surface composition. Decreasing stopping distance is beneficial in several ways. First, some crashes can be completely avoided. Second, some crashes will still occur, but they occur at a lower impact speed and so reduce the severity of the crash and the injuries suffered.

In winter conditions deceleration decreased twice, and in some cases even more [6, 7]. It often happens that the roads are covered with snow trampled during the braking process of cars to be carried out on it.

The aim of this article is to establish the influence of tire pressure on deceleration when braking on asphalt covered with trampled snow.

2. Experimental procedure and equipment

A study of the pressure in tires influence on vehicles deceleration VBOX 3i Data Logger and IMU02 (fig. 1), of a Racelogic Ltd UK company are carried out [9]. VBOX 3i is highly valued test instruments for non-contact speed and distance measurement. It has a very powerful processor ensuring low latency with updates of speed, position and acceleration, 100 times a second. All data is logged to a compact flash card [10].

Fig. 1. *Acceleration sensors IMU02 (1) and VBOX 3i 100Hz GPS Data Logger (2)*

The IMU02/YAW03 channel data will be recorded along with the existing GPS data in VBOX 3i 100Hz GPS Data Logger on the SD card. Accuracy of acceleration measurement is 0,5% [9].

The IMU02 from Racelogic is a full Inertial Measurement Unit that can measure Z, Y and X axis rotational rate (yaw, pitch and roll) as well as X, Y and Z axis acceleration. For this study a lateral accelerations (X axis) are used.

The IMU02 is mounted as close as possible to the centre of the vehicle. It is also important to mount the sensor so that it is level with the ground.

Method of the study involves a series of tests to determine the cars deceleration (tire–road coefficient of friction) and tire pressure influence on this deceleration for covered with trampled snow during emergency braking.

Fig. 2. *ABS off*

The studies were conducted by Ford Focus, Citroen Xsara Picasso and Opel Astra with recording equipment VBOX 3i Data Logger and IMU02 (fig. 1)., tests were cared out with ABS and ABS off (fig. 2)

Fig. 3. *Winter conditions*

Tests were conducted with three different cars with tires for winter conditions (fig. 3). The description of tires for various cars is shown in Table 1.

Table 1
Description of tires for various cars

Car	Dimensions of tires	Dot tires	Type of tires	Tire's company
Ford Focus	195/65 R15	4112	winter conditions	Hankook
Citroen Xsara Picasso	195/60 R15	4011	winter conditions	Michelin
Opel Astra	195/70 R14	3808	winter conditions	Continental

During measurement the vehicle was loaded with two adult sitting on the front seats and one on rear (the driver and two passengers). The cars were tested at about 50 km/h initial speed measured by the speedometer of the car (speed is more precisely defined by the system of data collection VBOX 3i Data Logger). In every case, when the desired speed was reached, sudden braking was realized by the service brake (wheels of cars without ABS were locked during braking), the brake pedal was held pressed down till the car full stop. Every measurement was repeated three times in driving in the opposite direction.

Proper-inflated tire pressure is selected the recommended pressure written on plates of cars, namely 0,22MPa. There is no universal definition of what constitutes an "under-inflated tyre". The US Federal Motor Vehicle Safety Standard 138 requires a warning if tires are under-inflated by more than 25% [8]. Therefore, in under-inflated pressure is selected 0,15MPa.

3. Results and Discussion

The results of the study were obtained with VBOX Tools Software. The VBOX Tools software is a very powerful software analysis package. VBOX Tools has been designed to easy to setup and use, yet very flexible allowing many custom styles of test to be performed, as well as providing templates of common test setups. Processing mode, a ".vbo" file were taken from a compact flash card and loaded into the software, allowing graphing, analyzing and replaying the data.

The results are processing and presented determining of the maximum car deceleration (fig. 4). Average deceleration reported data after the increase in the values and their establishment to start reducing deceleration.

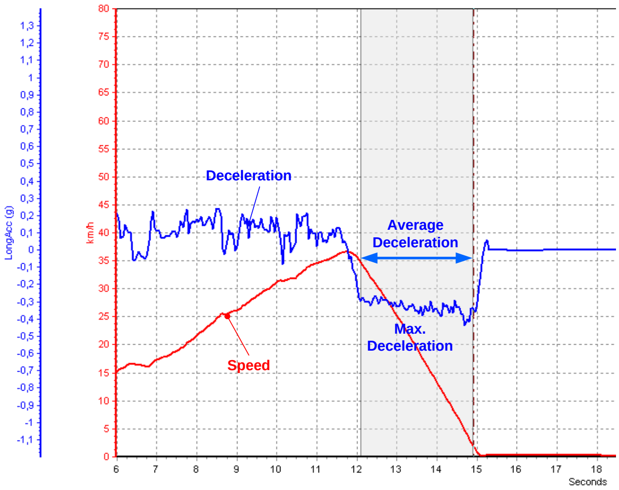

Fig. 4. *VBOX Tools Software chard*

The Report Generator is the main "numbers engine" in the VBOX Tools software, and is designed to create a highly configurable table of results (fig. 5).

Channel	Start	End Value	Difference	(Max-b)	(Min-b)	Average
Time (Time)	12,120	14,920	2,800	------	------	------
Speed (km/h)	34,480	1,810	-32,670	35,169	1,810	19,308
Distance (metres)	50,979	66,275	15,295	------	------	------
LongAcc (g)	-0,288	-0,347	-0,059	-0,266	-0,439	-0,329

Fig. 5. *VBOX Tools software table of results*

The columns of the table can contain any parameter logged by the VBOX, and may also shows maximums, minimums, and averages. The scale and offset of any channel is also configurable [11].

To evaluate the dissipation of the values of each test the coefficient of variation is used. It is calculated by the following equation:

$$V = \frac{S}{\overline{x}} 100, \% \qquad (1)$$

$$S = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \overline{x})^2}{n}} \qquad (2)$$

Considering that the coefficient of variation V for all series of tests was in the range of (3 – 8)% that the scattering of the results obtained is not significant.

The figure 6 shows average values of maximum deceleration in depending on pressure in tires and ABS on or ABS off in winter conditions on trampled snow for Ford Focus.

The biggest average deceleration was registered for braking with the nominal level of the pressure in tires (0,22MPa) of the vehicle, irrespective of whether ABS is on (about 2,84 m/s^2 for braking with ABS and about 3,02 m/s^2 when ABS is off). Braking with other pressure than nominal one (0,15MPa), according to processing (fig. 6) shows that the deceleration for ABS and ABS off are respectively 2,55 m/s^2 and 2,72 m/s^2.

Comparing the under-inflated (0,15MPa) tyre deceleration with proper-inflated (0,22MPa) tyre deceleration for Ford Focus (fig. 6) follows: for braking with ABS – 11,37% decrease; for braking with ABS off – 11,03% decrease.

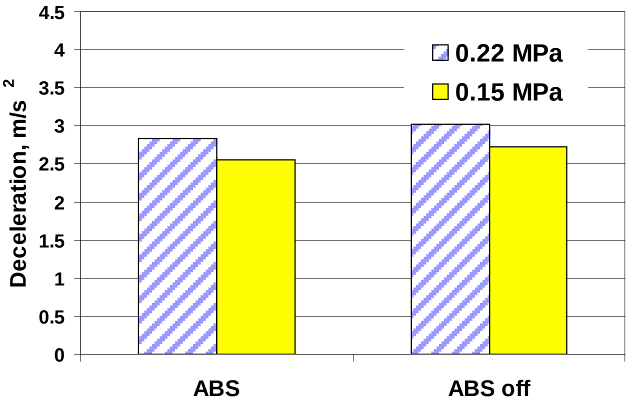

Fig. 6. Average longitudinal deceleration for Ford Focus terms of pressure in tires

The figure 7 shows average values of maximum deceleration in depending on pressure in tires and ABS on or ABS off in winter conditions on trampled snow for Citroen Xsara Picasso.

The biggest average deceleration was registered for braking with the nominal level of the pressure in tyres (0,22MPa) of the vehicle, irrespective of whether ABS is on (about 3,04 m/s^2 for braking with ABS and about 3,27 m/s^2 when ABS is off). Braking with other pressure than nominal one (0,15MPa), according to processing (fig. 7) shows that the deceleration for ABS and ABS off are respectively 2,81 m/s^2 and 3,07 m/s^2.

Comparing the under-inflated (0,15MPa) tyre deceleration with proper-inflated (0,22MPa) tyre deceleration for Citroen Xsara Picasso (fig. 7) follows: for braking with ABS – 8,18% decrease; for braking with ABS off – 6,51% decrease.

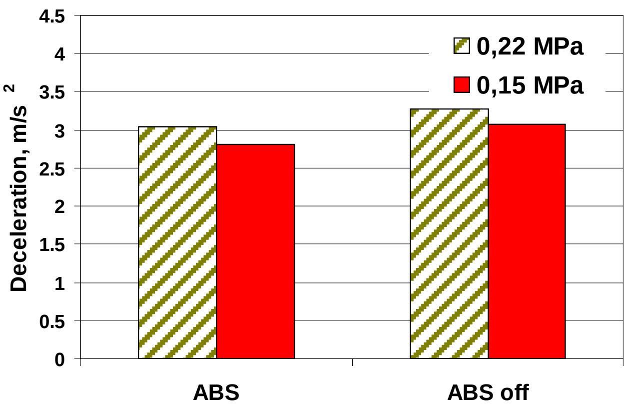

Fig. 7. Average longitudinal deceleration for Citroen Xsara Picasso terms of pressure in tires

The figure 8 shows average values of maximum deceleration in depending on pressure in tires in winter conditions on trampled snow for Opel Astra.The car has no factory ABS.

The biggest average deceleration was registered for braking with the nominal level of the pressure in tires (0,22MPa) of the vehicle (about 2,43 m/s^2 without ABS). Braking with other pressure than nominal one (0,15MPa), according to processing (fig. 8) shows that the deceleration is respectively 2,23 m/s^2.

Comparing the under-inflated (0,15MPa) tyre deceleration with proper-inflated (0,22MPa) tyre deceleration for Opel Astra (fig. 8) follows 8,97% decrease.

Opel Astra car is fitted with tires produced more years ago. It is no equipped with the factory ABS. The results of the comparison of the two decelerations in the other vehicle equipped with a newer tire indicate that the deceleration in the Opel Astra is lower than with (20-35)%.

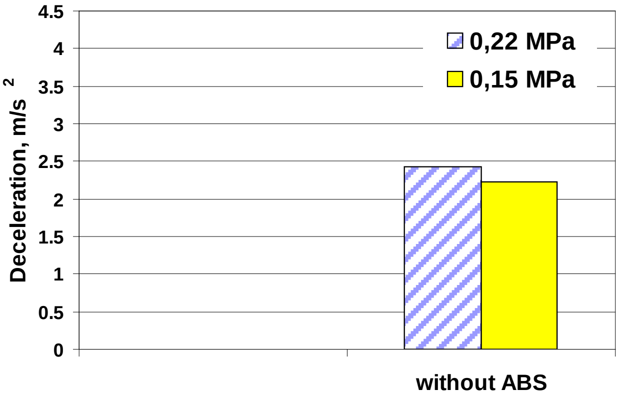

Fig. 8. Average longitudinal deceleration for Opel Astra terms of pressure in tires

The results of this study indicate that the longitudinal deceleration influence of the pressure in tires of these cars is greatest for proper-inflated tires. It is in the range of from 6,51 % to 11,37%. For trampled snow-covered surface for two cars ABS off longitudinal deceleration is greater. The results indicate that further research is needed to determine the ABS longitudinal deceleration influence for snow-covered surface.

Lower values of the deceleration when tires are under-inflated probably due, the shape of the tyre's footprint and the pressure it exerts on the road surface are both altered (fig. 9). This degrades the tyre's ability to transmit braking force to the road surface.

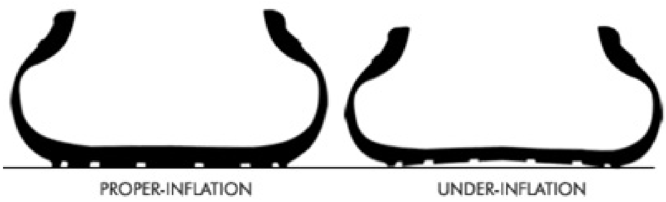

Fig. 9. The reduced pressure tyre exerts on the road surface when tires are under-inflated

4. Conclusion

On the basis of investigation results observed that:

- For Ford Focus the under-inflated (0,15MPa) tyre deceleration with ABS - 11,37% decrease, with ABS off – 11,03% decrease, to proper-inflated (0,22MPa) tyre deceleration.

- For Citroen Xsara Picasso the under-inflated (0,15MPa) tyre deceleration with ABS – 8,18% decrease, with ABS off – 6,51% decrease, to proper-inflated (0,22MPa) tyre deceleration.

- For Opel Astra the under-inflated (0,15MPa) tyre deceleration – 8,97% decrease, to proper-inflated (0,22MPa) tyre deceleration.

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Contacts:

Georgi Kadikyanov, Department Engines & Transport Engineering – University of Rousse, 8 Studentska Str., 7017 Ruse, Bulgaria. E-mail: gkadikyanov@uni-ruse.bg

Daniel Lyubenov, Department of Transport – University of Ruse, 8 Studentska Str., 7017 Ruse, Bulgaria. E-mail: dliubenov@uni-ruse.bg