Influence of the different brands of braking pads in performance of vehicle braking system

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Abstract: *In the Republic of Kosovo, the unemployment rate has an increasing trend, the average monthly income is still low, which makes it impossible to buy a new vehicle, so they are forced to buy vehicles imported from European countries, which have a high rate of amortization.*

Citizens who own used vehicles are obliged to perform services that cost less by avoiding quality equipment and replacing them with non-know manufactures for spare parts which cost cheaper compared to manufacturers of well-known and guaranteed brands. The use of such spare parts is directly affecting the increase in the number of accidents in the territory of the Republic of Kosovo.

In this paper is study the efficiency of brake pads from different manufacturers – brands in the term of the braking system in passenger vehicles such as: braking time, maximum deceleration and braking distance. The tests were done with used vehicles equipped with the ABS system, on roads with dry asphalt. The used tires are from radial construction with summer characteristics. Depending on the treated methodology, the adequate equipment such as Xl meter, video cameras and meter are used. The obtained results through the decelerometer device (Xl meter) for deceleration of the vehicle and other indicators of the efficiency of the braking system has done with the case of emergency braking. Prior to each test, the predicted used vehicle has performed also technical inspection of the vehicle braking system in the Licensed Centers for technical inspection of the vehicle.

Keywords: DISK BRAKE, BRAKE PADS, ROAD, TIRES, FRICTION, DECELERATION, BRAKING DISTANCE, VEHICLES.

1. Introduction

Most of the vehicles circulating in the territory of the Republic of Kosovo are used and imported from various European countries. Statistics that are public on the official website of the Police of the Republic of Kosovo show that the number of accidents with material damage and fatalities is increasing from year to year.

The vehicle's braking system is one of the main elements of active vehicle safety. Citizens lack awareness of the role of the braking system and the consequences in the event of its failure. The actuating elements of the brake system, such as brake discs and brake pads have a certain service life and should be replaced with new ones.

In the Republic of Kosovo, the unemployment rate has a growing trend, the average monthly income is still low, drivers provide the necessary services in unauthorized workshops and at the same time supply parts - equipment of dubious origin and unverified or certified that do not provide information on their composition and effectiveness.

If even regular services are applied, they are made in cheaper forms, and then cheap parts-equipment are applied. These devices can also be used, dismantled by a wrecked vehicle or waste, or they can be a new second or third class, but from manufacturers who are cheaper and more present in the market.

There are different types of brake pads, the friction layer is treated with a combination of different materials that are bonded to the metal plate. Usually, three main categories of materials are used for the friction layer: semi-metallic, organic and ceramic. Each material has its advantages and disadvantages with respect to the driver rating.

Different materials are combined for maximum possible vehicle braking efficiency. Brake pads and disks can be found in car shops, garages and other places that can be ordered online.

The aim of the research is the influence of different brand of brake pads such us SCT, BREMBO, COMELINE, TEXTAR and brake disc from brands FEBI on the performance of the brake system.

2. Motion Equations that Describe Vehicle Braking Process

Depending on how braking force is transmitted to tires, the vehicle braking system may be:

- Mechanic,
- Hydraulic, and
- Pneumatic.

The hydraulic and the pneumatic systems are the most used ones. In these systems, the pressure is proportional to the force of the brake pedal. The moment of braking is proportional to the pressure of the braking system, which mathematically can be expressed as follows [1-4]:

$$M_b = K_p \cdot p_b \tag{1}$$

The proportional coefficient K_b is a function of a large number of factors. However, the value of this coefficient can be considered constant in passenger cars.

The moment of braking by the force Fb which acts on the contact surface of the tire with the road, is:

$$F_b = \frac{M_b}{r_d} \tag{2}$$

The braking force F_b can be increased up to the value of the tangential reaction of the path, i.e., until it does not reach its maximum value for given conditions; the value of the force of adhesion is:

$$F_{bmax} = \varphi_x \cdot G \tag{3}$$

When moving on dry paved or concrete roads, modern passenger cars' braking systems can realize moments (braking forces) that are significantly greater than the frictional force. As a result, the wheels are often stuck and slip on the road during rapid braking. Fig. 1 shows the most important forces that act on the vehicle during vehicle braking.

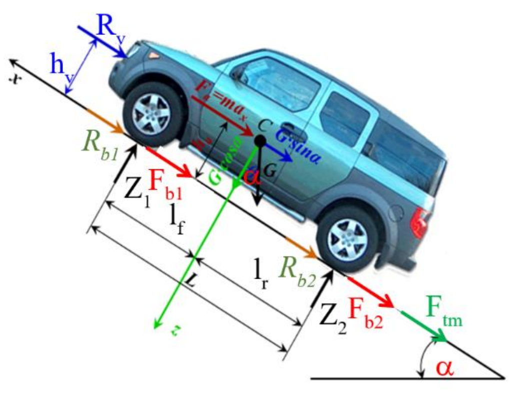


Fig. 1. Forces that act on vehicles

The horizontal components in relation to the road plane are [1-2, 5]:

$$F_{b1} + F_{b2} + R_{b1} + R_{b2} + R_{\alpha} + R_{v} + F_{tm} + F_{xx} - R_{a} = 0 \quad (4)$$

$$F_{b} + R_{\psi} + F_{tm} + F_{xx} + R_{v} - R_{a} = 0 \quad (5)$$

If engine is disconnected, braking is carried out only by the braking system, thus allowing the cancellation of the traction force on the wheels or $F_{tm} = 0$. Since the drag resistance effect is minimal when the speed of motion braking process is reduced, the drag resistance's overall impact can be discounted, resulting in $R_v = 0$. The magnitude of the friction force of F_{xx} transmitters compared to the overall braking force is also quite small or negligible allowing for
$F_{xx} = 0$ [1-5]. After considering the assumptions made above, equation (5) can be written as:

$$F_{b} + R_{\psi} - R_{a} = 0 \quad (6)$$

$$\varphi_x \cdot G + \psi \cdot G - \delta \cdot G \cdot \frac{a}{g} = 0 \quad (7)$$

From equation (7), the maximum deceleration can be calculated, which is:

$$a_{max} = \frac{g}{\delta} \cdot \left(\varphi_x + f\right) \quad (8)$$

It is considered that: $\delta = 1$ and $g = 9.81$ [m/s^2] which is significantly greater than the roll friction coefficient. Therefore, it can be concluded that the highest or maximum value of deceleration that can be realized with all-wheel braking would be:

$$a_{max} = 9.81 \cdot \varphi_x \quad (9)$$

3. Methodology of Measurement of the Braking performances with the "XL METER"

The place where the tests were performed is located in the outskirts of the city of Pristina, ie in the village of Shkabaj, the road leading to the facility where the fairs are held. At this point the road is at a sufficient distance to perform tests. The part of the road used for the tests has a length of 500 meters (Fig. 2), a width of 7 meters and a longitudinal slope <1%. The condition of the road is new asphalt.

Fig. 2. Orthophoto of the location and space where the tests were performed

XL Meter ™ Gamma Pro is designed to measure acceleration/deceleration in two axes (longitudinal and transverse). The main purpose of the XL Meter device is to make the evaluation of the braking system performance as easy and accurate as possible. The rules for measuring braking efficiency are described in ECE regulation R13. According to this regulation, "The efficiency of the braking system is determined by the braking distance or the average deceleration during braking".

Then, the braking distance (S_f) is calculated from the double integration of the acceleration data in the braking interval. The Successful evaluation gives the following results:

– distance in the time of braking T_{br} (S_f [m]),
– initial vehicle speed at the time of braking (V_0 [km/h]),
– time from the start till the end of braking (T_{br} [s]), and
– averaged maximal vehicle deceleration (MFDD [m/s^2]).

The deceleration (MFDD = a_2) is calculated as the average deceleration of the vehicle motion distance in the range from speed V_b to speed V_e according to the following formula:

$$MFDD = \frac{V_b^2 - V_e^2}{25.92 \cdot \left(S_e - S_b\right)} \quad (12)$$

According to ECE R13 regulation, the vehicle's deceleration accuracy with XL Meter during braking should be within the range ± 3%. For the testing of any vehicle, the braking performance should be measured during vehicle braking under the conditions specified in ECE Regulation R13 [12].

In Figure 3 are presented equipment for measuring vehicle braking performance: a) process of controlling the quality of the brake fluid before performing the vehicle braking tests; b) tire tread depth gauge; c) XL meter device fixed in front vehicle windshield; d) smartphone camera for recording vehicle speed in vehicle odometer fixed to the steering wheel; e) brake pedal force gauge – dynamometer; f) tyre pressure gauge – manometer; g) strip meter; h) Golf IV dashboard; i) measurement of the braking distance by strip meter.

Braking distance is the distance from the point of braking up to the front end of the front-wheel tires.

a)

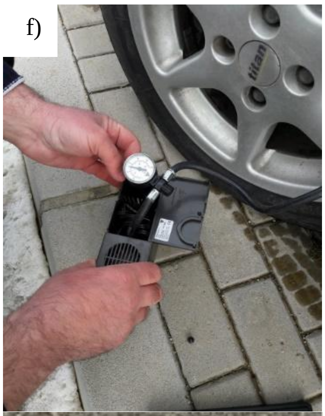
b)

c)

d)

e)

f)



g)

h)

i)

Fig. 3. Equipment for measuring vehicle braking performance [3]

4. Measuring results from test drive

Type of the vehicle used to test braking performance [3] has been Golf IV, 1998 model year, breaking system with ABS, and test drives have been performed in the testing polygon (Fig. 2). The evaluation of the braking performance has been carried out with an XL Meter device.

New brake discs of the Febi brand are installed in the car, which have not been replaced, while brake pads have been replaced with new ones, after each test (Fig. 4). The following brands are used for this work: SCT, BREMBO, COMELINE, TEXTAR [3].

The tire brand is FULDA, with size 205/55 R16 for summer season. The asphalt is dry and new.

Fig. 4. Installation of new brake discs Febi brand and new brake pads at the Golf IV

4.1. Test drive with new brake pads brand SCT

In Fig. 5 are presented the new brake discs brand FEBI and brake pads brand SCT: a) braking discs for front axles brand FEBI; b) braking discs for rear axles brand FEBI; c) front axle brake pads brand SCT and d) rear axle brake pads brand SCT.

a) b) c) d)

Fig. 5. New brake discs brand FEBI and brake pads brand SCT

During the test drives, the following parameters have been maintained: air temperature 26 °C and dry asphalt. Tires characteristics have been as follows: tire brand Fulda for summer season, size 205/55 R16. Vehicle with brake disks FEBI brand and brake pads brand SCT.

The results of the test as illustrated in Figure 6 indicate that:

- initial vehicle speed at the time of braking: $V_0 = 78.4$ [km/h],
- time from the start till the end of braking: $T_{br} = 2.52$ [s],
- distance in the time of braking: $S_f = 29.1$ [m] and
- averaged maximal vehicle deceleration: MFDD = 8.78 [m/s^2].

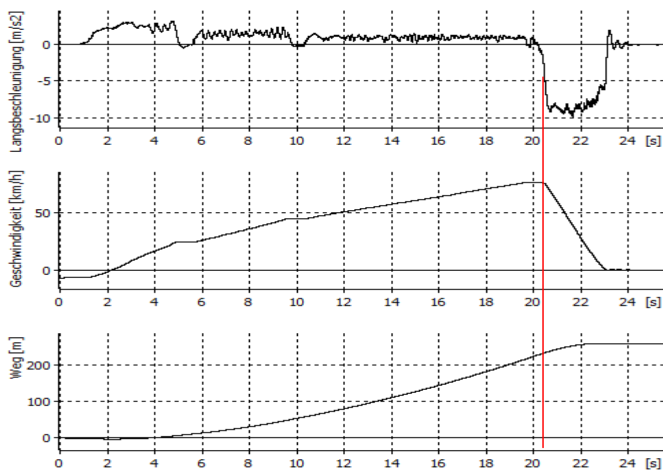


Fig. 6. Diagrams of measured braking performance performed with XL Meter for the "Golf IV" with brake pads brand SCT at initial vehicle speed at the time of braking $V_0 = 78.4$ [km/h]

4.2. Test drive with new brake pads brand BREMBO

During this test drives, is used new brand of brake pads BREMBO (Fig. 7) and the following parameters have been maintained: air temperature 28 °C, dry asphalt. Tires characteristics have been as follows: tire brand Fulda for summer season, size 205/55 R16. Vehicle Golf IV with new break disks FEBI brand and brake pads brand BREMBO.

Fig. 7. Installation of new brake pads brand BREMBO in the Golf IV

The results of the test as illustrated in Figure 8 indicate that:

- initial vehicle speed at the time of braking: $V_0 = 81$ [km/h],
- time from the start till the end of braking: $T_{br} = 2.93$ [s],
- distance in the time of braking: $S_f = 31.82$ [m] and
- averaged maximal vehicle deceleration: MFDD = 8.35 [m/s^2].

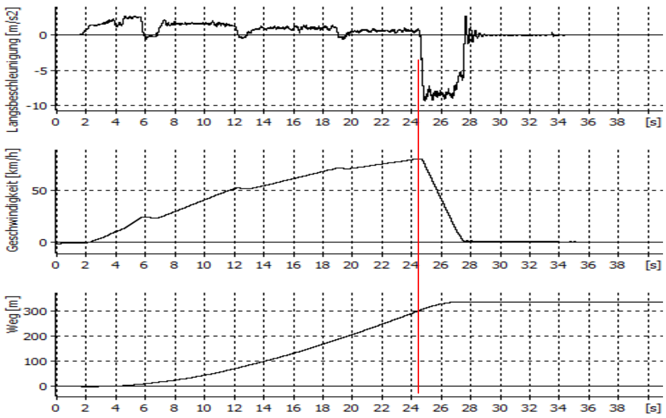


Fig. 8. Diagrams of measured braking performances performed with XL Meter for the "Golf IV" with brake pads brand BREMBO at initial vehicle speed at the time of braking V_0 = 81 [km/h]

4.3. Test drive with new brake pads brand COMELINE

During this test drives, is used new brand of brake pads BREMBO (Fig. 9) and the following parameters have been maintained: air temperature 28 °C, dry asphalt. Tires characteristics have been as follows: tire brand Fulda for summer season, size 205/55 R16. Vehicle Golf IV with break disks FEBI brand and new brake pads brand COMELINE.

Fig. 9. Installation of new brake pads brand COMELINE in the Golf IV

The results of the test as illustrated in Figure 10 indicate that the:

- initial vehicle speed at the time of braking: V_0 = 82 [km/h],
- time from the start till the end of braking: T_{br} = 3 [s],
- distance in the time of braking: S_f = 29.8 [m] and
- averaged maximal vehicle deceleration: MFDD = 8.67 [m/s^2].

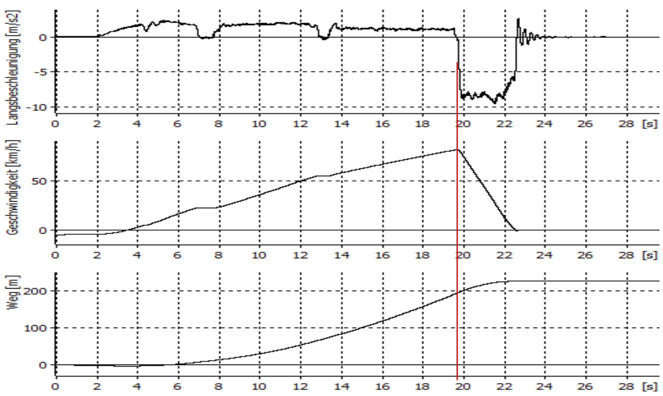


Fig. 10. Measured diagrams of braking performances performed with XL Meter in the "Golf IV" with brake pads brand COMELINE *at initial vehicle speed at the time of braking V_0=82 [km/h]*

4.4. Test drive with new brake pads brand TEXTAR

During this test drives, is used new brand of brake pads TEXTAR (Fig. 11) and the following parameters have been maintained: air temperature 27 °C, dry asphalt. Tires characteristics have been as follows: tire brand Fulda for summer season, size 205/55 R16. Vehicle Golf IV with break disks FEBI brand and new brake pads brand TEXTAR.

Fig. 11. Installation of new brake pads brand TEXTAR it the Golf IV

The results of the test as illustrated in Figure 12 indicate that the:

- initial vehicle speed at the time of braking: V_0 = 81 [km/h],
- time from the start till the end of braking: T_{br} = 3 [s],
- distance in the time of braking: S_f = 32.71 [m] and
- averaged maximal vehicle deceleration: MFDD = 8.40 [m/s^2].

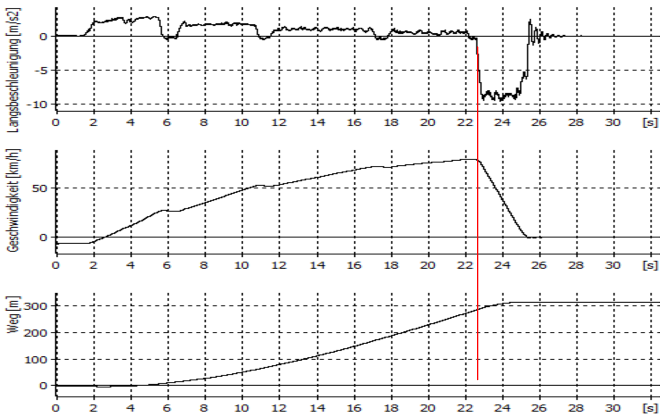


Fig. 12. Diagrams of measured braking performances performed with XL Meter for the "Golf IV" with brake pads brand TEXTAR at initial vehicle speed at the time of braking V_0 = 81 [km/h]

5. Result discussion

The used brake pads for this research have been new. After their installation, the vehicle covered about 200 km and then continued with testing. The presented tests were done at a speed of about 80 [km/h]. Prior to each test, the predicted used car Golf IV has performed also technical inspection of the vehicle braking system in the Licensed Centers for technical inspection of the vehicle. After the tests made for each brake pads brand, these results were obtained.

SCT brand brake pads have a large contact surface with the surface of the braking disc with a vertical channel for dust removal. During braking the averaged maximal vehicle deceleration is MFDD = 8.78 [m/s^2] and the braking forces of the left and right wheel on the same axle have a small difference (front axle 2% and rear axle 6%). Weakness which is presented during the testing is the creation of noise during the braking process. These tiles are characterized by low consumption.

Brembo brand brake pads has a smaller contact area with the disc surface compared to SCT brake pads. During the braking process does not create noise, the results of braking forces the left and right wheel on the same axle have a small difference (front axle 5% and rear axle 4%). Also during the braking process the average maximum deceleration is achieved: MFDD = 8.35 [m/s^2].

Comline brand brake pads which in their structure contain metal elements that negatively affect the consumption of the brake disc and a large increase in temperature during the application of frequent braking on long slopes. Their weakness are that it makes noise, heats up quickly and the large difference in braking forces left and right wheels of the same axle (front axle 20% and rear axle2%). During the braking process, the average maximum deceleration of the vehicle is MFDD = 8.54 [m/s^2].

Textar brand brake pads offer good grip with the brake disc. They have good properties during the braking process because not create noise, do not heat up during the application of long braking and the braking forces of the left and right wheel on the same axle have a small difference (front axle 1% and rear axle 4%). During the braking process, the average maximum deceleration of the vehicle is MFDD = 8.40 [m/s^2].

6. Conclusions

Obtained results from this research are important for traffic safety. From the braking system is required a large value of maximum average deceleration and a small difference of braking forces on the right and left wheel of the same axle.

SCT and **COMELINE** brand brake pads have a low price on the market of Republic of Kosova, but they make high level of noise during braking process. Therefore, when choosing brake pads, drivers should pay attention to **BREMBO** and **TEXTAR** brands, which have higher prices on the market of Republic of Kosova but provides better performances.

7. References

[1] N. Lajqi. *Exploitation and Maintenance of Vehicle*. Dispense for students. University of Prishtina, Faculty of Mechanical Engineering, Prishtina, 2010.

[2] H. Cakolli. Motor Vehicles. University of Prishtina, Faculty of Mechanical Engineering, Prishtina, 2013.

[3] A. Rama. *Influence of different kind of brake pads as braking system performance*. *Master Thesis*. University of Prishtina "HASAN PRISHTINA", Faculty of Mechanical Engineering, Prishtina, 2018.

[4] R. Mazrekaj, N. Lajqi, E. Tofaj. *Influence of Tires Age on Vehicle's Braking Performance: a Case Study*. International Review of Mechanical Engineering, Volume 14, No 10 (2020), pp. 646-657, DOI: https://doi.org/10.15866/ireme.v14i10.20235.

[5] Shpetim Lajqi, Stansilav Pehan. *Designs and Optimizations of Active and Semi-Active Non-linear Suspension Systems for a Terrain Vehicle*. Strojniški vestnik - Journal of Mechanical Engineering, pp. 732-743, 58(12), 2012.

[6] XL Meter ™ Gamma Pro / http://www.nehodar.cz/docs/xlmdatasheet.pdf (access 15.01.2021).

[7] P. Nawangsari, J.Jamasri, H. Santoso, B. Rochardj), A. T. Waskito, BaSO4-Friction Dust Filler Improves Friction Characteristic in Non-Asbestos Brake Pad Composite, Vol 13, No 9 (2019), DOI: https://doi.org/10.15866/ireme.v13i9.17669

[8] Sh. Lajqi, J. Gugler, N. Lajqi, A. Shala, R. Lika. *Possible Experimental Method to Determine the Suspension Parameters in a Simplified Model of a Passenger Car*. International Journal of Automotive Technology, pp. 615-621, 13(4), 2012,

[9] E. Tofaj. *Analysis of Impact of Tyres' Age in Relation to Parameters if Braking System. Master Thesis*. University of Prishtina "HASAN PRISHTINA", Faculty of Mechanical Engineering, Prishtina, 2018.

[10] T. Tang, K. Anupam, C. Kasbergen, A. Scarpas, Study of Influence of Operating Parameters on Braking Distance. Transportation Research Record: Journal of the Transportation Research Board, No. 2641, 2017, pp. 139–148. http://dx.doi.org/10.3141/2641-16

[11] A.M. Ribeiro, A. Moutinho, A.R. Fioravanti, Estimation of Tire-Road Friction for Road Vehicles: a Time Delay Neural Network Approach, Journal of the Brazilian Society of Mechanical Sciences and Engineering, Ar XIV: 1908.00452V2[cs.NE], 14 Nov. 2019.

[12] L. Jayakumar, K. Balamurugan, C. Ezilarasan, Wear and Friction Behaviour of 7075Al-25 SiC Particle Composites Sliding Against Automobile Friction Material, Vol 8, No 1 (2014), International Review of Mechanical Engineering IREME.

[13] Poul Greibe. *Braking distance, friction and behaviour*. Traffic. July 2007, Denmark.