RESEARCH ON WEAR VARIATION OF BRAKE PADS AND DISCS OF ROMANIAN DACIA LOGAN CARS

Gheorghe Voicu[1], Cristina Apetrei[1, 2], Paula Tudor[1], Gabriel-Alexandru Constantin[1], Gabriel Musuroi[1], Sorin-Dan Iordache[1], Marina-Teodora Dudau[1, 3]
[1]National University of Science and Technology Politehnica of Bucharest, Romania;
[2]George Bibescu Technological High School Craiova, Romania;
[3]DMT Teodora Distribution SRL, Romania
gheorghe.voicu@upb.ro, cristinatartaleanu@yahoo.com, paula.tudor@upb.ro, gabriel.constantin@upb.ro, gabriel.musuroi@upb.ro, jordacheeng@yahoo.com, marinateodora11@gmail.com

Abstract. The braking system of Romanian Dacia cars is, in general, with pads and disc (solid or ventilated) on the front axle (on newer versions also the rear axle). Our paper analyses the wear of brake pads and discs for 20 Dacia Logan cars, the data being taken from a service workshop in Craiova, Romania. A relatively linear variation of the wear of the friction material of the brake pads was found with values between 5.55-17.01 mm, both for the inner and outer pads, for both wheels on the front axle, for distances travelled between 2000-60000 km. For the same distances travelled, most of the weights of the worn brake pads had values in the range of 0.180-0.330, with random variations of the values of this parameter. The variation is also relatively linear, with the distance travelled, but the correlation coefficient has lower values compared to the variation of the wear of the brake pad material. The same trend of linear variation of the data regarding the thickness and weight of the brake discs with the distance travelled is maintained both for the right and left front wheels, although the correlation coefficient also has low values. From the comparative analysis of the experimental data with the theoretical data expressed by the manufacturer, significant differences are found between them, but the inadequate operation of the cars leads to very different variations between the wear of the brake pads and discs compared to those expressed theoretically. We do not have information whether the 20 cars belong to individuals or companies, although the bibliographic references mention a more rational operation of the cars belonging to individuals. The authors recommend that owners of such cars have their braking system checked at least annually and that the brake pads (mainly) and discs be replaced whenever necessary, but also that the other components of the braking system be checked.

Keywords: Dacia Logan cars, braking system, brake pad wear, brake disk wear, distance travelled.

Introduction

The braking system is the most critical safety system of a vehicle, having the role of converting kinetic energy into thermal energy through friction. For an accurate diagnosis in the time domain, specific analyses must be performed, both on specific stands and in the field. Analysis of data in the time domain for braking systems is an effective method for diagnosing defects (such as pad wear or fluid leaks), because it preserves the non-stationary characteristics of the signals that can be lost by transforming them into the frequency domain. Brake pads and discs are analysed on accelerometers in terms of vibrations occurring during their contact that can indicate uneven wear or vitrification of the wear material. Deformed discs can lead to periodic oscillations of the braking force in relation to the rotational speed, and pad wear leads to an increase in the RMS amplitude of the vibrations and the appearance of high-frequency peaks (squeaking).

Analysis of the failures of light commercial vehicle (LCV) braking systems shows that failures often arise from premature wear of brake linings, hydraulic leakage and thermal overload, especially in manual adjustment systems. The main failure areas include friction components, hydraulic actuators and electronic control units (ECCU), with high failure rates in urban traffic or during summer. Common problems include brake failure, wheel cylinder leakage and reduced performance due to improper maintenance. The braking system of motor vehicles is presented and analysed in various specialized papers published in several journals. Thus, in the paper [1], Krishnan et al. performed the simulation of the signal received by the driver using the MatLab program, its characteristics referring to the asymmetry, maximum, minimum, RMS (root mean square) value, standard deviation and variance of the braking signal in the program used. It was concluded that these parameters are sensitive to the multiple events that may occur on the route and required specific analyses. However, RMS is the best method for classifying braking conditions compared to the others, with the highest classification rate (98.73%).

Considering the total failure of the braking system, the paper [2] shows how to obtain a block diagram of the system reliability based on the fault tree (FTA). In order to familiarize with the braking system from the perspective of the occurrence of failures and to record as much as possible the potential failure modes of the constituent elements, the authors formed the fault tree for the peak event “Reduction in brake system performance”, the application of the FTA method allowing a detailed understanding of the considered machine system from the point of failure.

Standard operating procedures for periodic testing should be updated to reduce the risk of potential accidents. Fault tree analysis and failure mode, and effect analysis methods are used to identify and analyse risks. The results of the study in [3] provide new insights into revising the rules for periodic vehicle testing. Fault tree analysis is also used in [4] to identify failure modes, such as leakage or pressure regulation problems in train car braking systems, and Weibull distribution analysis of time-to-failure data is used to determine maintenance intervals. Also, [5] analyses the reliability of cable braking systems using fault tree analysis, focusing on modelling the complete loss of braking function, in accordance with current standards. The reliability of the braking system using risk theory can provide data on its failures, using Weibull distributions estimated by maximum probability. The authors of the paper [6] establish a fault tree according to the failure principle of the braking system, and the reliability of the braking system is analysed and evaluated by analysing the fault tree to provide a reference for the design and development of the braking system. The braking system of Dacia Logan cars is a dual-circuit hydraulic system equipped as standard with ABS (Anti-lock Braking System), EBD (Electronic Brake Force Distribution) and, in newer models, with an automatic emergency braking system.

The front axle of the car is equipped with ventilated disc brakes for efficient heat dissipation and superior braking power, while the rear axle predominantly used drum brakes on older variants (Logan I), but later versions (Logan II, Logan III) switched to disc brakes on the rear axle, improving overall braking performance.

Our paper analyses the evolution of the physical parameters of brake pads and discs with the distance travelled for 20 Dacia Logan cars that arrived at the service workshop with problems with the braking system and continues the research presented in the paper [7]. Depending on the distance travelled by the car, the average total thickness of the brake pads, respectively the wear material, as well as the variation in the thickness of the friction discs and the weight of these discs, are analyzed as options for assessing the wear parameters of the braking system elements that other authors have not treated in their works.

Materials and methods

Used brake pads from 20 Dacia Logan cars were taken from a service workshop in Craiova, Romania. Data was collected on the distance covered by each car. The pads on the front wheels were then measured and weighed to determine the degree of wear. The thickness of the pads was measured at both ends (since uneven wear was observed) and an average of this parameter was made. The thickness and weight of the brake discs on which they were mounted were also determined in order to analyse how they varied with the distance covered by each car.

Fig. 1. **Pads for ventilated discs (left) and pads for solid discs (right)**

Determinations were made for both the left wheel (LW) and the right wheel (RW) pads, mounted on the outer or inner side of the brake disc. All cars were driven both in urban and extra-urban environments. The data obtained from the measurements are presented in Table 1.

The data presented in the table were processed in the MS Excel program and characteristic charts were drawn in order to identify the variation of the wear parameters of the brake system pads and discs. It is worth mentioning that the vehicles presented in the table had their ITP on time, and they came to the service for maintenance.

Table 1

Physical characteristics of brake pads and discs from Dacia Logan cars analysed

No. cars	Brake pad mounting location	Distance travelled, km	*Average total thickness, mm	Brake pad thickness, mm	Average plate weight, kg	Used disc thickness, mm	Disc wear, mm	Used disc weight, kg
0.	**New pads and discs**	**0**	**17.01**	**11.50**	**0.336**	**22**		**5.414**
1.	LW outside	27431	12.25	6.73	0.275	17.52	4.48	4.472[1)]
	LW inside		12.39	6.92	0.273			
	RW outside		9.73	4.26	0.256	17.80	4.20	4.489[1)]
	RW inside		9.06	3.56	0.242			
2.	LW outside	28943	12.87	7.45	0.262	17.26	4.74	4.492
	LW inside		12.25	6.85	0.257			
	RW outside		12.68	7.3	0.259	16.82	5.18	4.484
	RW inside		11.16	5.76	0.196			
3.	LW outside	46971	12.03	6.72	0.253	17.39	4.61	4.487[1)]
	LW inside		16.26	2.51	0.165			
	RW outside		11.72	6.41	0.222	17.32	4.68	4.539[1)]
	RW inside		11.63	5.88	0.218			
4.	LW outside	26527	10.71	5.23	0.214	17.99	4.01	4.558
	LW inside		13.01	7.56	0.232			
	RW outside		9.18	3.76	0.201	17.76	4.24	4.486
	RW inside		11.26	5.72	0.245			
5.	LW outside	29549	9.32	3.93	0.182	17.65	4.35	4.483
	LW inside		12.06	6.56	0.251			
	RW outside		12.40	6.92	0.246	17.67	4.33	4.490
	RW inside		10.58	5.17	0.211			
6.	LWO/LWI	59842	8.08/7.44	2.6/1.98	0.195/0.180	18.22	3.78	4.275
	RWO/RWI		5.43/7.62	0.02/2.15	0.173/0.179	17.21	4.79	4.272
7.	LWO/LWI	27823	13.38/13.15	7.91/7.68	0.294/0.282	18.24	3.76	4.432
	RWO/RWI		12.76/13.2	7.30/7.74	0.261/0.289	18.22	3.78	4.429
8.	LWO/LWI	28298	12.57/12.40	7.09/6.92	0.259/0.233	17.50	4.50	4.571
	LWO/LWI		12.60/12.45	7.12/6.97	0.267/0.271	17.91	4.09	4.562
9.	LWO/LWI	33797	10.35/13.40	4.88/7.93	0.207/0.292	17.96	4.04	4.556
	LWO/LWI		9.78/10.60	4.33/5.15	0.199/0.223	18.01	3.99	4.469
10.	LWO/LWI	33744	11.38/10.56	5.91/5.12	0.266/0.243	18.05	3.5	4.476
	LWO/LWI		12.12/9.40	6.67/3.95	0.275/0.193	17.92	4.08	4.478
11.	LWO/LWI	2093	16.94/16.93	11.50/11.44	0.340/0.330	21.96	0.04	5.409
	LWO/LWI		16.92/16.96	11.43/11.42	0.339/0.331	21.91	0.09	5.405
12.	LWO/LWI	9876	16.76/16.71	11.46/11.26	0.336/0.318	21.87	0.13	5.398
	LWO/LWI		16.68/16.82	11.21/11.18	0.327/0.322	21.64	0.29	5.387
13.	LWO/LWI	15794	16.52/16.49	11.32/11.05	0.324/0.304	21.72	0.28	5.378
	LWO/LWI		16.38/16.67	11.45/10.88	0.315/0.313	21.60	0.40	5.351
14.	LW outside	61397	6.89	11.16	0.215	20.73	1.27	4.854[2)]
	LW inside		7.43	1.52	0.226			
	RW outside		9.48	1.95	0.241	20.78	1.22	4.907[2)]
	RW inside		8.74	3.99	0.226			
15.	LW outside	55291	11.87	3.26	0.268	20.91	1.09	4.839
	LW inside		12.34	6.40	0.270			
	RW outside		7.72	7.09	0.230	20.91	1.09	4.826
	RW inside		8.83	2.24	0.241			

Table 1 (continued)

No. cars	Brake pad mounting location	Distance travelled, km	*Average total thickness, mm	Brake pad thickness, mm	Average plate weight, kg	Used disc thickness, mm	Disc wear, mm	Used disc weight, kg
16.	LW outside	36944	12.23	3.36	0.269	20.88	1.12	4.853
	LW inside		10.56	6.77	0.250			
	RW outside		12.33	5.11	0.268	20.89	1.11	4.824
	RW inside		8.70	6.86	0.241			
17.	LW outside	17479	16.43	3.23	0.336	21.15	0.85	5.405
	LW inside		16.39	10.94	0.326			
	RW outside		16.41	10.90	0.334	21.29	0.71	5.402
	RW inside		16.37	10.92	0.324			
18.	LW outside	31127	11.78	10.88	0.280	21.23	0.77	4.864
	LW inside		12.04	6.31	0.260			
	RW outside		12.64	6.56	0.282	21.07	0.93	4.867
	RW inside		11.18	7.16	0.259			
19.	LW outside	42868	9.98	5.69	0.255	20.95	1.05	4.796
	LW inside		9.11	4.49	0.241			
	RW outside		8.20	3.65	0.228	20.92	1.08	4.798
	RW inside		9.76	2.72	0.259			
20.	LW outside	24401	14.61	4.29	0.283	21.15	0.85	4.968
	LW inside		13.26	9.15	0.276			
	RW outside		15.25	7.78	0.279	21.10	0.90	4.967
	RW inside		15.71	9.77	0.268			

Notes: * Total pad thickness (metal + brake pad); 1) different wear at ends of pad; 2) taxi regime

To analyse the evolution of brake system wear in relation to the distance travelled (between 2000 and 60000 km), the arithmetic mean of the thickness of the brake pads at both ends of each part was calculated, to compensate for the errors introduced by the observed uneven wear. Linear regression analysis was then performed to model the relationship between the distance travelled and physical parameters (thickness and weight) of the brake pads and discs. This allowed the identification of variation trends and drawing of specific regression lines for each component (left/right wheel, inner/outer). The experimental data resulting from the regression were compared with the theoretical models provided by the manufacturer (which predict an exponential variation available for pads and linear for discs) to highlight the impact of real operating conditions on wear.

Results and discussion

The charts allow mainly qualitative assessment of the variation of wear, and show a decreasing trend of friction pad wear with the distance covered by the cars. This distance is between about 2000-60000 km. The slope of the regression lines is relatively the same for both the left and right pads, inner or outer. There are friction pads that have worn out almost completely for distances covered close to 60000 km, which means that they arrived at the workshop much too late. For the data presented, the regression analysis shows an R^2 coefficient ≅ 0.70, for all four pads, as can be seen in Fig. 2.

Centralizing the wear of the brake pads from Dacia Logan cars that arrived at the service with problems with the braking system, it is observed that this wear has an increasing linear variation, for both wheels, both on the outer side and on the inner side of the disc (see Fig. 2).

The value of the R^2 coefficient and the layout of the experimental points on the charts in Fig. 2 show a relatively uneven distribution of the friction plate wear values from all four wheels. It should be remembered here that the developers of the braking system for Dacia Logan cars give a decreasing exponential variation as a model for the variation of the thickness of the friction plates [8], and for the thickness of the brake discs a slowly decreasing linear variation.

If we were to exclude only one to three values of the thickness of the plates that fall far outside the average range of values, the regression coefficient R^2 would present values between 0.81-0.91 for all four plates from the front wheels.

Regarding the variation of the total weight of the worn brake pads in relation to the distance travelled, a decreasing variation of the values of this parameter is also observed here.

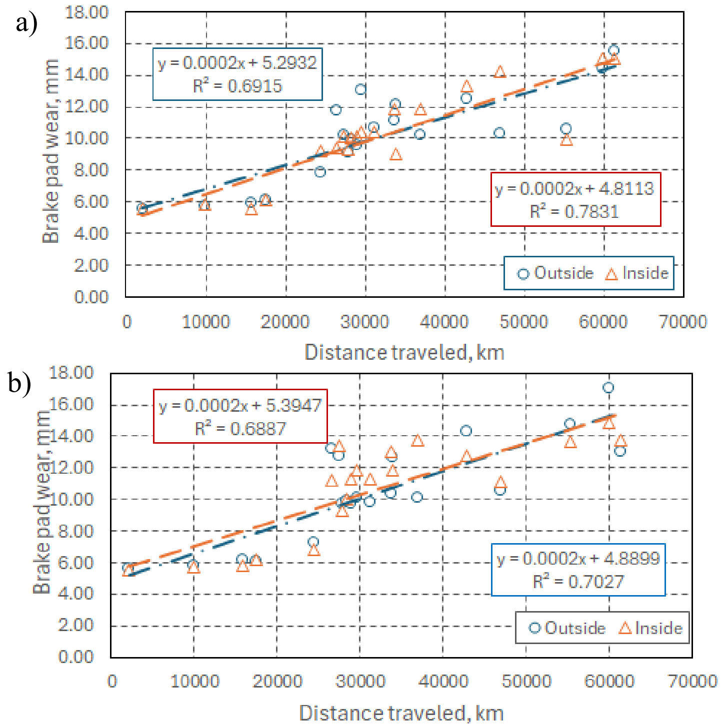

Fig. 2. **Wear of friction pads of the brake system on Dacia Logan cars:**
a – left wheel; b – right wheel

Also, if we centralize the data regarding the variation of the total weight of the brake pads (the metal part plus the wear pad), the decreasing linear variation mentioned above is observed, but it can be observed that the slopes of the regression lines are relatively similar, even if the values of the regression coefficient R^2 are very small (this is due to the very random arrangement of the values of this parameter) (see Fig. 3).

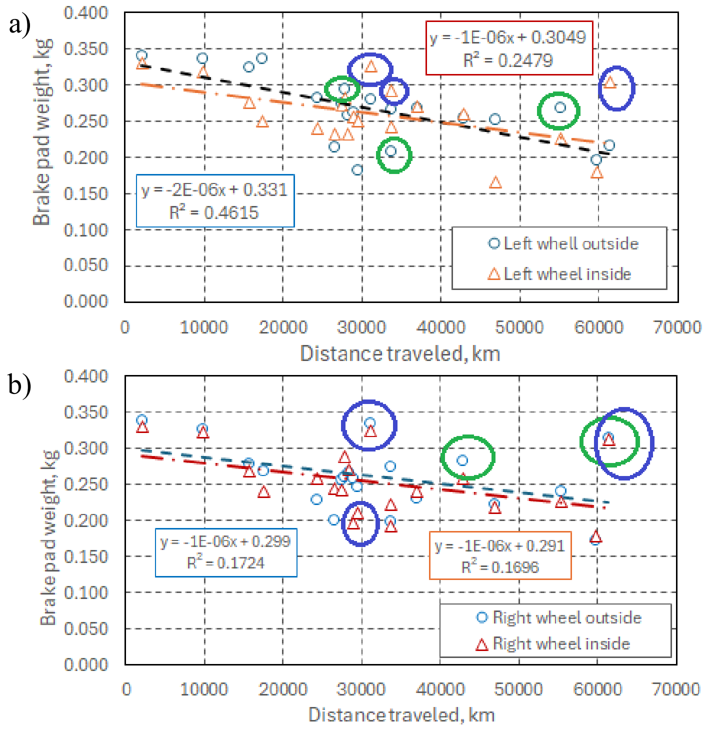

Fig. 3. **Weight of brake pads on Dacia Logan cars, depending on the distance travelled:**
a – left wheel; b – right wheel

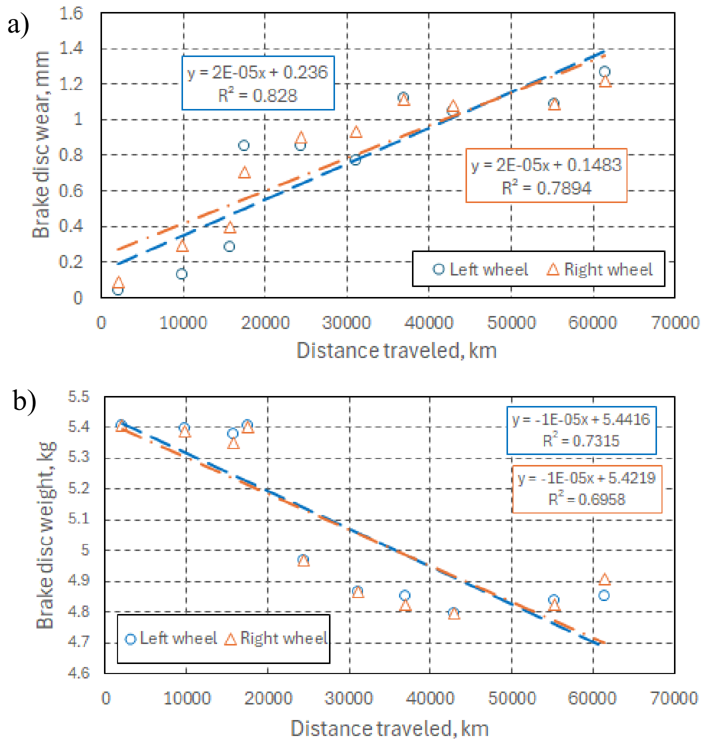

Fig. 4. **Wear and weight of brake discs on Dacia Logan cars, on the two front wheels:**
a – disc wear (new disc thickness approx. 22 mm); b – disc weight (new disc approx. 5.41 kg)

In contrast, for the second parameter analysed, namely the weight of the brake discs, it has a decreasing linear variation, although for both parameters a distribution with value points further away from the regression line can be observed. In this case, the regression coefficient has values around R^2 = 0.6958-0.7315 (see Fig. 4).

Conclusions

1. The ventilated disc brake system uses discs made up of two adjacent surfaces, separated by slots, which allow air circulation and efficient cooling. This construction prevents overheating, reduces pad wear and increases thermal cracking resistance by over 40% through superior heat dissipation, making it ideal for performance vehicles.
2. A linear distribution of brake pad wear was found for Dacia Logan cars, but there are many cars that do not meet the deadline for visiting service workshops for brake system maintenance. This is both in terms of friction pad thickness and weight.
3. There are no significant differences between the wear of the brake pads on the front wheels (left-right), mounted on the inside and outside of the brake disc.
4. Also, the total weight of the brake pads decreases relatively linearly with the distance travelled by the cars, although there are several cars that deviate from this rule and lead to a low value of the regression coefficient R^2. The same applies to the variation in the thickness and weight of the brake discs on which the pads are mounted.
5. The analysis method can be applied to all categories/models of cars, but it requires data collection at different distances travelled. We believe that it would also be necessary to know what distance was travelled on roads of different categories, but it can be said that relatively high wear values at short distances travelled are obtained on roads of lower categories.
6. The authors' recommendations include checking at the service workshop whenever problems are detected with the car braking system for road safety.

Acknowledgements

We would like to thank the ITP station and the car service workshop "ETY Tehnic SRL" from Craiova for their support in the data collection process used in this study. Their availability and technical support contributed to the proper conduct of the research activities.

Author contributions

Conceptualization, G.V.; methodology, G.V., C.A. and S.D.I.; software, G.V and P.T.; validation, G.V. and G.A.C.; formal analysis, G.A.C. and G.M.; investigation, C.A., G.V., S.D.I. and M.T.D.; data curation, A.A., V.B. an J.I.; writing – original draft preparation, G.V.; writing – review and editing, G.A.C. and M.T.D.; visualization, G.V., G.M.; project administration, G.V.; funding acquisition, C.A. All authors have read and agreed to the published version of the manuscript.

References

[1] Krishnan P., Yaacob S., Husaini M. Data analysis for braking system in time domain for fault diagnosis, International Research Journal of Engineering and Technology (IRJET), Vol. 05, Iss. 08, 2018, pp. 348-354.
[2] Catic D.M., Glisovic J., Failure analysis of light commercial vehicles' braking system, 13th International Quality Conference, Serbia, Kragujevac, 2019, pp. 1019-1024.
[3] Ansori I., Waskito D.H., Mutharuddin M., Irawati N., Nugroho S., Sulastry T., Subaryata S., Siregar N.A.M. Enhancing brake system evaluation in periodic testing of goods transport vehicles through FTA-FMEA risk analysis, Automotive Experiences, 6(2), 2023, pp. 320-335.
[4] Rakipovski E., Milcic D. Reliability analysis of distributor valve of air brake system for freight wagon, Facta Universitatis, Series Working and Living Environmental Protection, Vol. 16, no. 2, 2019, pp. 95-106.
[5] Ce Z., Han Y., Lin Y., Wang D. Reliability analysis of brake-by-wire systems on fault tree, Journal of Physics Conference Series, 2021, 2029(1):012135.
[6] Liu L., Liu X., Wang X., Wang Y., Li C. Reliability analysis and evaluation of a brake system based on competing risks, Journal of Engineering Research, 5(3), 2017, pp. 150-161
[7] Apetrei C., Voicu Gh., Iordache S., Constantin G.-A., Saracin I., Tudor P., Ipate G. Research on the efficiency of the braking system in Dacia Logan cars, Machines 2025, 13(10), 896.
[8] *** Dacia Logan brake system specifications, [online] [11.02.2026] Available at: https://garage.wiki/dacia/logan/first-generation-facelift/2022/brake-system-specifications.html