Aspects of Measuring Brake Parameters on Heavy Trucks Using a Roller Brake Stand

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Abstract. Performance analysis and measurement of braking parameters are two essential aspects for the correct operation of braking systems but also for their development. The identification of wear patterns and the analysis of wear trends make it possible to develop new systems and make a massive contribution to increasing traffic safety and the availability of a vehicle, while massively reducing maintenance costs. The current study proposes an analysis of the data obtained by braking on the roller stand, for different types of commercial vehicles of different configurations and for different scenarios. Among the main parameters analyzed are: weight on each wheel, distribution of braking forces and actuating pressures.

Keywords: Brake · Commercial vehicle brake · Brake stand

1 Introduction

The study of the braking system remains an important aspect in the future development of motor vehicles, regardless of how they are propelled (based on fossil fuels or renewable energy sources). In this sense, the study addresses the analysis of the performance of braking systems and the analysis of possibilities to improve them by increasing the life of the elements in the system. Finally, the aim is to achieve a significant increase in traffic safety, while a significant reduction in maintenance costs.

The study focused on the situations in which there are significant differences in the distribution of braking forces, and then to establish the risk areas for the analyzed category, but also the causes that favor the accentuated or unnatural wear of the elements in the braking system. In this way, a link is sought between certain factors identified in operation and the affected elements of the system, in order to minimize the incidence of failure.

2 Elements of Analysis

The experimental study of the data obtained when braking on the roller stand, has as main purpose the determination of the main static parameters that govern the braking process, in order to carefully analyze the following main aspects:

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- establishing the tendencies of distribution of forces, at wheels and axles, to different types of vehicles, in order to identify the determining factors;
- identifying potentially risky situations for the braking process in order to increase traffic safety;
- identifying situations with the potential for increased wear and tear in the system, in order to reduce maintenance costs and increase the availability of a vehicle;
- analysis of the need for periodic tests on the stand for the braking system, to increase traffic safety, the availability of a commercial vehicle and to reduce downtime;
- identification of solutions for efficient diagnosis of defects in the earliest stages, so as to reduce maintenance costs;
- correlation of constructive and external influencing factors with the obtained performances and with the possible performances.

The literature contains a significant number of articles dealing with the construction [1], operation [2, 3] and analysis [3–5] of roller stands. However, there are quite a few studies that analyze the results obtained from the tests on the stand. Moreover, a completion of this analysis with a series of experimental tests would lead to much more complex in-depth studies and would validate a number of results obtained. Such experimental studies, which analyze the braking parameters in real time, as in the case of Popa M, et al. [6], provide complex data but are quite expensive and difficult to approach. Computer simulations offer a good study alternative but the accuracy of the results depends a lot on the fidelity and complexity of the data entered. In this case the main disadvantages are the large volume of data to be managed and time required.

Adhesion control can be effectively studied on roller stands, and Xiangdang X, et al. in [1], presents such an experiment that links the measurements on the proposed stand to the rotation sensors of the ABS system to determine the adhesion in different conditions. Other studies [4, 5] address the sizing of a roller brake stand so that it can provide the most complex analysis data possible.

Using a roller stand, Toma M, et al., in the study [3], analyzes the effects of shoulder wear (lateral wear on the surface of the brake disc). A similar type of analysis was used for the current study, being the identification of some methods of analysis of wear starting from the results provided by the brake stand.

3 Study and Results

In order to obtain data on braking parameters, the results obtained from the test on the roller brake stand of the vehicles in a service unit were analyzed. Data from light commercial vehicles and trucks were analyzed. The study was carried out over three years starting with 2017 and until 2019, during which time a number of 70 tests were performed on the roller brake stand.

Figure 1 shows the distribution of the study vehicles grouped into the four categories in which they were included. The largest share is light commercial vehicles, which have been divided into two categories: those with a maximum authorized mass of up to 3.5 t and those with a maximum authorized mass between 3.5 and 5 t. This category of vehicles currently comprises a particularly important sector of road transport in Europe. These

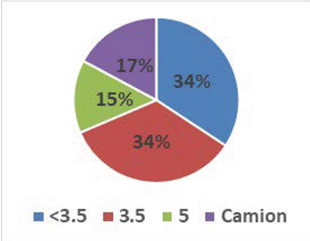


Fig. 1. Distribution of study vehicles by categories

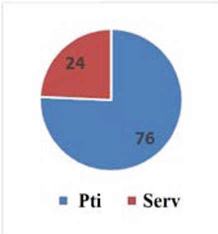


Fig. 2. The reason for performing the tests on the stand in the workshop

light commercial vehicles, although carrying low loads, are very efficient in transporting packages (of small mass and dimensions) over long distances in a much shorter time than a truck. These specific operating conditions (low masses but high speeds) make the analysis of the braking systems of light commercial vehicles a different sector from that of both cars and trucks. How these vehicles are located between cars and trucks, the analysis of the braking systems, generates a series of essential and useful aspects for both categories.

An important factor in the study was the analysis of the reason for the presence in service for each vehicle tested. Thus, two general reasons were outlined: 1) for carrying out the periodic technical inspection (Pti-according to the norms in force); 2) for various specific service operations (Serv-situations that also required testing on the roller brake stand).

It was found that the vehicles present in the service for the periodic technical inspection (Pti) have a higher frequency for the on-site inspection. Of the total number of tests analyzed, 24% were in service for interventions, which required a standstill check of the braking parameters. Such interventions relate to maintenance repairs (replacement of wear and repair or other defects) or various checks depending on the customer's complaint. The graphs obtained regarding the distribution of the vehicles according to the reason for performing the tests on the brake stand are shown in Fig. 2. Also, in Fig. 3 are shown the same distributions of the vehicles according to the reason for performing the tests on the stand, but this time vehicles were grouped into 4 significant categories (A-vehicles under 3.5 t; B-commercial vehicles with a maximum mass of up to 3.5 t; C-trucks with a maximum mass of up to 5 t; D-heavy trucks). It can be observed that the main reason for carrying out the tests on the stand in the workshop, does not have as main cause the defects occurred in operation, which is based on the need to perform periodic checks imposed by the authorities. In this case, the preventive aspect and the continuous need to monitor the braking process can be emphasized, the ultimate goal being to maintain or even increase traffic safety. Moreover, in the context of future generations of vehicles, these rules will have to be adapted and as a consequence, on the one hand, traffic safety should be increased, but on the other hand, maintenance costs will also increase.

In the context of increasing traffic safety and setting the guaranteed operating range as high as possible, based on the results obtained, two scenarios can be outlined regarding the future of motor vehicles:

a) Reducing the periodic inspection period of motor vehicles by legislation - which is not a prospective solution, given that the evolution of motor vehicles has led to a massive increase in their availability, and such a measure would be a setback. However, in Romania, due to the age of the car fleet, starting with 2018 [7], the periodic annual inspection of vehicles older than 10 years was required (decrease of the interval from two years to one year). This measure is welcome, but let's not forget that it is a compromise solution, which comes at best, to maintain traffic safety, without bringing opportunities for progress.
b) Identifying new solutions to improve the reliability and increase the safe operation of the braking systems - this can be the basis for future research and development in the field of motor vehicles. At the same time, finding new innovative solutions can be of major importance in identifying new systems, which in turn can be used for future autonomous vehicles.

If we analyze the fact that 76% of the vehicles were presented for regular checks and 24% for interventions involving the braking system, it can be said that the efficiency of the current braking system is quite good. However, the braking system is the most important safety system on a car, so we can't talk about almost exactly, it is necessary to develop and analyze it continuously until a variant is obtained that does not allow failures outside the pre-established maintenance program.

In the graphs obtained following the distribution by types of vehicles (Fig. 3) it is observed that the frequency of failures which also involves the verification on the stand of the brakes is: very low for light vehicles; maintained at a constant level in the field of light commercial vehicles; grows sharply in the field of heavy trucks. This aspect and the causes that lead to the increase of the frequency of failures in the field of truck trucks, has been analyzed several times in the paper. In fact, the identification of a high frequency of failure in the field of heavy trucks was one of the triggers for the study of the possibilities of improving maintenance periods by eliminating serious and unforeseen defects in operation.

On the other hand, although the number of trucks in the study was lower, they were analyzed more carefully, with additional issues related to the actuation pressures in the braking chamber for each wheel and axle. The trends identified in trucks, although similar to those of light commercial vehicles, highlight a number of peculiarities due to their mass and size. It should also be noted that the average mileage covered by the stand test is much higher in trucks than in the other vehicles in the study (Fig. 4). However,

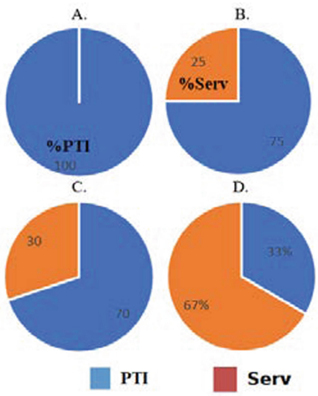


Fig. 3. Reason for performing stand tests for motor vehicles

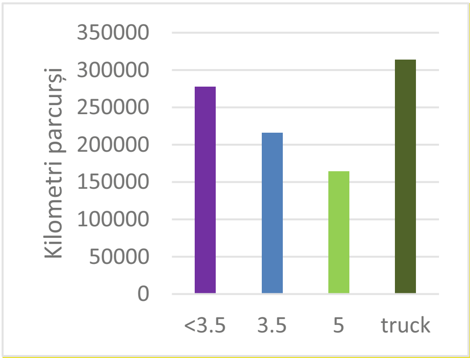
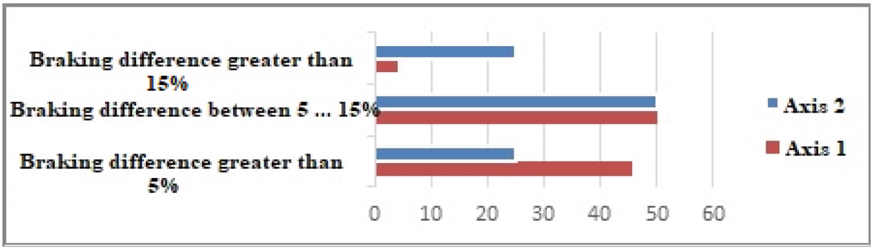


Fig. 4. Average number of kilometers covered by the stand test for each category

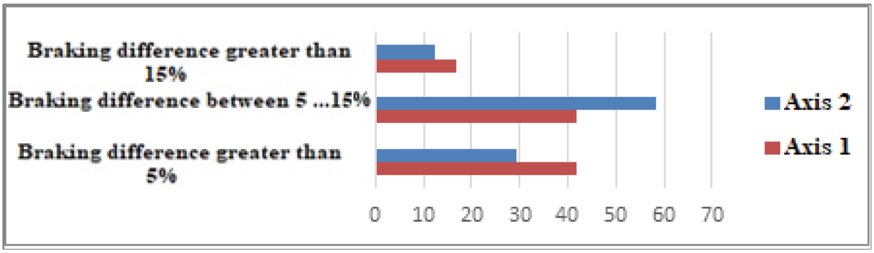
for an even more accurate analysis, this graph should also be analyzed in terms of the age of the car park, in order to establish the time in which the intervals of kilometers were covered. It is observed that the trucks in the category with the maximum authorized mass of more than 5 t, have the lowest average of the kilometers covered. This is natural because these commercial vehicles are used for local distribution in urban areas that are difficult to access for large trucks. This type of operation imposes specific conditions on the braking system. It can be approximated that these vehicles operate in parameters similar to the cars used exclusively in urban traffic, so in conditions of acceleration and repeated braking at low speeds.

According to the measurements performed, it can be stated that with the increase of the demands in the system, the wear and tear also increase and the possibility of the occurrence of unforeseen defects also increases. The distribution of the obtained values represented a first step in the analysis of the causes that lead to the appearance of the major defects of the braking systems in the trucks. Figure 5 shows the distribution of data according to the difference between the measured values for the braking force on each wheel (A-vehicles under 3.5 t; B-commercial vehicles with a maximum mass of

A.



B.



D.

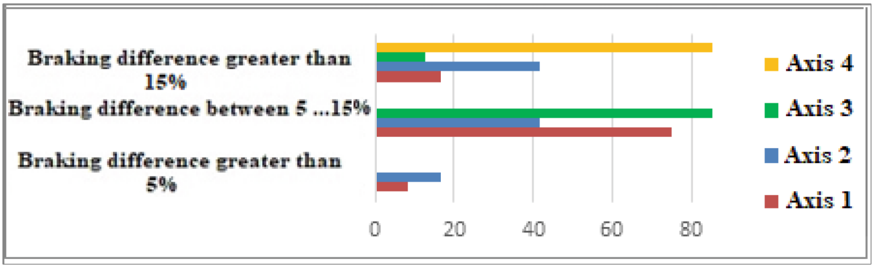


Fig. 5. Braking difference (left/right) indicated by the stand for each axle on vehicle groups

up to 3.5 t; D-heavy trucks). These values are obtained by comparing the braking forces measured on each wheel. Based on the difference or imbalance between left and right, the percentage of cases in which the differences fall into the three groups of values is analyzed. This difference automatically generated by the brake stand plays an important role in determining the final verdict on the operation of the braking system. According to [7], a series of maximum permissible values for the braking imbalance are established for each type of vehicle. The higher the measured difference, the more prone the system is to failure.

As heavy-duty trucks identified several risk factors for major defects and also in this category a much higher weight was identified in the uneven distribution of braking forces, the process was analyzed more carefully. Thus, the analysis of the braking process on the stand was performed, adding a study on the connection between the measured braking force and the pressure applied in the braking chamber. The main purpose was to obtain additional data to identify the main factors leading to the creation of imbalances in the braking system. As mentioned earlier, system imbalances are a key factor in reducing the life of the elements in the braking system.

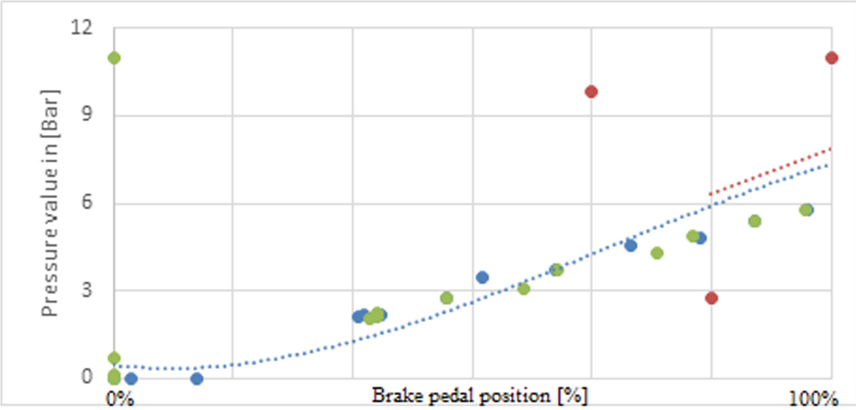


Fig. 6. Values obtained for brake chamber pressure

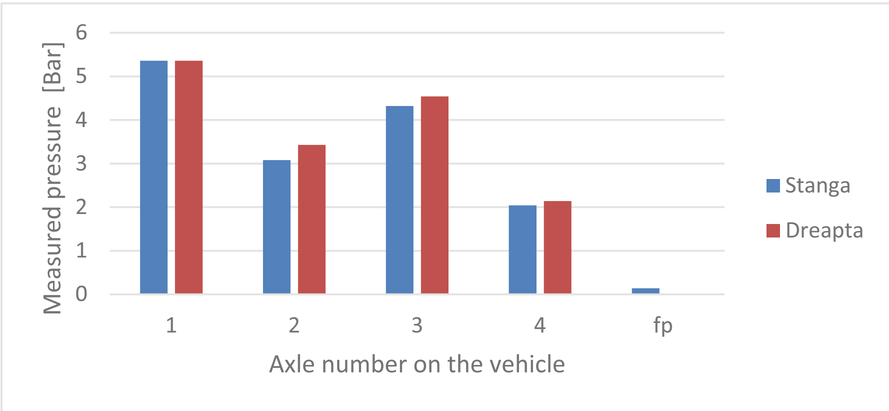


Fig. 7. Pressure values obtained for a 4-axis dump truck

Figure 6 shows the measured values for the brake chamber pressure applied to obtain the measured braking forces. It is observed that there is a higher distribution frequency for the values between 2 and 6 bar and for the maximum and minimum values the distribution is quite low. The operation of the system within these limits is the most efficient so the failure rate will be minimal for these pressure values. Brake actuation pressure measurements were performed for various truck configurations. The graph in Fig. 7 shows the measured values for the brake chamber pressure on a 4-axle truck (8x4). Measurements were made for each wheel and for each axle.

The graph in Fig. 8 shows the dependencies between the applied pressure and the braking force measured on the stand. Such tests were performed on trucks with different configurations. In all cases the ratio between the value of the applied pressure and the value of the measured braking force was closely related to the weight of the axle and its type (steering axle or driving axle). Under these conditions in all cases a higher pressure

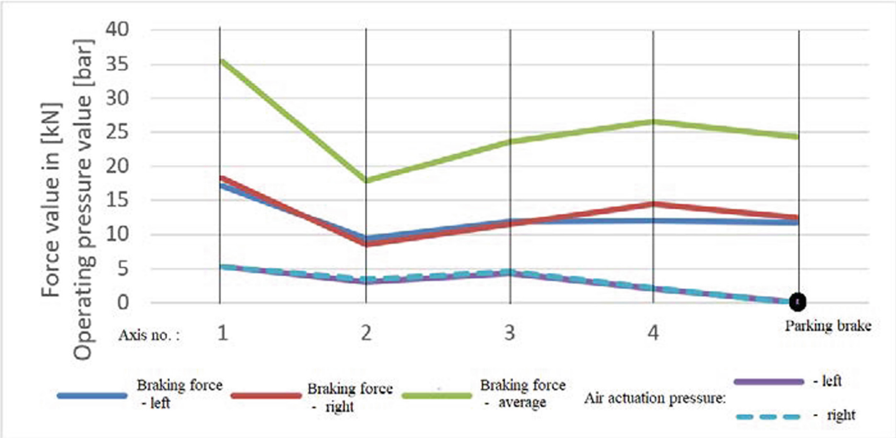


Fig. 8. Ratio of applied pressure to braking force for a 4-axle truck

was applied to the first axle than to the next axle and the braking force obtained was also higher. The average values applied for the control pressure of the first axis were approximately 5 bar and for the second axis 3 bar. When analyzing the wheels on the same axle, no significant differences were found in the applied pressure. However, even if the differences were small, this aspect should not be neglected because, as shown, the pressure difference will turn into a difference in wear and thus can cause serious operating problems.

4 Conclusions

The tests on the stand allow a local analysis of the braking forces in static conditions and thus data on the distribution of braking forces can be generated. Based on the analysis of these distributions, the main factors that lead to the occurrence of system defects and the occurrence of premature wear can be established.

The main objectives of the study are to identify situations with a potential risk of declining braking performance. During the work, the practical research identified a number of problems with the braking system that were not initially foreseen and whose impact is significant in terms of aspects such as braking performance, traffic safety or maintenance costs.

The performance analysis on the brake stand, in the first phase, identifies the trends of the distribution of the braking force on each wheel depending on the constructive parameters and the test conditions. An analysis of the link between the data obtained on the stand and the data obtained in real conditions is then carried out in order to identify effective solutions to reduce the failure rate and increase the performance of the braking systems.

All of this can lead to: improved braking performance, reduced braking system failure rates, reduced maintenance costs, increased traffic safety, or even the identification of new solutions for braking systems.

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