Advanced Engineering Days

aed.mersin.edu.tr

Influence of wheel diameter difference on their stability against derailment

Angela Shvets*[1]

[1]Ukrainian State University of Science and Technologies, Department of Engineering and Design Specialized Department «Microprocessor-Based Control Systems and Safety in the Railway Transport» (EDSD MBCSS), Ukraine, angela_shvets@ua.fm

Cite this study: Shvets, A. (2023). Influence of wheel diameter difference on their stability against derailment. Advanced Engineering Days, 8, 97-99

Keywords
Gondola cars
Railway
Wheel derailment factor
Mathematical modeling
Difference in wheel diameters

Abstract

In railway transport, there is a very acute problem of intensive wear of the lateral surface of the tread and wheel flanges. Traffic safety and dynamic loading of rail vehicles largely depend on the technical condition of their running gear. Therefore, this research is devoted to the study of the influence on the stability of the wheel from derailment of deviations in the running gear of cars that inevitably arise during their operation. To assess the impact on the stability of the wheel from derailment, the differences in the diameters of the wheels of one wheelset, as well as the differences in the diameters of the wheels of the wheelsets of one bogie, are considered. A freight car was chosen as the most numerous type of rail vehicle, and a four-axle gondola car was taken among the freight cars. The values of the wheel derailment factor are obtained taking into account the specified deviations of the technical condition of the wheelsets within the existing tolerances in operation.

Introduction

The increase in wear of the flanges of wheelsets of rolling stock and the side surfaces of the rail heads is one of the most serious problems of railway transport. The wear of wheels and rails depends on the physical and mechanical processes occurring in the area of their contact [1-4]. The nature and the intensity of these processes largely depend on the interaction forces of the contacting bodies and their relative displacements. Therefore, one of the possible ways to solve the problem of reducing wear is to establish conditions for reducing the dynamic loading of the contact area. The solution to the problem is reduced to minimizing the interaction forces and mutual displacements of wheels and rails in the contact area. An important aspect of this problem is also ensuring the safety of train traffic in the presence of wear of wheels and rails [5-8].

Material and Method

Traffic safety is influenced by a large number of different factors [9-12]. To assess the impact on wheel stability from derailment, this paper considers the impact of only some of them:

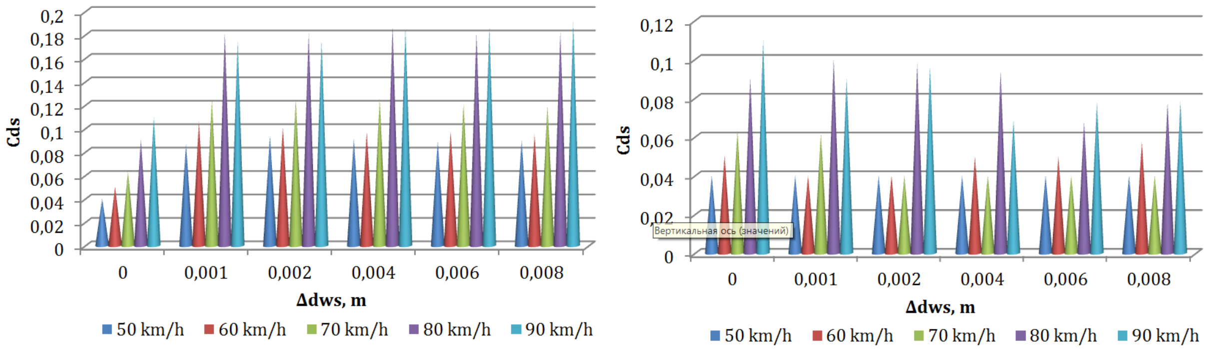
- the difference in diameters of wheels of one wheelset;
- the difference in diameters of the wheels of wheelsets of one bogie.

The study was carried out by the method of mathematical modeling using the model of spatial oscillations of freight cars [13-15]. Theoretical studies were carried out during the movement of a gondola car model 12-532 with standard bogies 18-100 at speeds in the range from 50 to 90 km/h in curves with radii of 350 and 600 m, with elevations of the outer rail of 130 and 120 mm, respectively. A 12-532 gondola car on 18-100 model bogies was chosen for the reason that these cars have low critical speed from the point of view of movement stability; when exceeding it, continuous oscillations of wheelsets, limited by railway lines, occur. The stationary mode of movement of the freight cars in the curve was investigated in order to establish the influence of only the factor under consideration, namely, the difference in wheel diameters. The running gear of the car, the rolling surface of the wheel, and the rail head profile were provided in normal technical condition [16, 17].

Results

Traffic safety, as you know, depends on many factors, including the design features of the track and running gear of the rolling stock, but to a greater extent, it is determined by their condition during operation. Let us consider the impact on the stability of the wheels from the derailment of the difference in the diameters of the wheels of one wheelset – in particular, the first wheel pair and the change in the diameter of the leading wheel.

Differences in the diameters of the wheels of one wheelset are considered in the range from 0 to 8 mm. Figure 1 shows graphs of changes in C_{ds} indicators during the movement of a loaded gondola car with standard bogies with an increase in the radius of the leading wheel.



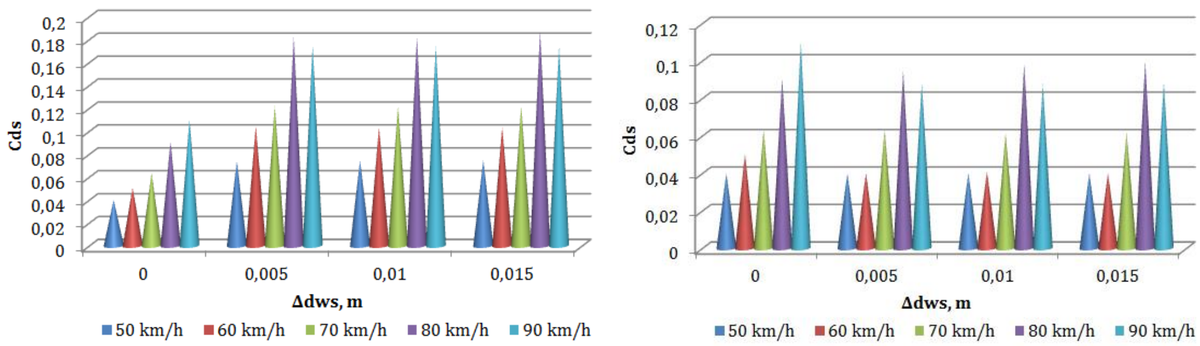
a *b*

Figure 1. The influence of the difference in the diameters of the wheels of one wheelset on C_{ds}: *a* – R=350 m; *b* – R=600 m

As you know, an increase in the radius of the leading wheel directs to an increase in the longitudinal sliding of this wheel. If, at the same radii of one wheelset, its hunting had a certain negative value, then with an increase in the sliding of the leading wheel in the curves R=600 m, this negative value decreases (Figure 1, b). This means that the wheelset fits into the curve with a smaller striking angle.

When changing the radius of the non-running wheel, the results in the R=350 m curve are similar in Figure 1 (*a*). In the R=600 m curve, with a difference of 0.002 m, an increase in the wheel derailment factor C_{ds} occurs over the entire speed range.

Further, the influence on the wheel derailment factor from the convergence of the difference in the diameters of the wheels of the wheelsets of one bogie was considered (Figure 2). The results are given for the case when the radii of the wheels of the front wheelset of the bogie are greater by 0.005-0.015 m than the radii of the wheels of the rear wheelset (the radii of the wheels are the same in each wheelset).



a *b*

Figure 2. The influence of the difference in the diameters of the wheelsets of one bogie on Cds: a – R=350 m; b – R=600 m

According to the Standards for the release of cars from depot repairs, the difference in wheel diameters in the rolling circle for one bogie should not exceed 20 mm. With an increase in the radii of the wheels of the rear wheelset, the stability indicators from derailment also increase.

The results for the case when the radii of the wheels of the front wheelset of the bogie are less by 0.005-0.015 m are similar to changes with an increase in diameters. With a decrease in the diameter of the front wheelset in the bogie, the stability indicators from derailment practically do not change in curves of both radii.

Conclusion

As a result of the theoretical studies of the spatial oscillations of a freight car, using the example of a gondola car, the values of the wheel derailment stability coefficient were obtained, which makes it possible to objectively assess the effect of the difference in the diameters of the wheel pairs of one bogie on traffic safety.

The driving performance of the car depends on the values of the set of parameters characterizing the state of the running gears of the rolling stock and the railway track. Therefore, at the next stages of research on this problem, it is necessary to solve the problems of traffic safety and minimization of wear as multi-parameter. Despite the great work done by many organizations to study the causes of intensive wear of wheels and rails, the solution to the problem cannot be considered complete due to its versatility. It is necessary to continue not only theoretical research but also specially designed experiments in natural conditions. It is advisable to develop such methods for direct assessment in real conditions of the wear of the surfaces of the rails and wheels of the rolling stock, which makes it possible to identify locomotives and cars that cause increased wear.

References

1. Blokhin, E. P., Pshinko, O. M., Danovich, V. D., & Korotenko, M. L. (1998). Effect of the state of car running gears and railway track on wheel and rail wear. Railway Bogies and Running Gears: Proceedings of the 4th International Conference, 313-323. Budapest, Hungary.
2. Shvets, A., Muradian, L., & Shvets, A. (2023). Investigation of wear of wheels and rails when the center of mass of cargo in gondola cars shifts. Advanced Engineering Days, 7, 109-112.
3. Fomin, O. V., Shvets, A. O., Bolotov, O. M., & Saparova, L. S. (2020). Definition of indicators wear in an uneven load freight rolling stock. Bulletin of Certification of Railway Transport, 1, 19-29.
4. Shvets, Angela O., Bolotov, O. M., Saparova, L. S., & Shvets, Angelika O. (2019). Wear wheels and rails at the uneven loading of gondola cars. Bulletin of Certification of Railway Transport, 1(53), 4-17.
5. Muradian. L., Pitsenko, I., Shaposhnyk, V., Shvets, A., & Shvets, A. (2022). Predictive model of risks in railroad transport when diagnosing axle boxes of freight wagons. Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit, 1-5. https://doi.org/10.1177/09544097221122043
6. Myamlin, S., Neduzha, L., & Shvets, A. (2014). Determination of friction performance influence in the system "body–bogie" on the freight car dynamics. Science and Transport Progress, 2 (50), 152-163. https://doi.org/10.15802/stp2014/23792
7. Lazaryan, V. A., Dlugach, L. A., & Korotenko, M. L. (1972). Stability of rail vehicle movement. Kiev: Naukova dumka.
8. Shvets, A., Shvets, A., & Kasianchuk, V. (2020). Research of strength characteristics of element of the unit rolling stock. Railroad car fleet, 1 (157), 7-12.
9. Shvets, A. O. (2021). Research of stability of the freight rolling stock in noncentral interaction automatic couplers two cars. Bulletin of Certification of Railway Transport, 2 (66), 50-62.
10. Shvets, A. O. (2020). Stability of freight wagons under the action of compressing longitudinal forces. Science and Transport Progress, 1 (85), 119-137. doi: 10.15802/stp2020/199485
11. Shvets, A. O. (2023). Influence of the instability form on the traffic safety of freight rolling stock. Advanced Engineering Days, 6, 111-113.
12. Malysheva, A. A. (1999). Influence of difference of diameters of the wheels on their wear. Transport. Stress loading and durability of a rolling stock, 2, 139-143.
13. Shvets, A. O. (2019). Gondola cars dynamics from the action of longitudinal forces. Science and Transport Progress, 6 (84), 142-155. doi: 10.15802/stp2019/195821
14. Myamlin, S., Neduzha, L., & Shvets, A. (2013). Research of friction indices influence on the freight car dynamics. Teka. Commission of motorization and energetics in agriculture, 13 (4), 159-166.
15. Myamlin, S., Neduzha, L., & Shvets, A. (2013). Technical condition of sliders as one of the factors influencing the dynamics of freight cars. Collection of scientific works DonIRT, 35, 65-72.
16. Muradian, L., Shvets, A., & Shvets, A. (2023). Some dynamic processes at longitudinally-transverse shift of the cargo. Scientific Journal of Silesian University of Technology. Series Transport, 120, 187-204. https://doi.org/10.20858/sjsutst.2023.120.12
17. Shvets, A. (2023). Multibody model of freight railcars interaction in a train. Transportation Energy and Dynamics, 217–241. https://doi.org/10.1007/978-981-99-2150-8_10