UDC 629.2

T. F. MOKRII, M. B. SOBOLEVSKA, H. M. KOVTUN, L. G. LAPINA, D. V. HOROBETS, S. S. PASICHNYK, V. V. MALIY

UKRAINIAN ROLLING STOCK RENEWAL ORIENTED AT INTEGRATION INTO THE EUROPEAN RAILWAY NETWORKS

The strategic aim of further development of the Ukrainian railways is rolling stock and infrastructure renewal to meet the demands of the Ukrainian economy, including a rapid integration into the European transport service. The paper presents the results of recent studies conducted at the Department of Statistical Dynamics and Multidimensional Mechanical System Dynamics, the Institute of Technical Mechanics of the National Academy of Sciences of Ukraine and the State Space Agency of Ukraine, with the aim to solve important problems in the development of the Ukrainian railway transport.

The studies were aimed at developing scientifically substantiated decisions on Ukrainian rolling stock renewal oriented at integration into the European railway networks. To do this, a cycle of theoretical and experimental studies was conducted at the department. Consideration was given to the problem of wheel–rail contact pair improvement by identifying a wheel profile that would offer an acceptable car ride performance and acceptable conditions of car–rail interaction both on the Ukrainian and the European railways and reduce vehicle and rail wear. The car ride performance of an articulated passenger train was simulated mathematically for its motion at different speeds along a track of arbitrary alignment and profile, and the effect of different car and track parameters on the ride performance was estimated. Energy-absorbing devices were developed to increase the passive safety of a speedy locomotive-hauled passenger train and a multiple-unit train in emergency collisions with obstacles according to the Ukrainian Standard DSTU EN 15227. Service loads on the load-bearing components of swap-body freight cars were estimated, and recommendations were developed on fasteners that would provide safe transportation of various freights in swap-body cars.

Based on the results of the studies, a number of design solutions were proposed for Ukrainian railway vehicle components. Their implementation will offer a sizeable economic benefit, increase the train speed and safety, improve the vehicle–track interaction, and facilitate the formation of an up-to-date home railway complex and its integration into the European railway networks.

Keywords: *Ukrainian railway transport renewal, freight and passenger service, wheel profile, articulated car, train operation safety, emergency collision, passive safety system, integration into the European railway service.*

1. National Economic Strategy 2030. URL: https://nes2030.org.ua/#rec246067109 (Last accessed on June 7, 2021). (in Ukrainian).

2. Kurgan N., Voznaya E. Interoperability improvement in the Austria-Slovakia-Ukraine-Rusia international railway service. Ukrainski Zaliznytsi. 2014. No. 12 (18). Pp. 24-33. (in Russian)

3. Gauge-changeable wheelset. URL: https://pikabu.ru/story/razdvizhnyie_kolyosnyie_paryi_6989147 Last accessed on January 6, 2020). (in Russian).

4. Xuel X., Ingleton S., Roberts J., Robinson M. qualitative comparison of the characteristics of articulated and non-articulated trains and their effects on impact. Proceedings of the Institution of Mechanical Engineers. Part F. Journal of Rail and Rapid Transit. January 2011. Pp. 24-37. https://doi.org/10.1243/09544097JRRT303

5. High-speed traffic. According to La Vie du Rail materials. Zheleznye Dorogi Mira. 2009. No. 7. Pp. 9 - 20. (in Russian).

6. Lipp A., Yon D., Mangler R. et al. Velaro high-speed train for Russia. Zheleznye Dorogi Mira. 2009. No. 1. Pp. 36 - 50.

7. Universal speedy electric train for the Spanish railways. According to Talgo materials. Zheleznye Dorogi Mira. 2009. No. 11. Pp. 37 - 40. (in Russian).

8. Wingler F. Crash-energy manangenent, Part II. URL: http://www.drwingler.com/wp-content/uploads/2016/08/Crash-Energy-Management.pdf (Last accessed on June 24, 2024).

9. Alstom Coradia Regional Trains. URL: https://www.railway-technology.com/projects/alstom-coradia-regional-trains/ (Last accessed on June 24, 2024).

10. Zderzenie dwóch pociągów w Warszawie. URL: https://deon.pl/swiat/wiadomosci-z-polski/zderzenie-dwoch-pociagow-w-warszawie,278115 (Last accessed on June 24, 2024).

11. Innovations WASCOSA flex freight system® with timber cassette swap body. URL: https://www.wascosa.ch/wagenpark/pdf/en/innovationen/inno_wascosa_flex_freight_system_timber_swap_body.pdf (last accessed on November 1, 2023).

12. TransANT: innovative freight cars. URL: https://www.railway.supply/transant-innovaczionnye-gruzovye-vagony/ (Last accessed on May 8, 2023).

13. Kiruna Wagon. URL: https://kirunawagon.com/wagons/modular-system (Last accessed on May 8, 2023).

14. Ushkalov V. F., Lashko A. D., Mokrii T. F. Freight car truck retrofit as a way of freight car running gear renewal. Vestnik VNIIZhT. 2013. No. 5. Pp. 8 - 15. (in Russian).

15. Markova O., Kovtun H., Maliy V. Modelling train motion along arbitrary shaped track in transient regimes. Rail and Rapid Transit. 2015. V. 229(1). Pp. 97-105. https://doi.org/10.1177/0954409713501806

16. Ushkalov V. F., Mokriy T. F., Malysheva I. Yu. Mathematical model of interactions between railway and track considering distributions of contact forces throughout contact spots. Teh. Meh. 2015. No. 2. Pp. 79-89. (in Rusian).

17. Sobolevska M., Telychko I. Passive safety of high-speed passenger trains at accident collisions on 1520 mm gauge railways. Transport Problems. 2017. V. 12. Iss. 1. Pp. 51 - 62. https://doi.org/10.20858/tp.2017.12.1.5

18. Ushkalov V. F., Mokrii T. F., Malysheva I. Yu., Bezrukavyi N. V. Wear-resistant wheel profile for a freight car with an increased axle load. Teh. Meh. 2018. No. 1. Pp. 20 - 29. (in Russian). https://doi.org/10.15407/itm2018.01.020

19. Ushkalov V., Mokriy T., Malysheva I., Lapina L., Pasichnik S., Bezrukavyi N. Reduction of freight car wheel wear of 1520 mm gauge railways.. - IOP Conf. Series: Materials Science and Engineering. 2020. V. 985. 012004. https://doi.org/10.1088/1757-899X/985/1/012004

20. Sobolevskaya M., Naumenko N., Gorobets D. Development of passive protection devices for a power head of a high-speed multiple unit train at its collisions according to DSTU EN 15227. IOP Conf. Series: Materials Science and Engineering. 2020. V. 985. 012016. https://doi.org/10.1088/1757-899X/985/1/012016

21. Markova, O., Kovtun, H., Maliy, V. Comparison of articulated and conventional passenger train dynamic characteristics at various motion regimes. Lecture Notes in Mechanical Engineering. 2022. Pp. 217-228. https://doi.org/10.1007/978-3-031-07305-2_23

22. Sobolevska M. B., Horobets D. V. Recommendations on manufacturing head car passive protection devices with the use of different materials. Teh. Meh. 2022. No. 2. Pp. 101 - 114. (in Ukrainian). https://doi.org/10.15407/itm2022.02.101

23. Mokrii T. F., Malysheva I. Yu., Lapina L. G., Bezrukavyi N. V. Passenger car wheel profile for the operation on the Ukrainian and European railways. Teh. Meh. 2022. No. 4. Pp. 111 - 120. (in Ukrainian). https://doi.org/10.15407/itm2022.04.111

24. Olofsson U., Telliskivi T. Wear, plastic deformation and friction of two rail steels - a full-scale test and a laboratory study. Wear. 2003. No. 254 (1-2). Pp. 80 - 93. https://doi.org/10.1016/S0043-1648(02)00291-0

25. Podielnikov I. V. Identification of typical shapes of worn rail heads in curves. Teh. Meh. 2009. No. 3. Pp. 39 - 43. (in Russian).

26. Ushkalov V. F., Lapina L. G., Mashchenko I. A. Simulated disturbances to study railway car dynamics. Zaliznychnyi Transport Ukrainy. 2012. No. 1. Pp. 38 - 41. (in Russian).

27. Bondarenko I., Lunys O., Neduzha L., Keršys R. Dynamic track irregularities modeling when studying rolling stock dynamics. Transport Means. Proceedings of the International Conference 2019-October. Pp. 1014-1019.

28. Lapina L. G., Malysheva I. Yu., Mokrii T. F. Study of the possibility of using disturbances formed from recorded track irregularities in the calculation of high-speed rail vehicle dynamics. Teh. Meh. 2022. No. 2. Pp. 115 - 122. (in Ukrainian).
https://doi.org/10.15407/itm2022.02.115

29. Mokrii T. F., Malysheva I. Yu., Lapina L. G., Pasichyk S. S. Wheel-rail interaction for a passenger car with the ITM-73ER new wheel profile in curves. Teh. Meh. 2023. No. 2. Pp. 84 - 90. (in Ukrainian).
https://doi.org/10.15407/itm2023.02.084

30. Mokrii T. F., Malysheva I. Yu., Pasichyk S. S. Wheel profile of a freight car with prospective trucks for the combined operation on the Ukrainian and European railways. Teh. Meh. 2023. No. 4. Pp. 90-103. (in Ukrainian)
https://doi.org/10.15407/itm2023.04.090

31. Markova, O., Kovtun, H., Maliy, V. Mathematical modeling of articulated passenger train spatial vibrations. Teh. Meh. 2021. No. 2. Pp. 91 - 99.
https://doi.org/10.15407/itm2021.02.091

32. Ukrainian State Standard 7774:2015. Locomotive-hauled main-line passenger cars. General technical regulations for the calculation and design of car hardware. Introduced on April 4, 2016. Kyiv: Ukrainian Research Center for Standardization, Certification, and Quality, 2017. 150 pp. (in Ukrainian).

33. Ukrainian State Standard EN 12663-1:2018. Railway Transport. Requirements for railway vehicle body design. Part 1. Locomotives and passenger cars (and an alternative method for freight cars) (EN 12663-1:2010 + A1:2014, IDT). URL: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=80589 (Last accessed on June 24, 2024). (in Ukrainian).

34. Ukrainian State Standard EN 15227:2015. Railway transport. Requirements for rail vehicle crashworthiness (EN 15227:2008+A1:2010, IDT). URL: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=74051 (Last accessed on June 24, 2024). (in Ukrainian).

35. Sobolevska M., Horobets D. The passive safety system of a high-speed multiple-unit train. MATEC Web of Conferences. 2024. V. 390. 02002. URL: https://www.matec-conferences.org/articles/matecconf/pdf/2024/02/matecconf_eot24_02002.pdf. (Last accessed on July 10, 2024).
https://doi.org/10.1051/matecconf/202439002002

36. Sobolevska M. B., Horobets D. V. Features of fastening a swap body on the undercarriage of a freight car. Teh. Meh. 2023. No. 4. Pp. 76 - 89. (in Ukrainian).
https://doi.org/10.15407/itm2023.04.076

37. Ukrainian State Standard EN 12663-2:2018 (EN 12663-2:2010, IDT) Railway Transport. Design Requirements for Rail Vehicle Bodies. Part 2. Freight Cars (EN 12663-2:2010, IDT). URL: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=81572 (Last accessed on July 15, 2024).

.

Received on July 15, 2024,
in final form on September 20, 2024