3. Mansingh B. B., Selvakumar K. S., Kumar S. R. Automation in unmanned railway level crossing. *2015 IEEE 9th International Conference on Intelligent Systems and Control (ISCO)*. 2015. P. 1–4. DOI: 10.1109/ISCO.2015.7282344.

4. Dhande B. S., Pacharaney U. S. Unmanned level crossing controller and rail track broken detection system using IR sensors and Internet of Things technology. *2017 International Conference on Inventive Communication and Computational Technologies (ICICCT)*. 2017. P. 206–210. DOI: 10.1109/ICICCT.2017.7975189.

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OPERATION OF TRAINS WITH MAGNETIC SUSPENSION ON THE WAY OF RAILWAY TRANSPORT DEVELOPMENT

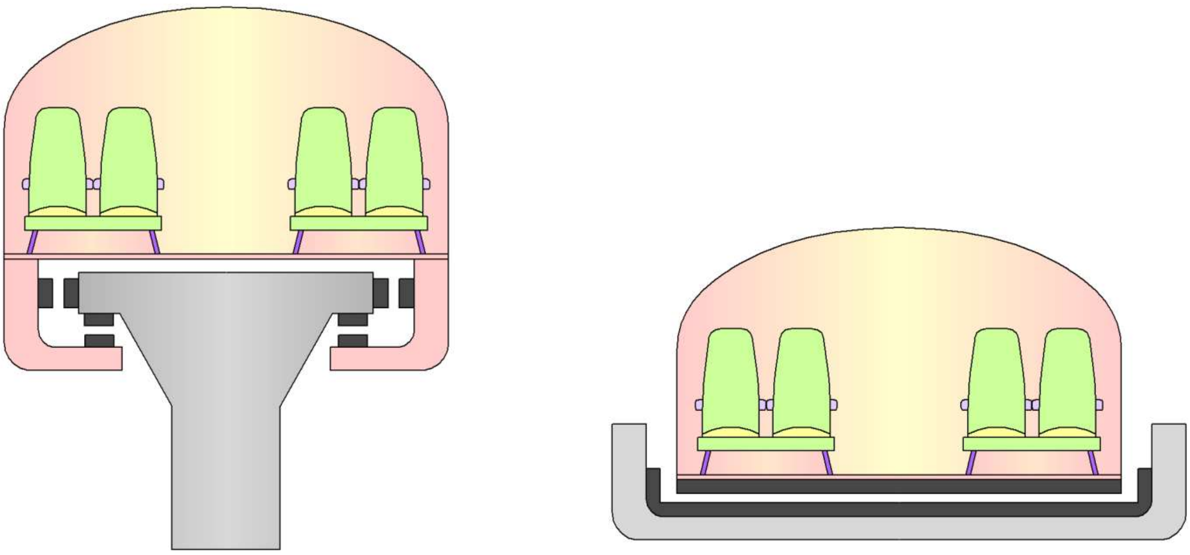
Every year there are more new and improved technologies that do not bypass railway transport. They make it possible to make passenger and cargo transportation economical, convenient and accessible to most segments of the population. The result of the development of modern technologies is the creation of trains with magnetic suspension [1, 2].

A magnetic train is a train on a magnetic suspension that moves and is controlled by magnetic forces. Unlike ordinary trains, such a train does not touch the surface of the rails during movement. At the same time, friction is eliminated due to the presence of a gap between the train and the canvas surface. The only braking force is aerodynamic resistance [3, 4].

Magnetic suspension technologies are based on three main subsystems. These include stabilization, acceleration and levitation. Two main technologies of magnetic suspension are known: EMS and EDS [5] (Fig. 1).

Trains designed with electromagnetic suspension technology for EMS levitation apply an electromagnetic field whose strength changes over time. The practical implementation of this system is similar to the operation of railway transport. In this case, a T-shaped rail fabric made of conductors is used. Instead of wheel pairs, the train uses a system of guide and support magnets, which are located on the edges of the T-shaped track parallel to the ferrimagnetic stators.

Among the advantages of EMS technology is the levitation system, which works thanks to batteries installed on the walls of the train. They are charged by linear generators built into the support magnets. Thus, in the event of a stop, the train will be able to levitation on batteries for a long time.



a) *b*)

Fig. 1. Magnetic suspension technologies:
a – EMS; *b* – EDS

The main disadvantage of the EMS technology is the distance between the stator and the reference magnet, which is equal to 15 mm. This gap is controlled by special automated systems depending on factors including the erratic nature of the electromagnetic interaction.

For trains designed with EDS electrodynamic suspension technology, levitation is carried out due to the interaction of the magnetic field in the canvas and the field created by superconducting magnets on the walls of the train. On the basis of EDS technology, electromagnets and coils conduct electric current at the moment of power supply. Superconducting electromagnets conduct electric current even after the power source is turned off. Therefore, it is possible to save energy by cooling the coils, as the cryogenic cooling system used to maintain lower temperatures in the coils is quite expensive.

The main advantage of EDS technology is high stability. A repulsive force occurs when the distance between the canvas and the magnets is slightly reduced. It returns the magnets to their original position. As the distance increases, the force of repulsion decreases and the force of attraction increases. This leads to stabilization of the system.

Disadvantages of EDS technology include maintaining sufficient force to levitate the train, which is provided only at high speeds. At low speeds in the front and rear parts of the magnets in the web, there is a frictional force acting against them. Therefore, the train must be equipped with wheels that can provide movement at low speeds of up to 100 km/h.

Of the considered magnetic suspension technologies for train movement, the EDS technology is most often used, as it has high stability. That is, the distance between the train and the canvas remains unchanged without the use of electrical energy, which ensures safe transportation of passengers. In addition, this technology is potentially the most economical.

References

1. Nerubatskyi V., Plakhtii O., Hordiienko D.,Podnebenna S. Synthesis of a regulator recuperation mode a DC electric drive by creating a process of finite duration. *2021 IEEE 3rd Ukraine Conference on Electrical and Computer*

Engineering (UKRCON). 2021. P. 272–277. DOI: 10.1109/UKRCON53503.2021.9575792.

2. Nerubatskyi V. P., Plakhtii O. A., Hordiienko D. A., Syniavskyi A. V., Philipjeva M. V. Use of modern technologies in the problems of automation of data collection in intellectual power supply systems. *Modern engineering and innovative technologies*. 2022. Issue 19. P. 38–51. DOI: 10.30890/2567-5273.2022-19-01-058.

3. Nasiri-Zarandi R., Hekmati A. A Review of Suspension and Traction Technologies in Maglev Trains. *2019 International Power System Conference (PSC)*. 2019. P. 129–135. DOI: 10.1109/PSC49016.2019.9081455.

4. Zhai D., Lai X., Meng J., Liu G., Wu J., Xiao S. The Hybrid Suspension System for Middle-to-Low-Speed Maglev Trains Considering the Prevention of Firm Absorption. *IEEE Transactions on Transportation Electrification*. 2022. Vol. 8, No. 1. P. 1482–1492. DOI: 10.1109/TTE.2021.3109166.

5. Inoue S., Fujimoto Y. PM Magnetic Levitation Train Using Hybrid Electromagnetic- and Electrodynamic-Suspension System. *2022 International Power Electronics Conference (IPEC-Himeji 2022 – ECCE Asia)*. 2022. P. 415–421. DOI: 10.23919/IPEC-Himeji2022-ECCE53331.2022.9806950.