

Innovative Risks of Introducing Advanced Technical Solutions in Transport**M. Gorbunov¹, V. Nozhenko², M. Kovtanets³, O. Porkuyan⁴**¹*Volodymyr Dahl East Ukrainian National University, Central Avenue 59-a, 93400 Sewerodonetsk, Ukraine, E-mail: gorbunov0255@gmail.com*²*Volodymyr Dahl East Ukrainian National University, Central Avenue 59-a, 93400 Sewerodonetsk, Ukraine, E-mail: vladymyrnozhenko@gmail.com*³*Volodymyr Dahl East Ukrainian National University, Central Avenue 59-a, 93400 Sewerodonetsk, Ukraine, E-mail: kovtanetsm@gmail.com*⁴*Volodymyr Dahl East Ukrainian National University, Central Avenue 59-a, 93400 Sewerodonetsk, Ukraine, E-mail: olga.porkuyan@gmail.com***Abstract**

This article contains the analysis of possible investment ways for the development of industrial technologies on the example of railway transport and the associated decision-making process. A risk assessment method was used in this study when introducing innovative technical solutions for improving friction interaction in a two-point «wheel-rail» contact, which is based on the Monte Carlo method. The result of simulation modeling is forecasting of the most and least risky technical solutions for introducing them in railway transport and reducing such risks.

KEY WORDS: *making decisions, risk, innovation activity, studies, risk management, introduction, railway transport*

1. Problem Statement

Aging of Ukrzaliznytsya, JSC fleet of trains, the technical condition of which does not meet modern requirements, the end of the normative life of most locomotives, freight, passenger cars and other rolling stock require the introduction of innovative technologies and technical solutions.

Investments are the main method of extended reproduction of capital stock. Innovative investment is one of the promising investment methods in the advanced countries of the world. A study of the state of innovation in the railway industry of Ukraine indicates that its level remains low. Namely, the share of enterprises that implemented innovations is about 11% - 12% [1, 2]. The main reason, which hinders innovation in industry was and remains the risk of introducing new technical solutions, according to the State Committee on Statistics of Ukraine [3].

Decision-making support suite of tools is essential for increasing the efficiency of decision-making on the implementation of innovative projects at a machine-building enterprise. It shall include an assessment of the level of risks and economic security, which shall be carried out using expert assessments and allows increasing the likelihood of making the right managerial decision.

2. Actual Scientific Researches and Issues Analysis

A study of foreign experience indicated that investments in innovative activities of enterprises are on average highly cost-effective, despite the significant risk of such investments and a long payback period. Moreover, investments in scientific developments bring effect not only to a single enterprise, which implements them, but also to society as a whole [4]. While assessing the efficiency of investments in the innovative activity of enterprises, there is a risk that when choosing individual innovations for such studies, it is necessary to consider those that provide a high return on investment.

Traffic safety during the transportation of freight and passenger trains is the main criterion for assessing the risk in railway transport. It is customary to characterize the level of safety with the probability of the implementation of certain dangers and threats, occurring phenomena and processes that are accompanied by the formation of factors that negatively affect the person and the environment. This is the mathematical expectation of the most important types of damage [5].

Possible scenarios for the implementation of innovative technical solutions can lead to significant material losses. This has led to the creation and practical application of system approaches, methods and tools for assessing the risk of their introduction.

The risk assessment process includes the following:

- description of the system, hazard identification and generation of possible scenarios of accidents and the consequences of certain events that are related to the transportation process;
- assessment of the impact or consequences of influence of such events on people, tangible assets and the environment;
- calculation of probability of such an adverse result in practice and its consequences, depending on various operational and organizational safety measures;
- quantitative description of risk levels beyond the boundaries of the object in terms of consequences and

probability;

- assessment of risk levels by the means of comparing them with certain quantitative criteria.

Monte Carlo method is one of the methods that allows quantifying the risks of implementation, namely, simulating random variables in order to calculate the characteristics of their distributions. Simulation according to Monte Carlo method allows building a mathematical model for a process with uncertain parameter values. And, while knowing the probability distributions of process parameters, as well as the relationship between parameter changes (correlation), get the distribution of project profitability.

3. Materials and Results of the Study

Different types of projects have different vulnerability to risks. It is revealed during simulation. Simulation modeling according to Monte Carlo method has several stages.

Creation of a forecast model is the first stage of the risk analysis process. Such a model determines the mathematical relationships between numerical variables that relate to the forecast of the selected financial indicator.

The source data of the current forecast of economic benefits and expenses shall be indicated in the tables below (Table 1). Their maximum and minimum values, in which each of the technical solutions that were suggested for implementation was investigated, shall be taken from literary sources [6-9].

The model for calculating the NPV indicator (net present value) is usually used as a basic model for the analysis of investment risk. The NPV of the project will be positive, and the project itself will be effective in case if the calculations indicate that the project covers its internal costs, and also brings capital owners an income not lower than they set.

Simulating of a forecast model is the second stage. A sufficiently large volume of random scenarios is generated. Each of these scenarios corresponds to certain values of cash flows. The generated scenarios shall be gathered together and processed statistically in order to determine the share of scenarios that correspond to a negative NPV value. The ratio of such scenarios to the total number of scenarios gives an assessment of the risk of investment.

Distributions of probabilities of variable models impose the possibility of choosing values from certain ranges. Distributions are mathematical tools that help weighting all the possible outcomes. This controls the random selection of values for each variable during the simulation. Information, which is contained in a probability distribution with multiple values, is used during risk analysis.

Table 1

Initial data for forecasting the resulting economic benefits and expenses while introducing innovative solutions

Economic effect factors			Cost factors during introduction		
Designation	Name	Meas. unit	Designation	Name	Meas. unit
ES	Energy saving	UAH	IC	Intellectual expenses	man/hour
RS	Resource saving	UAH	MC	Material expenses	UAH
LS	Labor saving	UAH	LC	Labor costs	man/hour
EC	Environmental saving	UAH	SC	Maintenance service	man/hour

During the simulation, the values of the variables shall be randomly selected within the boundaries of the given ranges, according to the distributions of probabilities and correlation conditions. The value of the project efficiency indicator shall be calculated for each set of such variables. An example of calculating project efficiency is shown in Fig. 1. All obtained values shall be stored for subsequent statistical processing.

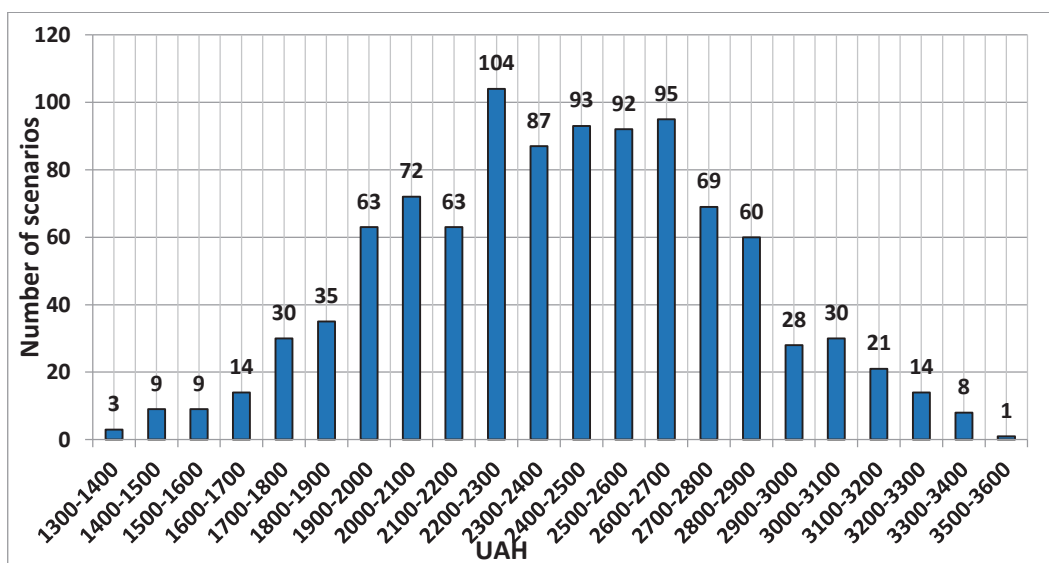


Fig. 1 Example of calculating project efficiency

For the practical implementation of the risk assessment of the introduction of new technical solutions in transport according to the Monte Carlo method, simulation shall be performed in the Microsoft Excel software package. This package generates random numbers that are calculated according to a specific algorithm based on the use of a pseudo-random number sensor. A feature of this package is the fact that it can generate correlated random numbers.

The processing and interpretation of the results obtained at the stage of model simulation is the final stage of risk analysis. Each simulation represents an event probability, which is equal to:

$$p = \frac{100}{n}, \tag{1}$$

where p – probability of a single prediction; %; n – sample size.

As a risk measure, it is advisable to use the security of the simulated project, which is expressed as a percentage, during investment designing (Fig. 2).

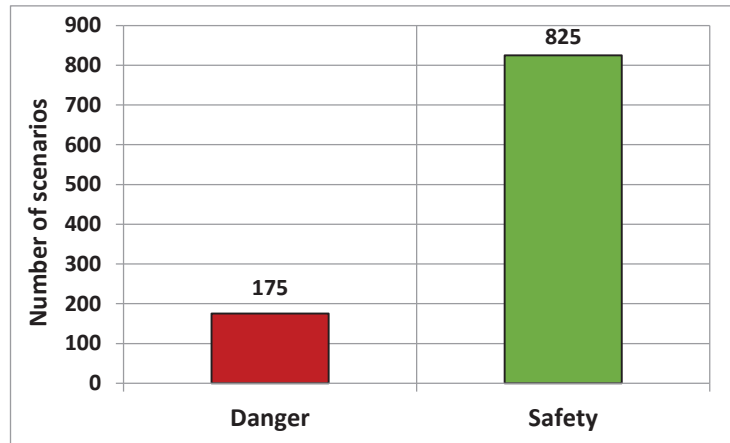


Fig. 2 An example of simulating the security of an investment project

For sake of graphic example, let’s consider advanced technologies, namely, methods for optimizing the frictional interaction of a wheel with a rail, which is the basis for the safety of rolling stock. They are applicable in railway transport and theoretically are cost effective. However, in practice, the solution of these issues is associated with a certain degree of risk, which is currently difficult to predict and take into account. We will be based on methods for optimizing the frictional interaction of wheels with rails that are shown in Fig. 3 [9].

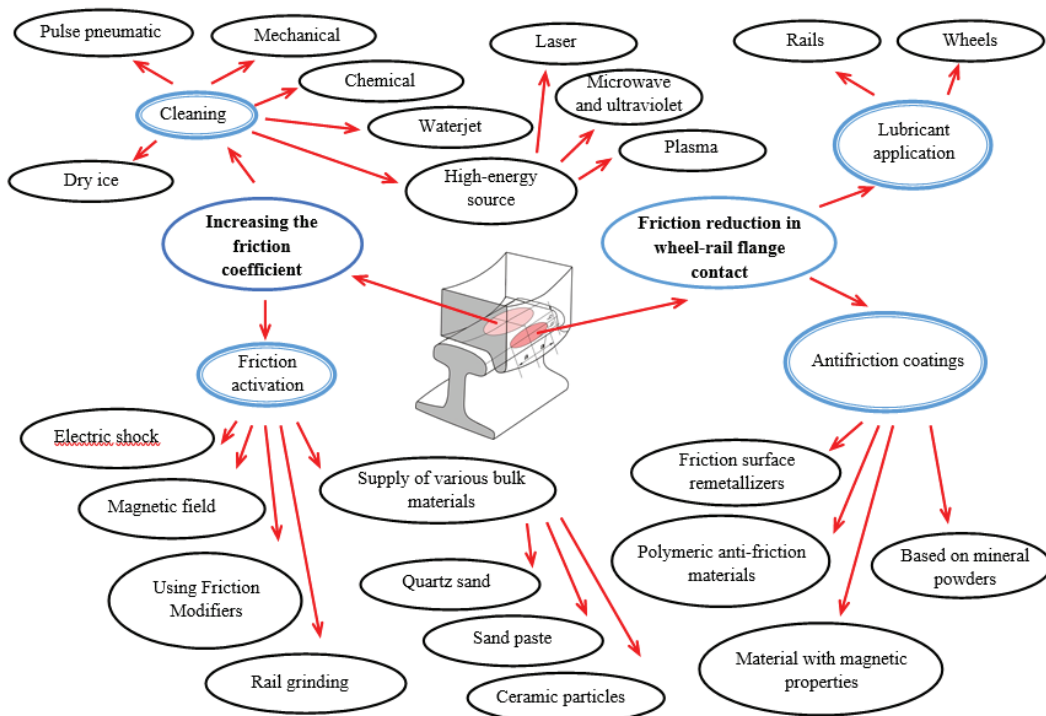


Fig. 3 Methods for optimizing the frictional interaction of wheels with rails

Risk assessment of the introduction of innovative technical solutions that are indicated above was carried out. The results of this are shown in Figs. 4 and 5.

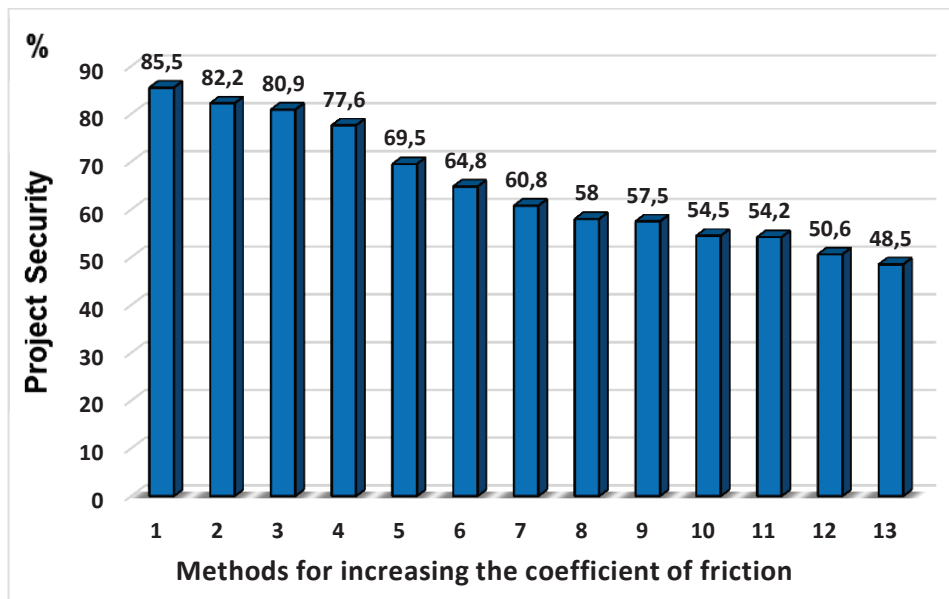


Fig. 4 Risk assessment of the introduction of innovative methods for increasing the coefficient of friction 1 – current electricity activation, 2 – pneumo-pulse cleaning, 3 – pneumo blasting, 4 – rail abrasion, 5 – dry-ice cleaning, 6 – laser cleaning, 7 – use of friction modifiers, 8 – plasma stripping, 9 – microwave and UV cleaning, 10 – supply of ceramic particles, 11 – chemical cleaning, 12 – cleaning using magnetic field, 13 – mechanical treatment

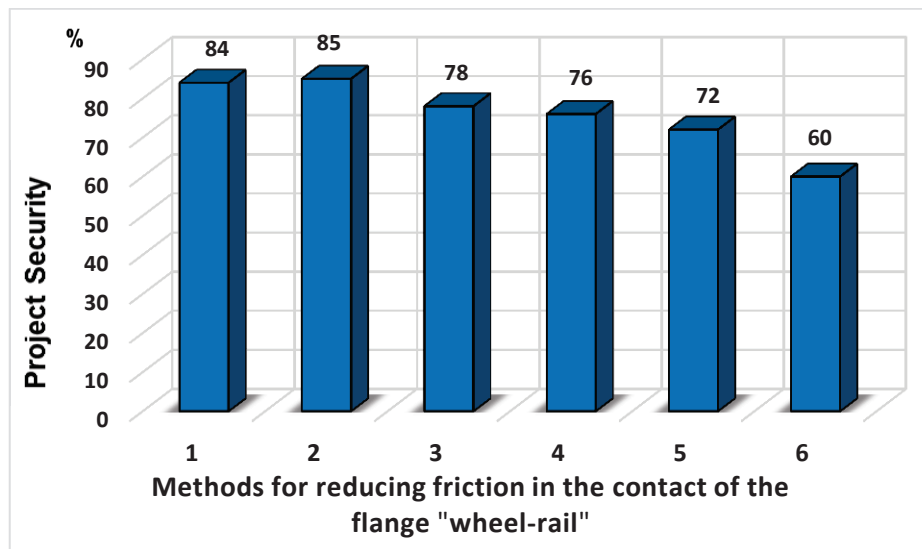


Fig. 5 Risk assessment of the introduction of innovative methods for reducing the friction in the «wheel flange – rail» contact: 1 – application of lubricants on flanges of set of wheels, 2 – application of lubricants on rails, 3 – application of lubricants that have magnetic properties, 4 – application of polymer antifricition materials, 5 – application of mineral-based powders, 6 – use of remetalizators on the friction surface

Use of the suggested decision-making procedure will increase the level of economic security during the introduction of innovative technical solutions in railway transport that are aimed at reducing real hazards and risks of economic security of the enterprise, the optimal distribution of resources for the innovative development of railway production.

A risk assessment method was used in this study when introducing innovative technical solutions for improving friction interaction in a two-point «wheel-rail» contact, which is based on the Monte Carlo method. In this case the results of the simulation coincide with the decision for choosing the most promising ways in order to improve the contact conditions in the «wheel-rail» tribocoupling using expert assessment [10, 11]. The least risky technical solutions for the introduction of railways that are aimed at reducing them were identified as a result of the simulation.

4. Conclusions

On the basis of the analysis of theoretical and experimental studies of friction contact, it can be stated that control of the mechanical component is not sufficient for achieving consistently high traction qualities of the rolling stock. Therefore, it is suggested to control the clutch of the tribological «wheel-rail» system by controlling and regulating the local-mechanical temperature component in the range from 250 to 450°C, depending on the frictional conditions of contact.

Based on the results obtained, an algorithm for controlling the thermomechanical loading of a local tribological contact was developed, consisting in cleaning and cooling the contacting surfaces with a two-phase flow of dry ice granules and forced cooling with compressed air using a Ranque-Hilsch tube in order to achieve a stable contact temperature.

Acknowledgement

This study was partially financed at the expense of grant (state registration № 0118U001668) from the Research Council of Lithuania and the Ministry of Education and Science of Ukraine, in cooperation between Volodymyr Dahl East Ukrainian National University, Ukraine; and Vilnius Gediminas Technical University, Lithuania, 2017-2018. This study was also partially financed at the expense of a state theme DN-01-20 «Theory and practice of a systematic approach to creating a new rolling stock of railways with multifunctional control of thermomechanical loading «wheel-block-rail» to improve safety, energy and resource conservation», which is financed by the Ministry of Education and Science of Ukraine (state registration № 0120U102220).

References

1. Industry innovation. Economist directory. K.: 2019. №2. 94 p.
2. **Gorbunov, M.; Pistek, V.; Kovtanets, M.; Nozhenko, O.; Kara, S.; Kučera, P.** 2017. Research to improve traction and dynamic quality of locomotives, JVE International LTD. *Vibroengineering Procedia* 13: 159-164.
3. **Hristianovskij, V.; Shherbina, V.** 2000. Economic risk and methods for measuring it. Donetsk. DonNU, p. 197.
4. **Buzko, I.R.; Vartanova, O.V.; Golubenko, G.O.** 2020. Strategic management of investments and innovative activities of the enterprise. Monograph. – Lugansk: publishing house SNU them. V. Dahl. p. 176.
5. **Elohin, A.N.; Kapica, S.P.; Kurdjumov, S.P.; Malineckij, G.G.** 2003. Risk analysis and management: Theory and Practice. – 2-e izd. —M.: OOO «PoliMedia», Synergetics and future forecast. — M.: Editorial URSS.
6. **Gorbunov, M.; Kovtanets, M.; Bureika, G.; Kovtanets, T.** 2019. Reducing the wheel-rail system wear intensity with thermomechanical impact, The proceedings of the 23rd International Scientific Conference. *Transport Means* 2019, 1260-1265.
7. **Gorbunov, M.; Kovtanets, M.; Kostyukevich, A.; Nozhenko, V.; Vaičiūnas, G.; Steišūnas, S.** 2018. Development of the theory and methodology of controlling the local tribological contact thermomechanical loading. The proceedings of the 22nd International Scientific Conference. *Transport Means* 2018, 1383-1388.
8. **Kostyukevich, A.; Gorbynov, N.; Nozhenko, V.; Kovtanets, M.; Tsiganovski, I.** 2012. Friction interaction management in two-point «wheel-rail» tribocontact // Silesian University of Technology Faculty of Transport (Poland). – *Transport Problems* 7(3): 53-59.
9. **Gorbunov, M.; Prosvirova, O.; Kovtanets, M.; Nozhenko, V.; Bureika, G.; Skrickij, V.** 2018. Experimental study of the influence of friction surfaces cooling parameters on the efficiency of the braking system of a railway vehicle operation. The proceedings of the 22nd International Scientific Conference. *Transport Means* 2018, 1435-1438.
10. **Koltynjuk, B.A.** 2003. Investments. Textbook. SPb. Publishing house Mihajlova V.A. p. 848.
11. **Golubenko, A.L.; Gorbunov, N.I.; Kovtanets, M.V.; Nozhenko, V.S.; Tsyanovsky, I.A.; Chmeljov, V.V.** 2010. Improving the adhesion of locomotives by controlling the friction interaction "wheel-rail"/ A.L. Golubenko, // *Bulletin of Volodymyr Dahl East Ukrainian National University.* – Lugansk: SNU them. V. Dahl. Part 1, 5(147): 7-14.