

ANNOTATION

for dissertation work for the degree of doctor of philosophy (PhD) in the specialty 6D071300 – «Transport, transport equipment and technology»

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IMPROVING THE DESIGN OF ELASTIC ELEMENTS OF THE CREW PART OF THE TE33A SERIES DIESEL LOCOMOTIVE TO IMPROVE DYNAMIC PERFORMANCE

Assessment of the current state of the solved scientific or scientific-technological problem.

Railway engineering is one of the main strategically important components of railway transport of the Republic of Kazakhstan, which produces and produces cargo and passenger rolling stock. During all the years of independence of the Republic of Kazakhstan, railway engineering has undergone major changes, including in terms of renewal and modernization of the locomotive fleet.

The length of the operational length of railway lines of the Republic of Kazakhstan at the beginning of 2021 was 16063 km, of which 26.4% were electrified, the share of double-track lines was – 31.4%. The main part of the transport takes place on non-electrified sections of railways, where – diesel locomotives are used as locomotives. At the beginning of 2022, 1846 locomotives were registered in the republic, including 1228 (67%) diesel locomotives. Seven of the ten locomotives available at the beginning of this year were considered to be worn out. This is reported in the concept of transport and logistics potential of Kazakhstan developed by the Ministry of industry and infrastructure development until 2030, presented for public discussion.

Compliance of the topic with the directions of development of science or state programs. The dissertation work was carried out in the framework of research work: Improvement of the design of elastic elements of the crew of the diesel locomotive of the TE33A series to improve dynamic indicators.

Relevance of the topic. Heat locomotives of the TE33A (Evolution) series of domestic production «Lokomotiv Kurastyr Zauyty» (g. Astana) is widely used in

the railway infrastructure of Kazakhstan, transportation of large freight and passenger trains. Of these, about 400 units (more than 32%) have been releasing in the last 5-10 years. Consequently, taking into account that these diesel locomotives have a service life of about 40 years, and in the future the fleet of locomotives will be replenished with diesel locomotives of domestic production of this series, the repair and maintenance of rolling stock in the Republic of Kazakhstan will mainly switch to them.

Operated diesel locomotives of the TE33A series meet all the requirements for operation in railway transport, however, have a number of drawbacks associated with the design of the crew part of the locomotive. Namely, structurally, the crew part of the diesel locomotive is made according to unified technology in the form of using a balanced spring suspension individually for each axis, consisting of helical springs and hydraulic vibration dampers using jaw axles, which causes frequent breakdowns leading to the repair of railway rolling stock.

To improve operational performance, it is required that the crew part of the rolling stock could withstand an axial load of up to 25 tons / s, and ensure the reliability of components and parts with minimal maintenance up to 1 million kilometers with speeds up to 120 km/h. In other words, the relevance of the chosen topic is primarily related to the economic aspect: improving the dynamic performance of a locomotive can increase driving speeds, as well as reduce fuel consumption and wear of parts and mechanisms, which will lead to reduced operating costs and increased productivity in the railway industry.

Improving the driving performance of locomotives to increase driving speeds increases the requirements for the use of high-quality components and parts in their design in order to reduce their wear during operation. Special attention should be paid to the running elements of the spring suspension of trolleys, this is one of the most important parts of the rolling stock that ensures traffic safety on the railway.

One of the promising directions in the field of suspension of railway carriages is the use of a pneumatic suspension system. A pneumatic spring (pneumatic spring, pneumatic cushion, pneumatic cylinder) is an elastic element of the air suspension of vehicles located between the wheel axle and the frame/body of the vehicle. The advantages of this concept are the ability to effectively increase static deflection using simple means, as well as the ability to provide vibration damping. In addition, the option of automatic control of the amount of air in the element is provided, which allows you to maintain a constant static deflection of the suspension under various loads, while changing the stiffness over a wide range. A significant advantage is also the exclusion of metal contact between the running gear and the body, which leads to the absence of transmission of vibrations and

noise from interaction with the rail track to the body. Thus, research aimed at developing methods and technologies for using pneumatic compressors in the running gear of TE33A locomotives in order to increase their dynamic performance, such as traffic efficiency, load resistance, vibration reduction and increased passenger comfort, are of direct economic interest to railway companies and the state as a whole.

The goals and objectives of the theoretical and experimental research are formulated on the basis of a comprehensive analysis of modern means and methods for increasing the dissipative ability of pneumatic suspension of sprung masses of traction rolling stock.

Objective and objectives of the study.

The aim of the work is to develop the design and manufacturing technology of elastic elements of spring suspension of diesel locomotive TE33A series, contributing to the improvement of dynamic characteristics to increase productivity and safety of its operation.

To achieve this goal, the following objectives of the study are defined:

- to analyze the existing methods of pneumatic spring suspension in locomotives to identify their advantages and disadvantages;
- to carry out measurements and numerical modeling of the dynamic characteristics of a diesel locomotive with current elastic elements to determine areas that need improvement;
- on the basis of analysis and evaluation, develop improved designs of elastic elements that contribute to more effective suspension and reduction of vibrations; to study the technological aspects of manufacturing new elastic elements, including the choice of materials and processing methods;
- carry out laboratory and field tests of new elastic elements to verify their effectiveness and compliance with safety requirements;
- analyze the economic aspects of the introduction of new designs and technologies, including production costs and potential savings.

Object of research. The object of the dissertation research is the design of the crew part of the diesel locomotive series TE33A (Evolution), namely the mechanisms and assemblies of elastic elements and their components.

The subject of the dissertation work is the design and properties of the elastic elements of the crew part of the diesel locomotive of the TE33A series and their influence on the dynamic indicators of movement.

Research methods. Theoretical and experimental studies were conducted using various general scientific and special methods. The basic principles of fundamental and applied sciences, such as elasticity theory, theoretical mechanics and mathematical modeling, were used to conduct theoretical research. These

principles were used to evaluate dynamic processes in mechanisms and components of vehicles, as well as to study the interaction of rolling stock with the railway track. As part of the experimental research, modeling of the processes of pneumatic springs and springs was used to measure forces in order to determine the driving characteristics of a locomotive in dynamics. The obtained results were processed using methods of mathematical statistics.

Information base of research. When writing the dissertation research, an extensive range of literature sources related to the research and application of air suspension in transport was used. Numerous works of prominent domestic and foreign scientists are devoted to this topic, such as: Kuznetsov A.B., Kutsenko S.M., Lapin A.H., Pakhomov M.P., Galiev I.I., Pevzner Ya.M., Ravkin G.O., Savushkin S.S., Filippov V.V., Kaspakbaev K.S., Hakobyan P.A., Biderman V.L., Vitashevsky E.P., Galashin V.A., Gorelik A.M., Kofman, Jarvis, Kaiserling, Schmucker, Falbuch, Hofer, Bryukha, Masaharu Kunieda, Matsudaira and many others.

Degree of scientific development of the problem. Despite the extensive literature in this field, including both fundamental and applied research, new locomotives do not always meet modern requirements for dynamics, reliability in operation and impact on the railway track. With increasing axial loads and increasing speeds, this problem becomes more important. Therefore, it is advisable to conduct additional theoretical and experimental studies in order to develop modern running gear of vehicles that ensure the achievement of high dynamic and reliable performance under operating conditions comparable to current standards.

Basic provisions for protection. Based on the results of the study, the following scientific provisions of the dissertation are formulated:

- measurements and numerical modeling of the dynamic characteristics of a diesel locomotive with current elastic elements are carried out, allowing to determine specific areas requiring improvement, and quantitative estimates of these changes are given. It is shown that the existing elastic elements do not provide sufficient rigidity and depreciation, which leads to increased vibrations, wear of parts and components of the locomotive;

- new designs of elastic elements have been developed, which contribute to a more effective suspension of the crew part of the diesel locomotive and a decrease in vibrations, which improves the dynamic characteristics of the diesel locomotive as a whole. A balanced combined pneumatic spring device is proposed, consisting of a helical spring and a pneumatic spring, having a synergistic effect, providing high rigidity, cushioning and wear resistance. Also proposed alternative – combined elastic elements consisting of a polymer shell and profiled metal elements;

- the technological aspects of the choice of materials and processing methods for the production of helical springs in combined elastic elements are investigated. The technology of production of hot deformation springs is established, based on methods of winding in hot condition, thermal and hydro-sand blasting. It is shown that these technologies allow to obtain high-quality products with specified geometric parameters and mechanical properties;

- laboratory tests of new elastic elements were carried out, the results of which confirm their effectiveness and compliance with safety requirements. It is revealed that the new elastic elements have higher rigidity and depreciation compared to the current ones, which leads to a decrease in vibrations, an increase in the speed of movement by 5-10% and an increase in comfort and safety of movement;

-economic assessment of the introduction of new structures and technologies for the production of combined elastic elements was carried out. Potential economic benefits and production costs are determined. It is shown that the introduction of new elastic elements leads to a decrease in the cost of fuel, repair and maintenance of diesel locomotives, as well as to an increase in profit from transportation.

Scientific novelty of the research:

- a comprehensive analysis of the work on the use of elastic elements, including pneumatic, which are used on railway rolling stock;

- new designs of locomotive pneumatic suspension devices have been developed (1 patent for invention has been obtained, the second application of the);

- the relationship between the dynamic characteristics of the locomotive and the characteristics of the pneumatic suspension system has been established. Based on the results obtained, an integrated pneumatic spring suspension system of a locomotive with the parameters proposed in this scientific study has been developed.

Theoretical and practical significance.

Theoretical studies and calculation methods, as well as the technology of manufacturing parts of combined pneumatic springs can be used to create the design of elastic elements when suspending rolling stock, including for locomotives and wagons.

The created designs of combined pneumatic springs for suspension in the second stage of locomotives have practical value, as the pneumatic spring suspension of the locomotive, performing a multi-purpose function (elastic depreciation of vertical and horizontal oscillations of the body), contributes to a significant improvement in the navigation qualities of the diesel locomotive and the high stability of the dynamic performance of the crew on the way of different condition.

Personal contribution of the applicant. The main conclusions presented for consideration in this dissertation have been carefully analyzed and presented by the author of the study. Among them, the results of theoretical and practical research conducted within the framework of the activities of JSC NC "KTZ" during the reporting period are highlighted. The work also highlights the devices, principles of operation and design of mechanisms and components of rolling stock, including detailed technical characteristics of each element. This analysis is based on the author's own research, representing an original contribution to the understanding of the topic.

Approbation and implementation of the research results: The recommendations presented on the basis of theoretical research were introduced into the design of pneumatic suspension during the modernization of the TE33A diesel locomotive at the enterprises of NC KTZ JSC, the research materials were successfully integrated into the educational process at the Department of Transport Engineering, Mechanical Engineering and Standardization of the International Transport and Humanities University, designed for training in disciplines: "Theory and design of the locomotive" and "Diesel locomotives". The main theses of the dissertation were presented at a scientific and practical conference and at a seminar of the Scientific and Technical Council of the International Transport and Humanitarian University.

Publications: Twenty works have been published on the subject of the dissertation. Of these, 3 articles from the Scopus database, 3 articles in collections of international scientific and practical conferences, 13 Articles in the publications recommended by the Committee for Quality Assurance in the field of education and science of the Ministry of Education and Science of the Republic of Kazakhstan and 1 patent for invention.

Contribution of the dissertation to the preparation of publications.

Drawing up plans for articles, writing sections, discussing the results of research and conclusions, drafting articles:

1 Обеспечение дополнительной устойчивости локомотива.

2 Применение системы Клуб-У на современных локомотивах.

Подбор материалов для обзора, написания обзора и введения, написание отдельных разделов и их результатов, оформление статей:

3 Вопросы улучшения динамических характеристик тягового подвижного состава

4. Применение кранов машиниста электронного типа

5 Важнейшее условие достижения ритмичности в пропуске поездов – организация труда и отдыха локомотивных бригад

6 Mathematical and computer models in estimation of dynamic processes of vehicles.

- 7 Формирование состава на железнодорожном пути с различной колеей.
- 8 Патент №34467- Пневмоподвешивание локомотива.
- 9 Влияние рессорного подвешивания локомотива на износ колесной пары
- 10 Перспективы улучшения горизонтальной динамики локомотива
- 11 Конструктивные особенности резино-кордных упругих элементов
- 12 Расстройство железнодорожного пути при воздействии подвижного состава
- 13 Перспектива улучшения пропуска контейнерных поездов
- 14 Применение двигателей, работающих на воде.
- 15 Станция Достық в роли логистического оператора международных перевозок
- 16 Модернизация локомотива с целью улучшения его динамических характеристик
- 17 Перспективы внедрения высокоскоростного движения в Казахстане
- 18 Оптимизация технико-технологических параметров работы станции и параметров грузовых поездов.
- 19 Adaptive frame of universal vehicle course.
- 20 Design of adaptive suspension for universal vehicle course

Work structure. The thesis consists of an introduction, five sections, an opinion set out on 131 pages, contains 65 figures, 14 tables, 84 sources and applications used.