ТЕХНИКА ТРАНСПОРТА

УДК 629.423.24

Kulagin D.A.

PROSPECTS OF MODERN DIESEL TRAINS CREATION IN THE COUNTRIES OF THE EURASIAN SPACE

Abstract. In the article analyzed a brief history, current status and scientific-practical perspectives of modern fleet diesel trains creation for high-speed traffic. It is shown that not the economy using of locomotive traction in the suburban movement and the prospect of writing off in the next decade, significant quantities of diesel trains, which are now operating on the Eurasian Railways, more acutely raises the question of creation of new rolling stock for commuter traffic with modern traction gear. Consequently the analytical study of current trends to build diesel trains, analysis and comparison of different traction types, causing the main prospects of scientific research in the relevant fields of science. This study allows determining basic directions of development of diesel rolling stock which will create progressive design practical solutions on the basis of scientific researches in this field.

Keywords: diesel train, traction transfer, suburban movement, railcar rolling stock, modernization, high-speed movement.

Railway transport is one of the basic sectors of the modern economy. Stable and efficient functioning in planning of rail transport it is necessary to ensure the defence, national security and integrity of the state, improve the quality of population life [1-4].

Currently the railway partially satisfy needs production and population in the transportation. Production condition and technical base of railways and technological level of traffic on many parameters does not match made stuck the company necessity and European quality standards for transportation services. This is obstructing water for the further socio-economic development of the state [3-5].

The emergence of problems in the activities and development of railway transport due to a number of negative factors, particulary the progressive ageing of the fixed assets. The average depreciation of fixed assets of the railway transport is 56 %, including rolling stock – 68%. The substantial upgrading of the railways infrastructure is required.

The strategic goal of the state policy in railway transport development is the creation of a competitiveness-potential of the rolling stock, as well as modern domestic capacity to produce and repair, i.e. the reduction of dependence on import deliveries of railway transport and spare parts [5].

Due to rising fuel prices is important modernization and updating of the Park of diesel trains [2, 4]. Priority direction of modernization is the development and introduction in manufacture of modern domestic aqueous diesel trains with optimal energy consumption [6-8].

Diesel train is a kind of railcar rolling stock powered by diesel. He used checking in suburban traffic on non-electrified and partially electrified railway lines [5].

Diesel train develop counting on a wide variety of operating conditions in different countries and regional-states. Currently the prevailing view is that they are more attractive for passengers from the point of speed and comfort view, more economical and easier to use than trains on locomotive traction [9]. In this aspect the main advantages of diesel trains are:

- negligible impact on the train the path through reduced axial loads;
- possibility of modular execution of bodies in General and accommodation of the equipment, including the equipment of interiors;
- lower life cycle;
- high energy efficiency;
- possibility of motion in both directions;
- large acceleration values;
- high reliability and availability;
- the possibility of increasing passenger capacity at the expense of placement of major components and assemblies, partly-do items traction transfer, under the car body [5].

Diesel trains classified by types of traction transfer (electrical, hydraulic or mechanical) and depending on structural speed [10-13]. On diesel trains common series areused, as a rule, a hydraulic or electric traction transfer [5]. The transmission of power from the diesel engine to the wheel pair must have high reliability and durability, minimum size, weight and cost, high efficiency in all modes of operation, minimal maintenance costs and repairs. For modern electrical transmission is characterized by capacity increasing while maintaining almost the same size, and a reduction of the mass of transmission elements. On diesel trains have used electric power transmission permanent, AC-DC and AC currents [5].

The dispersion in the world practice has transmission DC. This is because the efficiency of electric transmission DC with long-term operation mode at speeds up to 160km/h is 84-86%. But when speed diesel train over 160km/h transmission DC inferior AC transfer efficiency and energy indicators.

The transmission AC-DC is used for freight diesel

high-power trains [14]. In the conditions of the world rolling stock modernization and speed diesel trains increasing over 160 km/h is increasingly being used as traction AC power transmission [15]. Besides potions-trains with traction transmission of alternating current with the same mass as with other kinds of gears develop greater thrust that allows using fewer motorized of car axles for the same mass of rolling stock.

Currently in the world produces six types of diesel trains, designed to operate with maximum speed around 200 km/h. Trains for traffic with higher speed is not designed as an area of high-speed movement almost completely electrified.

In the world of high-speed diesel train widely used in long distance and regional communications, especially on the Railways of Germany (DBAG), the UK, Denmark (DSB) and Spain (RENFE) [1-5]. Common on such diesel trains are diesel engines of type QSK9R Cummins. In some cases, the design speed of 200 km/h is not being fully implemented - so dmus series IC3 on the Denmark and Sweden (SJ) Railways are operated with a maximum speed of 180 km/h (traction AC power transmission). At the same time, train family Venturio Siemens, the design of which has particularly high degree of modularity, designed to operate with a maximum speed of 160 km/h with hydraulic and 250 km/h with electric traction transfer [5] (traction AC power transmission).

In Germany are operated by diesel trains Alstom LHB (VT640, VT641) (traction AC power transmission), Siemens (VT642) (traction AC power transmission), Bombardier Talbot (VT643, VT644) (traction AC power transmission), Stadler/ Bombardier DWA (VT646) (traction AC power transmission), Adtranz (VT650, VT611, VT612, RS1) (hydraulic traction gear) and some other models [1-5].

In the world uses 18 types of diesel trains, designed to operate with a maximum speed of 120 to 160 km/h. Among diesel trains in this high-speed category can be noted Saemaul/DHC 200 (design speed of 150 km/h, the Republic of Korea; hydraulic traction gear), Aln 776 (145km/h, Italy; hydraulic traction gear), Endeavour (145km/h, Australia; traction transmission DC), BM/BS92 (140km/h, Norway; traction transmission DC), mddm (140km/h, Germany; hydraulic traction gear), 5600 MT (140km/h, Turkey; hydraulic traction gear) and MR /MRD (130km/h, Denmark; hydraulic traction gear) [5].

On the UK Railways operated diesel trains two-car trains series 158 and three-car train series 160, 165, 166, 170 (traction transmission DC). The company-operator Chiltern in the late 90-ies ordered the company Adtranz new four-car diesel trains series 168 with hydraulic transmission. These diesel trains showed high reliability, annual mileage of each of them is no less than 250 thousand km UK operators of passenger traffic Virgin North Western Train purchased 34 diesel trains 220 series and 44 trains series 221, produced at the plant Bombardier in Brugge (Belgium). These diesel trains has electric transmission of alternating current. This railcar rolling stock required for replacement of high-speed diesel trains series C that are released after the electrification of roads Western UZB-Riga, as well as for replacement of suburban trains on locomotive traction, which will allow to reduce expenses on exploitation, maintenance, repair and speed of motion.

On the French Railways (SNCF) operated diesel trains XTER, A-TER, TER 72500 (traction electrode-transfer DC). Trains series TER 72500 are designed to provide in the regional reports of the same level of comfort for passengers and train TGV high speed communications. These diesel trains are available in two variants: two-car and three-car [2-4].

In the framework program improvement of regional messages Spanish Railways chose for new diesel trains TRD concept of trains series C Danish Railways, which were built by the company Duewag in 1986-1987. But the company-manufacturer of ATS used in diesel trains trucks new design adapted to the wide gauge (1668mm), replaced the air cooling diesel engine water and set in traction hydraulic drive, not the guide-Romano transfer. Two-car diesel trains with bodies manufactured from aluminium alloy, equipped with a mouth-stops air-conditioning. In the train four power unit with a drive to one of the two wheel pairs skin-tion truck. The total order volume is 16 units. Annual mileage of each diesel trains is 120 thousand km of [5].

On the Russian and Belarusian Railways are operated the following series of rolling stock for urban, suburban of obtained deposits: 1 (hydro-mechanical traction gear), DR1 (hydraulic traction gear), D-3, MDP, MDP, MDP, MDP (hydro-mechanical traction gear), DPM, DT (hydro-mechanical traction data Dpsas, BCH, [DRB] (traction transmission DC). Among them there are trains with locomotive traction.

Modern Russian diesel trains manufactured by JSC «Metrowagonmash» RA-1 and RA-2, RA have hydro-mechanical power transmission. The modernized diesel train DB (Dpsas), produced by OJSC «Demikhovsky engineering plant» on the basis of two sections of the locomotive M, has traction power transmission DC. JSC «Torzhokskiy car-building plant» produces diesel trains DT-1 (a power transmission DC).

A large number of diesel trains for Russia, Belarus, Georgia, Estonia, Latvia and Lithuania supplies of JSC «Riga machine-building plant», which produces diesel train DR hydraulic traction gear «Voith» is further development series diesel trains DR1, DRP, DRA, DRB.

In Ukraine, operated models diesel trains that remained from the times of the USSR (D1, DR1, D-3 and others), as well as domestic developments of production of JSC HC «Luganskteplovoz».

In the period from 1997 to 2003 JSC HC «Luganskteplovoz» have created new types of rolling stock for Railways:

- diesel train locomotive traction DPL with modernized section of the locomotive ME and trailer leading car with control cabin. The prototype was built in 2001, adopted by the interdepartmental Commission and launched into production;
- diesel train locomotive traction DPL with modernized section of the locomotive 2TE116 and trailer leading car

with control cabin. The prototype was built in 2001, adopted by the interdepartmental Commission and launched into production;

- diesel train DEL-01 with AC power transmission. The prototype was manufactured in 1998. After implementation of the set of acceptance tests and finishing work was discontinued;
- diesel train DEL-02 (**Figure**) with AC power transmission. The prototype was built in 2003, adopted by the interdepartmental Commission and launched into production.

Appearance diesel train DEL-02

On modern diesel trains to improve passenger comfort you need to install a more powerful diesel engines on the ba-sis of 40-50 kW with an additional one car to the necessary power for traction (for use air-conditioning, internal hardware). New diesel trains are supposed to be used to combination-scheme of connection of the train. This will put six trucks fivecars with simplified bodies instead of four-cars on eight carriages. The length of the trains will remain the same, which will allow using existing platforms, the way station and depot. This principle the connection provides the following advantages in comparison with usual connection:

- increases the width of the car-to-car navigation;
- by reducing the number of platforms increased the number of seats on the average on 13%;
- reduction of time of boarding and landing at the expense of wider doors;
- better grip of the train rails (increase axial loads in the regulatory limits, because the train weight will remain the same, while the number of trucks will be reduced);
- high dynamic response to the roughness of the way through the mass concentration of the two-cars in one carriage;
- increase space for under-car equipment [13].

However, the disadvantages of such diesel trains include:

- the presence of a larger number of air conditioning installations;
- complex inter-tow hitch;
- the necessity of re-equipment depot for repair of this rolling stock [3-5].

Not the economy using of locomotive traction in the suburban movement and the prospect of writing off in the next decade, significant quantities of diesel trains, which are now used on Ukrainian Railways, more acutely raise the question of new rolling stock creation for commuter traffic. On average, the demand for suburban railway transportation is satisfied in Ukraine 70-75%, and in summer, weekends and holidays by 50-60%. In recent years, the technical condition of the rolling stock acquired a critical state because of shortage of spare parts and the virtual absence of updates. This fully applies to the state of diesel trains, approximately 50% of the cars which are worked out their resource and require exceptions to the inventory Park, as not providing the requirements of traffic safety and the desired comfort level [5].

According to [5] provides that the using of domestic scientific-technical potential of Ukraine for the production of modern competitive freight and passenger diesel trains and technical modernization of railway transport, as a result of the reform, will create conditions for the implementation of the State program of reforming the railway transport.

In operation on the Odessa railway are series DEL-02 production JSC HC «Luganskteplovoz». Their development on the modern domestic element base and introduction for the using of the state administration of railway transport of Ukraine «Ukrzaliznytsya» fully corresponds to national plans and programs of reform and development of the railway industry.

Scientists explores the issues of diesel trains modernization DEL-02, in particular theoretical issues of building management information systems based on neural networks and artificial intelligence, optimization of movement and operation modes of the trains, construction of mathematical models of system components control power transmission. These studies contribute to a considerable qualities improvement of diesel-train movement DEL-02, helped to resolve a number of technical problems that existed in the initial stages of introduction in manufacture of prototypes data diesel trains.

The analyzed experience of diesel-train using DEL-02 and work with previous upgrades the conclusion about high reliability of this domestic developments and prospects of the diesel-train were using DEL-02. However, this experience also shows the number of unresolved technical problems traction power diesel train DEL-02:

- unsatisfactory performance of regulation and maintenance of a constant current value of a system for traction power, which is explained by the structure of the system of control transmission driving, the lack of effective current regulator and system sensitivity for the temperature parameters variations of elements of traction power;
- high values of working and maximum currents elements of the existing traction power diesel trains due to the absence of system power fast current limitation and normalized transient response current circuits;
- the need of increasing space acceleration (certain accel-

eration values according to technical specifications), the steady-state motion and inhibition (over a certain distance according to technical specifications) with control changes the speed, acceleration and leap through the creation of a combined unit of these values;

- low speed and quality of data in the system of control over the channel CAN (up to 1 Mbit);
- control system does not take into account the elasticity of certain elements of the traction power diesel trains.

These problems remain unresolved proposed funds.

In accordance with the terms of reference for the manufacture of diesel train DEL-02 minimum acceleration should be 0.4 m/s^2, and the maximum acceleration should be in the range of 0.8 to 1 m/s^2. The current design of the traction power allowed the acceleration at the level of 0.38 m/s^2.

The resolution of these technical issues through comprehensive modernization based on the experience of the syn-thesis and utilization of industrial transport of electric drives improves the efficiency of the control system of the traction power transmission diesel-train DEL-02. This will speed up the full transition Ukrzaliznytsya for the traction system of domestic production, and, in perspective, to create conditions for export of this traction unit or its components traction modules and units (that is real, given the competitive price, the needs of many States in diesel trains and high technical efficiency of a diesel train DEL-02 subject to a decision of the specified problems).

References

1. Basov G.G. Прогнозування розвитку дизель-поїздів для залізниць України [Development Forecasting the Diesel-trains for the Ukranian Railroads]. Kharkiv: Apeks+, 2004, 240 p.
2. Diesel-trains with manual transmission // Zheleznye dorogi mira [Railways of the World]. 2006, no.10, pp.25-27.
3. Shafi Naderi Ali Asgar. Sovremennye dizel'-poezda [Modern diesel trains] // Zheleznye dorogi mira [Railways of the World]. 2003, no.12, pp.22-33.
4. Lokomotiv dlja Evropy bez granic [Locomotive for Europe Without Borders] // Zheleznye dorogi mira [Railways of the World]. 2008, no.4, pp.35-41.
5. Kulagin D.O. Проектування систем керування тяговими електропередачами моторвагонних поїздів [Design of Control Traction Power Multiple Units]. Berdyansk: FO-P Tkachuk O.V., 2014. 154 p.
6. Alekseev A.E., Burkov A.T., Rudakov B.V. Novoe napravlenie v tjagovom privode dlja jelektropodvizhnogo sostava [A new direction in traction drive for electric rolling] // Usovershenstvovanie sistem jelektricheskogo podvizhnogo sostava / Sb. nauch. tr. Leningr. in-t inzh. zh.-d. transp. [Improvement of systems of electric rolling stock. Research collection of Leningrad In-stitute of Railway Transport]. Leningrad: 1972, no.336, pp. 3-13.
7. Andrienko P.D., Loboda V.D., Mishhenko A.V. Preobrazovateli chastoty dlja jelektroperedachi zheleznodorozhnogo transporta [Frequency converters for electro-power rail transport] // Elektrotehnika i elektroenergetika [Electrical and Power]. 2001, no.1, pp.55-58.
8. Basov G.G., Falendish A.P. Використання дизельного рухомого складу в приміському русі // Nauchno-tehnicheskij sbornik «Kommunal'noe hozjajstvo gorodov» [Scientific and technical collection «Utilities of Cities»]. 2003, no.47, pp.201-206.
9. Alekseev A.E., Kulagin D.O., Kachur O.S., Andrienko P.D. Розробка моделі модернізованого частотно-керованого тягового елект-роприводу зі змінним алгоритмом керування дизель-потяга ДЕЛ-02 [Developing a model modernized frequency-controlled electric-traction roprivoda variable control algorithm diesel train DEL-02] // Електротехніка та електроенергетика [Electrical and Power]. 2010, no.1, pp. 30-34.
10. Noskov V.I., Dmitrenko V.D., Zapolovskij N.I., Leonov S.Ju. Modelirovanie i optimizacija sistem upravlenija i kontrolja lokomotivov [Simulation and optimization of management and control systems of locomotives]. Har'kov: Transport of Ukraine, 2003, 324 p.
11. Orlovskij I.A., Kuleshov A.N. Uchet uprugih svjazej i raspredelennoj nagruzki pri vektornom upravlenii asinhronnym tjagovym privodom dizel'-poezda [Accounting of elastic connections and distributed load with vector control induction motor traction drive diesel train] // Вісник Дніпропетровського національного університету залізничного транспорту ім. В. Лазаряна [Vestnik of Lazaryan Dnipropetrovsk National University of Railway Transport]. 2007, no.19, pp. 209-213.
12. Silovoj agregat Powerpack dizel'-poezda Talent [The Power Unit Powerpack of Diesel Train Talent] // Zheleznye dorogi mira [Railways of the World]. 2002, no.2, pp. 21-23.
13. Tishhenko A.I. Spravochnik po jelektropodvizhnomu sostavu, teplovozam i dizel'-poezdam [Handbook of electric rolling stock, locomotives and diesel trains]. Moscow: Transport, 1976, vol.1, 432 p.
14. Congfeng Jiang. Energy Management for Microprocessor Systems: Challenges and Existing Solutions / Congfeng Jiang, Xianghua Xu, Jian Wan, Xindong You // International Symposium on Intelligent Information Technology Application Workshops, 2008, pp. 1071-1076.
15. Kulagin D.O. Спосіб апроксимації кривої намагнічування тягового асинхронного двигуна [Approximation Method of the Magnetization Curve of Traction Induction Motor]// Електротехніка та електроенергетика [Electrical and Power]. 2013, no.2, pp.66-70.

Information about author

Kulagin Dmitrij Aleksandrovich – Ph.D (Eng.), Associate Professor, The Department «Electrosupply of the industrial enterprises», Zaporozhye National Technical University, Ukraine. Phone: +38-066-236-52-71. E-mail: nemix123@rambler.ru.

ИНФОРМАЦИЯ О СТАТЬЕ НА РУССКОМ ЯЗЫКЕ

ПЕРСПЕКТИВЫ СОЗДАНИЯ СОВРЕМЕННЫХ ДИЗЕЛЬ-ПОЕЗДОВ В СТРАНАХ ЕВРАЗИЙСКОГО ПРОСТРАНСТВА

Кулагин Дмитрий Александрович – канд. техн. наук, доц. кафедры «Электроснабжение промышленных предприятий», Запорожский национальный технический университет, г. Запорожье, Украина. Тел.: +38-066-236-52-71. E-mail: nemix123@rambler.ru.

Аннотация. В статье проанализированы краткая история, современное состояние и научно-практические перспективы создания современного парка дизель-поездов для скоростного движения. Показано, что неэкономичность использования локомотивной тяги в пригородном движении и перспектива списания в ближайшее десятилетие значительного количества дизель-поездов, которые сегодня эксплуатируются на евразийских железных дорогах, все острее ставит вопрос создания нового подвижного состава для пригородных перевозок с современной тяговой передачей. Вследствие этого выполнено аналитическое исследование современных тенденций к конструированию дизель-поездов, анализ и сравнение различных типов тяговых передач, в результате чего выделены основные перспективы научных исследований в соответствующих отраслях науки. Проведенное исследование позволяет выделить основные направления развития дизельного подвижного состава, которые позволят создать прогрессивные конструкционные практические решения на основе научных изысканий ученых в данной отрасли.

Ключевые слова: дизель-поезд, тяговая передача, пригородное движение, моторвагонный подвижной состав, модернизация, скоростное движение.

Список литературы

1. Басов Г.Г. Прогнозування розвитку дизель-поїздів для залізниць України. Харьков: Апекс+, 2004. 240 с.

2. Дизель-поезда с механической передачей // Железные дороги мира. 2006. №10. С.25-27.
3. Шафи Надери Али Асгар. Современные дизель-поезда // Железные дороги мира. 2003. №12. С.22-33.
4. Локомотив для Европы без границ // Железные дороги мира. 2008. №4. С.35-41.
5. Кулагін Д.О. Проектування систем керування тяговими електропередачами моторвагонних поїздів. Бердянськ: ФО-П Ткачук О. В., 2014. 154 с.
6. Алексеев А.Е., Бурков А.Т., Рудаков Б.В. Новое направление в тяговом приводе для электроподвижного состава // Усовершенствование систем электрического подвижного состава / Сб. науч. тр. Ленингр. ин-т инж. ж.-д. трансп. Л., 1972. №336. С.3-13.
7. Андриенко П.Д., Лобода В.Д., Мищенко А.В. Преобразователи частоты для электропередачи железнодорожного транспорта // Електротехніка та електроенергетика. 2001. №1. С.55–58.
8. Басов Г.Г., Фалендиш А.П. Використання дизельного рухомого складу в приміському русі // Научно-технический сборник «Коммунальное хозяйство городов». 2003. №47. С.201-206.
9. Кулагін Д.О., Качур О.С., Андрієнко П.Д. Розробка моделі модернізованого частотно-керованого тягового електроприводу зі змінним алгоритмом керування дизель-потяга ДЕЛ-02 // Електротехніка та електроенергетика. 2010. №1. С.30-34.
10. Носков В.И., Дмитренко В.Д., Заполовский Н.И., Леонов С.Ю. Моделирование и оптимизация систем управления и контроля локомотивов. Харьков: ХФИ «Транспорт Украины», 2003. 248 с.
11. Орловский И.А., Кулешов А. Н. Учет упругих связей и распределенной нагрузки при векторном управлении асинхронным тяговым приводом дизель-поезда // Вісник Дніпропетровського національного університету залізничного транспорту ім. В. Лазаряна. 2007. №19. С.209-213.
12. Силовой агрегат Powerpack дизель-поезда Talent // Железные дороги мира. 2002. №2. С.21–23.
13. Тищенко А.И. Справочник по электроподвижному составу, тепловозам и дизель-поездам. М.: Транспорт, 1976. Т.1. 432 с.
14. Congfeng Jiang, Congfeng Jiang, Xianghua Xu, Jian Wan, Xindong You. Energy Management for Microprocessor Systems: Challenges and Existing Solutions // International Symposium on Intelligent Information Technology Application Workshops. 2008, pp.1071-1076.
15. Кулагін Д.О. Спосіб апроксимації кривої намагнічування тягового асинхронного двигуна // Електротехніка та електроенергетика. 2013. №2. С.66-70.

УДК 625.144.5/7

Фокин С.В., Бунаков П.Ю.

НАДЕЖНОСТЬ РАБОТЫ ЖЕЛЕЗНОДОРОЖНЫХ ПУТЕВЫХ МАШИН: ПРОБЛЕМЫ И ПУТИ РЕШЕНИЯ

Аннотация. В статье дается общее представление о необходимости применения бортовой системы мониторинга и диагностики на железнодорожных путевых машинах. Приводится методика выделения групп элементов, подлежащих диагностированию. Предлагается структурная схема, принцип организации человеко-машинного интерфейса и способ внедрения современной системы мониторинга и диагностики на железнодорожных путевых машинах.

Ключевые слова: система мониторинга и диагностики, путевые машины, диагностирование, человеко-машинный интерфейс.

Железные дороги – основная стратегическая транспортная сеть практически любого государства. Ритмичность и интенсивность железнодорожных перевозок является главным фактором, определяющим состояние экономики страны, поэтому состояние железнодорожного полотна служит ключом к обеспечению эффективного грузооборота. Для решения соответствующего комплекса проблем используются различные путевые машины. По этой причине, одним из важных направлений работы в железнодорожной отрасли является совершенствование специального подвижного состава. Высокая производительность и надежность машин дает возможность постоянно поддерживать состояние полотна в требуемом состоянии, гарантирующем высокий темп передвижения транспорта. Неисправность путевой машины часто приводит к значительным убыткам, поскольку нарушение графика ремонтных работ вызывает сбои в расписании движения поездов.

С развитием технологий ремонта и обслуживания пути, в конструкциях специального подвижного состава появляются новые агрегаты и узлы. Это приводит к повышению производительности путевых машин и снижению эксплуатационных затрат, а также дает возможность замены планового ремонта путевой техники ремонтом с учетом технического состояния подвижного состава. Решение данной задачи требует внедрения современных методов мониторинга, контроля и диагностики, которые позволяли бы своевременно и достоверно оценивать состояние узлов и деталей. Мониторинг текущего состояния путевых машин дает возможность выявить проблемы в их работе ещё до того, как они станут причиной поломки оборудования. В условиях эксплуатации, перспективной является бортовая система мониторинга, обеспечивающая оперативный контроль состояния машины и предоставляющая достоверные данные о работе отдельных узлов в реальном времени. Она должна быть универсальной (адаптируемой к различным типам машин), быстро окупаемой, сравнительно недорогой, максимально простой в эксплуатации и потребляющей минимальное количество энергии [1].

Наиболее сложной задачей при построении систем мониторинга и технической диагностики является выделение групп элементов, подлежащих диагностированию. Для разработки такой системы классификации целесообразно использовать технико-экономические критерии.

В число диагностируемых включаются те элементы подвижного состава, исправность которых в наибольшей степени обеспечивает безопасность движения и работоспособность каждой единицы подвижного состава. Отказы диагностируемых элементов непосредственно вызывают нарушение графика движения поездов, а также приводят к значительным энергозатратам на перевозки. Приоритетными для ди-