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SELECTION CRITERIA FOR TECHNICAL DIAGNOSTIC SYSTEMS AND INFORMATION TRAINING OF MOTOR VEHICLES

The aspects of the development of criteria for the selection tools and options for systems of technical diagnostics of vehicles are considered. Monitoring systems and forecasting the technical condition of vehicles will require expanding the range of monitored parameters. The above criteria for assessing the selection of the optimal set of measured parameters and their means of measurement to ensure the effectiveness of the developed systems monitoring and diagnostics. The main aspects of information preparation diagnostics and repair of motor vehicles are given.

The system approach to the issues of technical diagnostics of vehicles requires consideration of the system of quality management maintenance and repair as an integral part of management. The system of quality management of technical maintenance and repair serves to ensure a given level of the coefficient of technical readiness, reliability, durability vehicles, efficient use of them with minimal financial and labor costs. Thus, the quality management system of motor vehicles is based on a set of measures, which include technical, economic, and other interrelated actions to achieve the objectives set to achieve a high level of quality.

In developing the system for monitoring, diagnosing and forecasting of vehicles one of the important tasks is to determine the optimal set criterion for a set of measured parameters and their means of measurement, which ensure the economic efficiency of the control system.

The article notes that the main drawbacks of these criteria can be called either the requirements of a large amount of a priori information, which is often impossible at the design stage of the control, diagnosis and forecasting system, or insufficient account of the components of the quality controls and diagnosis, such as the duration and completeness of control.

The problem of quality in the maintenance and repair of motor vehicles is largely determined by the level of metrological support. Technical diagnostics involves determining the technical state of the diagnostic object with a certain accuracy. Therefore, to ensure the quality of the system of maintenance and repair of motor vehicles, it is necessary to use the principles of metrological support.

Keywords: diagnostics, forecasting, probabilistic method of forecasting, model of the object technical diagnostics, control systems, monitored parameters.

Introduction. A systematic approach to vehicle technical diagnostics (VTD) requires considering quality management system (QMS) and repair as an integral part of management. The system of quality management and repair serves to provide at a given level of the coefficient of technical readiness, reliability, durability of VTD, their effective use with minimal financial and labor costs. Thus, the quality management system of VTD is based on a set of measures, which include technical, economic and other interrelated actions to ensure the set goals aimed at achieving a high level of quality.

The problem of quality at maintenance and repair of VTD is largely determined by the level of metrological support (MS). Technical diagnostics involves determining the technical condition of the diagnosed object with some accuracy. Therefore, to ensure the quality of the system maintenance and repair of VTD, it is necessary to use the principles of metrological support.

Analysis of recent research. Modern diagnostics of cars has arisen at the intersection of such sciences as introscopy, mathematical logic, harmonic analysis, acoustics, radioisotope engineering, psychology, etc. The development of car diagnostics is closely linked to the history of the car [1].

As a result of the exceptional diversity, heterogeneity and complexity of vehicles, car diagnostics has not yet turned into a rigorous formalized system where any problems can be solved with a comprehensive set of ready-made algorithms. Therefore, successful diagnosis requires personal experience and engineering intuition. A specific feature that distinguishes the diagnosis from the usual definition of a technical condition is, first of all, the detection of faults without disassembly. A very important issue is the technological adaptability of diagnosis to the processes of maintenance and repair of cars. Technological adaptability stems from the accepted position that diagnosis is part of the maintenance of cars. The adaptability of diagnosis to maintenance and repair is expressed by technological purpose, deepening the definition of technical condition and degree of specialization, ie the degree of territorial isolation of diagnostic work [2].

Formulation of the problem. When developing a system of control, diagnosis and forecasting of vehicles, one of the important tasks is to determine the optimal set of measured parameters and the means of measuring them, which ensure the economic efficiency of the control system.

Most often, the criterion of control accuracy and the criterion of "reliability - value", the complex coefficient of efficiency, etc. are used to evaluate the choice of parameters to be measured and the means of control and diagnosis. The main disadvantages of these criteria may be the requirements of a large amount of a priori information, which is often not possible at the stage of designing a control, diagnosis and forecasting system, or insufficient consideration of the components of the quality of control and diagnosis, for example, the duration and completeness of control. In addition, there are no algorithms for determining these criteria, which are implemented on electronic computers, which complicates their application in computer-aided design (CAD) systems of control and diagnosis.

Presenting main material. The difficulty of choosing the appropriate criterion is that the system of control and diagnosis VTD must solve the problem of determining its technical condition, and in the case of assessment of VTD as incapable - to determine the cause of the malfunction, to solve the problem of diagnosis. In order to ensure the required quality of the control and diagnosis system, it is necessary to develop metrological support, which establishes the nomenclature of the measured parameters, their measurement range and requirements for accuracy, unify the methods and means of measurement taking into account the cost and duration of the control and diagnosis.

Often, solution of a single task without taking into account their relationship reduces the quality of the control and diagnosis system. So it is advisable to carry out an assessment of the technical condition according to a generalized indicator, but to solve the problem of diagnostics it is necessary to expand the range of controlled parameters. At the same time, an overestimated number of measured parameters complicates the control and diagnosis system. The same consequences can lead to an unreasonable increase in the accuracy of measurement parameters in the probabilistic assessment of the quality controls and diagnosis system without taking into account the cost of the means of control and technical diagnosis.

In the general case, VTD can be represented as the set R of interconnected subsystems. The technical condition of each subsystem is characterized by the value of the ρ-th quality index, where ρ =1,…, R. The value of the ρ-th quality indicator is determined by the direct measurement or the values of n_ρ associated with the controlled VTD parameters, where $n_\rho \leq N$. The values of the latter, in turn, are related to the values of m_i, structural parameters of the VTD, where $m_i \leq M$.

To determine the parameters controlled by VTD, a mathematical or functional model is used, by which a list of possible VTD states and corresponding combinations values of input and output parameters are established, and connections between the parameters of VTD are fixed. On the basis of the functional model of the VTD, a logical model of the VTD and a scheme of interconnection of parameters are built, the general appearance of which is presented in Fig. 1.

The parameter relationship diagram can also be represented as a matrix of controlled parameter relationships with the quality of the VTD subsystems:

$$S = \begin{bmatrix} s_{11} & \cdots & s_{1N} \\ \cdots & s_{\rho j} & \cdots \\ s_{R1} & \cdots & s_{RN} \end{bmatrix} \qquad (1)$$

$$S' = \begin{bmatrix} s'_{11} & \cdots & s'_{1N} \\ \cdots & s'_{mj} & \cdots \\ s'_{R1} & \cdots & s'_{RN} \end{bmatrix}, \qquad (2)$$

where $s_{\rho j}$ - coefficients characterizing relationship of the j-th controlled parameter with the quality index ρ-th subsystem VTD *N* - the number of all possible for this VTD controlled parameters; *R* is the number of VTD subsystems; s'_{mj} - coefficients characterizing the relationship of the *j*-th controlled parameter with the *m*-th structural parameter ($m = 1,\ldots, M$) *M* - the total number of structural parameters.

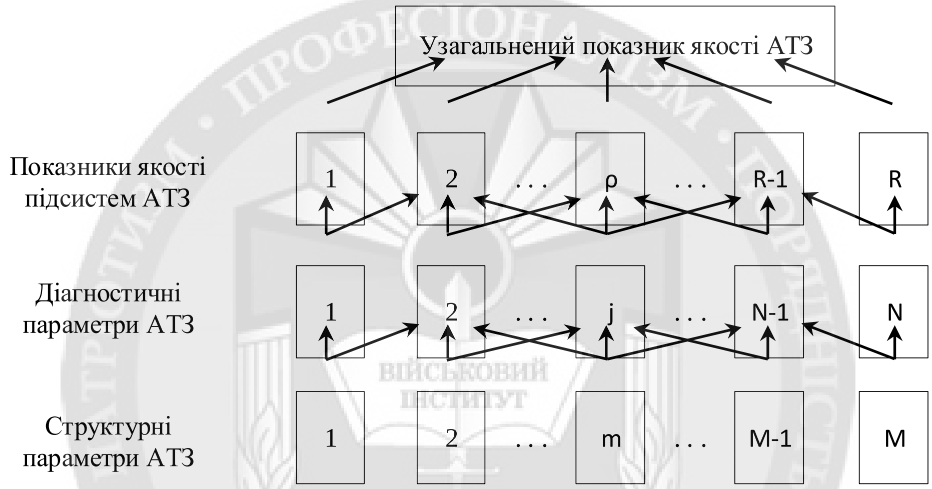

Figure 1 – Generalized view of the relationship of structural and controlled parameters and quality indicators VTD

Based on the data of matrices, they select the sets arameters that are controlled VTD.

From the analysis of VTD models it can be presented for metrological analysis (*k*) of variants controlled parameter sets. It should also be borne in mind that different methods and means of measurement may be used to implement each variant l_j – l the number of measurement means acceptable for measuring the *y*-th controlled parameter). We denote by I the number of all possible variants of implementation of the VTD control system (the number of variants sets ontrolled parameters taking into account specific measuring instruments).

Given that each controlled parameter can be defined by a set of l_j measuring instruments, we have I variants of implementation of the control system:

$$I = \sum_{i=1}^{k} \left(\prod_{j=1}^{N} l_j \right). \qquad (3)$$

The criteria for evaluating the choice optimal set of measured parameters and the means of measuring them should ensure effectiveness of the developed system of control and diagnosis. The choice of the most effective variant of implementation control system is carried out at the minimum cost of losses *C*, when implementing the *i*-th variant of the control system:

$$Q \sim min(C_i) \text{ при } P_{нз.\Sigma} \leq P_{нз.доп} \, , \quad (4)$$

where $P_{нз.\Sigma}$ − is the estimated probability of a wrong control inference for the *i*-th version of tcontrol system implementation; $P_{нз.доп}$ − valid value the probability of incorrect conclusion.

If the condition $P_{нз.\Sigma} \leq P_{нз.доп}$ is not fulfilled, then further consideration this variant of implementation of the system is impractical because it does not provide the necessary reliability of control.

For the relationship between magnitude osses and measurement error of the indicator, we solve the equation and equate resulting expression to magnitude of allowable losses:

$$\prod(\sigma_{\Delta x}) = \prod_{доп} \; . \quad (5)$$

Solving equation (5) we find the value standard deviation of measurement error corresponding to the permissible economic losses.

This value is used to calculate first and second error probabilities by typical methods.

The calculation of $P_{н.з.\Sigma}$ is performed taking into account the probabilities of incorrect conclusion $P_{н.з.j}$ for each quality index by the formula:

$$P_{н.з.\Sigma} = 1 - \prod_{j=1}^{R}\left(1 - P_{н.з.j}\right), \quad (6)$$

Based on the assumption that controlled parameters are selected in such a way that by measuring these parameters, the performance of non-intersecting VTD subsystems is checked.

The C_n - cost of the implementation particular variant control systems (*C*) is sum of two components: C_k - cost of losses for incorrect conclusions and C_k - the cost of the means of control and diagnosis, taking into account the costs of operation and carrying out the necessary operations, i $C = C_n + C_k$.

The most important, from a practical point of view, is the task of estimating the choice of controlled parameters at comparable values of the cost of losses from control errors and the cost of control costs, because when exceeding the first choice is to ensure a given control reliability, and when exceeding the second control system becomes ineffective.

Consider choosing the best option for implementing a control system for a single VTD subsystem. In the future, we assume that the optimal control system for the entire VTD consists of a set of optimal control systems for each subsystem VTD.

When choosing the sets of parameters to be controlled, completeness of the control should be taken into account

$$\pi_{pi} = n_i / N, \text{ with } 0{,}7 \leq \pi_{pi} \leq 1 \, , \quad (7)$$

where i - is the number of considered set i = 1,…, I; n_i - is the number of controlled parameters in this embodiment of the control system; n - is the number of parameters that uniquely characterize the state of VTD.

If condition (7) is not fulfilled, the i-th set of controlled parameters is rejected because it does not allow to solve the control problem for all subsystems or structural parameters of VTD.

We introduce the completeness of control into expression (4). The greater completeness of control corresponds to the best variant of implementation control systems:

$$Q = min\left(\frac{1}{\pi_{pi}} \cdot (C_i)\right). \qquad (8)$$

The cost of losses on incorrect conclusions is a function of the standard deviation measurement error $\sigma_{\Delta x}$

$$C_n = \chi \sigma_{\Delta x}, \qquad (9)$$

where χ - is the coefficient that depends on the type of loss function due to measurement errors and law of error distribution. In turn, the likelihood of an incorrect conclusion when controlling is also a function of $\sigma_{\Delta x}$, so the cost of loss C_n is proportional to $P_{\text{н.з.}}$.

When comparing variants of control systems implementation, it is convenient to use the relative values of value losses on incorrect conclusions $C_n / C_{n\,max}$ and the value of control means $C_k / C_{k\,max}$, where $C_{n\,max}$ – maximum value of losses on incorrect conclusions; $C_{k\,max}$ - maximum value of controls on proposed options and it can be stated that the ratio of losses to incorrect conclusions is proportional to the ratio of the probability of incorrect conclusion:

$$\frac{C_n}{C_{n\,max}} \sim \frac{P_{\text{н.з.}}}{P_{\text{н.з}\,max.}}, \qquad (10)$$

where $P_{\text{н.з.}} = P_1 + P_2$, - probability of incorrect conclusion; P_1 and P_2 first and second error probabilities; $P_{\text{н.з}\,max.}$ - maximum probability of incorrect conclusion, in the extreme case, equal to the probability of incorrect conclusion in the absence of control.

If the quality indicators are directly controlled (direct one-parameter control), the calculation of P_1 and P_2 is carried out according to the formulas

$$P_1 = 1 - \int_{x_{\text{н}}}^{x_{\text{в}}} \int_{x_{\text{н}}}^{x_{\text{в}}} f(x) f(\Delta x) d(x + \Delta x) dx \Bigg/ \int_{x_{\text{н}}}^{x_{\text{в}}} f(x) dx,$$

$$P_2 = 1 - \int_{x_{\text{н}}}^{x_{\text{в}}} \int_{x_{\text{н}}}^{x_{\text{в}}} f(x) f(\Delta x) d(x + \Delta x) dx \Bigg/ \int_{-\infty}^{\infty} \int_{x_{\text{н}}}^{x_{\text{в}}} f(x) f(\Delta x) d(x + \Delta x) dx, \qquad (11)$$

where *x* - is the controlled parameter, $x_{\text{в}}$ and $x_{\text{н}}$ - are the upper and lower bounds of tolerance field (*T*) of the controlled parameter, *f (x)* is the law of distribution values parameters *x*, *f (Δx)* is the law of distribution error measurement parameters *x*.

The calculation of P_1 and P_2 by these formulas is possible using numerical methods using a computer.

P_1 and P_2 are considered as functions of the coefficients $K_m = \sigma_{\Delta x} / T$ and $K_d = T / \sigma_x$ (де σ_x – is the root mean square deviation of the controlled parameter), i.e. $P_1 = f(K_m, K_d)$, $P_2 = f(K_m, K_d)$. This method of representation of P_1 and P_2 is convenient for their estimation if there is no complete data for calculation.

In the general case, the cost of loss of the first and second kind can be written as:

$$C_n = c_{P1} \cdot P_1 + c_{P2} \cdot P_2, \qquad (12)$$

where c_{P1} - is specific cost of first-order error losses; c_{P2} - is specific cost of second-order error losses then

$$\frac{C_n}{C_{n\,max}} = \frac{c_{P1} \cdot P_1 + c_{P2} \cdot P_2}{c_{P1} \cdot P_{1\,max} + c_{P2} \cdot P_{2\,max}} \tag{13}$$

We introduce a coefficient λ equal to the ratio of specific error values of the first and second kind, that is, $\lambda = c_{P1}/c_{P2}$.

If the cost of losses from errors of the first and second kind are equal, then

$$\lambda = \frac{C_{nк}}{C_n} = \frac{P_{апост}}{P_{апріор}} = 1, \tag{14}$$

where $C_{nк}$ - cost of losses on incorrect conclusions during the control. $(C_к = C_{nк} + C_{провк})$, were $C_{провк}$ – is cost of control costs; $P_{апост}$ - posterior probability of making wrong decisions; $P_{апріор}$ - priori probability of wrong decisions.

If the cost of loss from errors of the first and second kind are different, then $\lambda = \frac{C_\alpha}{C_\beta} - 1$, at $P_{апріор} = \beta$, $P_{апост} = \alpha + \beta$. The coefficients C_α and C_β which establish the magnitude of the cost of errors first and second kind, respectively, should be estimated by expert methods.

Substituting this expression in (13) we obtain:

$$\frac{C_n}{C_{n\,max}} = \frac{\lambda \cdot P_1 + P_2}{\lambda \cdot P_{1\,max} + P_{2\,max}} \tag{15}$$

Turning in expression (8) to the relative value of the cost of losses in terms of quality of a given subsystem VTD, we get an expression for the technical and economic indicator, the minimum of which characterizes the optimality of this system control and diagnostics for completeness reliability and cost of control:

$$Q = \min_{i=1,\dots,I}\left(\frac{1}{\pi_{pi}}\left(\prod_{j=1}^{n_i}\left(\frac{\lambda \cdot P_{1j} + P_{2j}}{\lambda \cdot P_{1\max} + P_{2\max}} + \frac{C_{kj}}{C_{k\max}}\right)\right)\right) \tag{16}$$

$$P_{нз.\Sigma} \le P_{нз.доп}$$

In order to compare different controls and technical diagnostics, besides cost and error, performance of control and diagnostics is of great importance. In the rank assessment of controls, the decrease in performance by increasing the cost of controls can be offset by productivity gains. Since performance is related to the timing of control operations and affects the effectiveness of control, it is proposed to take into account the multiplication of the relative value control means by a factor determined by the expression

$$K_j = t_j / t_{max}\,, \tag{17}$$

where t_j – is the time to control j-th measurement tool; t_{max} - time to control with the maximum value measuring instrument.

Moreover, time required for the measurement of t_j consists of the time for delivery of technical diagnostics systems (TDS) to workplaces and back t_{dj}, the time spent directly for the measurement of $t_{вим}$ itself and additional time for the installation of SI $t_д$ (taken on the basis of statistics):

$$t_j = t_{dj} + t_{вим} + t_д \quad . \tag{18}$$

So finally, we get:

$$Q = \min_{i=1,\dots,I}\left(\frac{1}{\pi_{pi}}\left(\prod_{j=1}^{n_i}\left(\frac{\lambda \cdot P_{1j} + P_{2j}}{\lambda \cdot P_{1\max} + P_{2\max}} + \frac{C_{kj}}{C_{k\max}} \cdot K_j\right)\right)\right) \tag{19}$$

$$P_{нз.\Sigma} \le P_{нз.доп}$$

The obtained criterion allows to choose the optimal from point of view of reliability - cost -

productivity - losses from errors of the first and second kind - completeness of control, parameter and means of its control to determine the technical state of ρ-th sub-system of VTD.

Conclusions. In view of all the above, method of implementing the choice of technical diagnostics by proposed criterion will contain the following steps: selection of quality indicators of units and units of VTD, the condition of which should be controlled by the synthesized control system; determination of data for calculation requirements for reliability of control selected quality indicators by the synthesized control system and calculation of this characteristic; identifying possible control options for selected quality indicators: they can be monitored directly or indirectly by defining the control parameters related to them functionally; identification of possible means control of the selected controlled parameters. The number of variants implementation control systems is calculated by (3); forming a data set for the calculation of criterion (19) for each variant of the control system implementation; consideration of individual case implementation of the control system: calculation of reliability of control of each quality indicator; if the value of the control reliability is greater than the allowable value of this parameter, then the option is not considered further; if the reliability of the control is satisfactory: calculation of the indicator (19); supplementing the options by means of solving the problem diagnosing a unit or unit of VTD; calculation of criterion (19); choice of implementation control system corresponding to the minimum criterion value (19).

Thus, the obtained method allows to choose the variant of implementation control and diagnosis system, optimal according to the criterion "reliability - cost - productivity - loss from errors of the first and second kind - completeness of control".

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КРИТЕРІЙ ВИБОРУ ЗАСОБІВ СИСТЕМ ТЕХНІЧНОГО ДІАГНОСТУВАННЯ ТА ІНФОРМАЦІЙНА ПІДГОТОВКА АВТОТРАНСПОРТНИХ ЗАСОБІВ

Розглядаються аспекти розробки критеріїв вибору засобів та варіантів систем технічного діагностування автотранспортних засобів. Системи контролю та прогнозування технічного стану автотранспорту потребують розширення діапазону контрольованих параметрів. Наведені критерії оцінки вибору оптимального набору вимірюваних параметрів і засобів їх вимірювання для забезпечення ефективності розроблюваної системи контролю та діагностування. Наведені основні аспекти інформаційної підготовки діагностики та ремонту автотранспортних засобів.

Сучасні вимоги до систематизації та узагальнень питань технічної діагностики транспортних засобів потребують розгляду системи управління якістю обслуговування та ремонту як однієї зі складових частин управління. Система управління якістю технічного обслуговування і ремонту призначена для забезпечення заданого рівня коефіцієнта технічної готовності, надійності, довговічності транспортних засобів, ефективного використання їх при мінімальних фінансових і трудових витратах. Таким чином, система управління якістю автотранспортних засобів базується на комплексі заходів, які включають технічні, економічні та інші взаємопов'язані дії для досягнення поставлених цілей для досягнення високого рівня якості.

Проблема якості при обслуговуванні та ремонті автотранспортних засобів значною мірою визначається рівнем метрологічного забезпечення. В статті відзначається, що технічна діагностика передбачає визначення технічного стану діагностичного об'єкта з певною точністю та достовірністю. Тому для забезпечення якості системи технічного обслуговування та ремонту автотранспортних засобів необхідно використовувати принципи метрологічного забезпечення.

Ключові слова: діагностика, прогнозування, імовірнісний метод прогнозування, модель об'єкта технічного діагностування, системи контролю, контрольовані параметри.

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КРИТЕРИЙ ВЫБОРА СРЕДСТВ СИСТЕМ ТЕХНИЧЕСКОГО ДИАГНОСТИКА И ИНФОРМАЦИОННАЯ ПОДГОТОВКА АВТОТРАНСПОРТНЫХ СРЕДСТВ

Рассматриваются аспекты разработки критериев выбора средств и вариантов систем технического диагностирования автотранспортных средств. Системы контроля и прогнозирования технического состояния автотранспорта потребует расширения диапазона контролируемых параметров. Приведенные критерии оценки выбора оптимального набора измеряемых параметров и средств их измерения для обеспечения эффективности разрабатываемой системы контроля и диагностирования. Приведены основные аспекты информационной подготовки диагностики и ремонта автотранспортных средств.

Современные требования к систематизации и обобщений по технической диагностики транспортных средств требуют рассмотрения системы управления качеством обслуживания и ремонта как одной из составных частей управления. Система управления качеством технического обслуживания и ремонта предназначена для обеспечения заданного уровня коэффициента технической готовности, надежности, долговечности транспортных средств, эффективного использования их при минимальных финансовых и трудовых затратах. Таким образом, система управления качеством автотранспортных средств базируется на комплексе мероприятий, которые включают технические, экономические и другие взаимосвязанные действия для достижения поставленных целей для достижения высокого уровня качества.

Проблема качества при обслуживании и ремонте автотранспортных средств в значительной мере определяется уровнем метрологического обеспечения. В статье отмечается, что техническая диагностика предполагает определение технического состояния диагностического объекта с определенной точностью и достоверностью. Поэтому для обеспечения качества системы технического обслуживания и ремонта автотранспортных средств необходимо использовать принципы метрологического обеспечения.

Ключевые слова: диагностика, прогнозирование, вероятностный метод прогнозирования, модель объекта технического диагностирования, системы контроля, контролируемые параметры.