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GROUNDING OF THE FREQUENCY RANGE CHOICE IN THE SYSTEM OF MONITORING OF THE OPERATION RELIABILITY OF THE TECHNICAL SYSTEMS

Dmitriy Marchenko

Volodymyr Dahl East-Ukrainian National University, Lugansk, Ukraine

Summary. There grounded the frequency range choice in the system of the operation reliability of the technical systems based on the application of probabilistic – statistical method.
Key words: monitoring, dispersion ellipse, cluster.

PROBLEM DEFINITION

In connection with great period of technical system operation and increasing of refusals connected with formation of operation defects in metal in the form of corrosion and erosion wear, dispersion and cracks, application of traditional discrete methods of inspection becomes ineffective because of great labour intensity, inopportuneness and locality of the given ways of investigation [Gnedenko B.V., Belyaev Yu.K., Soloview A.D., 1965]. A radical way of ensuring necessary level of operation reliability of the structures is application of the system of continuous tracking (monitoring) technical state in the process of operation on the base of acoustics-emission method, various methods of unfailed check and methods of experimental evaluation of tensile deformed state.

ANALYSIS OF THE PROBLEM

A wide introduction of the technical diagnostics is one of the most important factors of the effectiveness increase of the machine and technological equipment, decrease of the expanses required for these repair and operation [Thursdays V.A., 2003]. The system of the technical diagnostics acquire a great role in connection with the increase of reliability of the rolling stock, the system optimization of its plan preventive repair or repair due to its actual state of the object [Reshetov D.N., 1988]. It should be noted that the damage because of frequent repair of the units and sets connected with redundant labour intensity of disassembly and assembly work is so great that one of the most paramount problems is the problem of transfer from scheduled – preventive system to the operation according to the results of systematic vibro-acoustic diagnostics of the rolling stock equipment [Pakhomov E.A., 1985].

A new technology of operation aims at removing sudden break-downs, ensuring reliability of the equipment and economy of financial and material resources [Ostreikovskaya V.A., 2005]. The parameters of the diagnostic signal are the source of the technical state information in the given technology [Marchenko D., Vetrov A., 2003]. The changes of the properties of the signal are correlated with the changes of the technical state caused by the degradation of the units, change of geometrical sizes of the parts, wear. One of the most informed diagnostic features are the parameters of vibro-acoustic emission (VAE), Generated in the process of the mechanism work [Klyuyev V.V,. 2003].

The motions of the parts, units and sets of any machine are not random. They are performed along definite paths with definite speeds specified by existing kinematic links existing between the parts. In the ideal case the position and speed of any part are determined by position and speed of the drive member. Luck a mechanism is called ideal [Ivanova V.S., 1979]. Different defects of manufacture are shown in violation of designed links between the parts. Their motion differs from the specified one and it may be explained as emergence of additional degrees of freedom of the parts [Barenblatt G.I., 2003]. Motion of the parts in the kinematic chain of the machine by parasitic degrees of freedom rohich occur while wearing and other faults are accompanied by their collision and due to it elastic waves are spread in the body of the mechanism.

Many published investigations devoted to acoustic phenomena in the machines are directed to the search of the ways of reduction of general level of radiated noise power [Gnedenko B.V., Belyaev Yu.K., Soloview A.D., 1965, Gadasin V.A., Ushakov I.A., 1975, Bortsova A.T., 1983, Barzilovich E.Yu., Kashtanov V.A., 1971]. As for VAE the noise is used here as an information carries of the technical state of the equipment one of the advantages of VAE consists in the fact that the phenomena which break down the mechanism serve as a source of the diagnostic signal, that is, while vibro-acoustic diagnostics we obtain the information of the technical state of the machine [Baldin K.V., 2004].

Main reasons of the setting up the systems of diagnostic monitoring at the railway transport are the following: absence of access and difficult access to the object. High speeds of the growth of the operation defects in the structure; catastrophic consequences caused by the object break down [Ayzinbud S.Y., 1990].

The problem of providing maximum lifetime, «delay» of the system ageing, prolongation of their operation period under the conditions of resource restriction (financial possibilities, manpower resources, etc.) [Dodonov A.G,. 1988, Golubenko A., 2008], becomes one of the urgent problems for the scientists, economists and technical specialists of different countries. The consequences of the refusal rise, faults or defects in these system can bring even tragic consequences: global catastrophes, defeat of surroundings, human sacrifices, Great financial and material losses [Khaitun S.D., 1996]. The investigations in this direction are not possible without a system approach, taking into account various problems and their solution which can bring to improvement of the system state, guarantee some reliability and prolongation of its operation period with due regard for economical criteria and restrictions [Koks D.R., Smith V.Z.,1967].

Apparatus – programme complexes required for collection and measuring information processing on the basic of personal computers are necessary as a base means of measurement while monitoring [Nagovitsyn V.S., 2004, Pakhomov E.A., 1974]. These complexes give a high accuracy and operativeness of measurement, give wide possibilities while processing and keeping the results, multi-functionality, high mobility, rather low cost (in comparison with total cost of substituted devices).

The results of application of the continuous monitoring can be useful while grounding optimal volumes of repair-restore work which ensure the given prolongation of service life of analyzed systems [Terentyev V.F., 2003]. The analysis of the system reliability based on the dynamics of its operation gives the possibility to determine the present – day state of the system and to predict future of the system [Panin V.E., 1985].

But under these investigations the question arises whether this system is under control. Prediction of the further state of the system can be possible only in the case of positive reply regarding controllability.

THE PURPOSE OF INVESTIGATION

Development of the universal algorithm of identification of the working state of the system for accident (failure, break-down) or normal condition, algorithm of the system check by controllability and creation of automatic system of monitoring – scientific problems the solution of which allows to increase work ability and reliability of the system, decrease material expanses by timely substitution of defective units of the system.

These are no sudden refusals. One can foresee crash only in the case if the behavior of the system changes are known when it transfers from the normal regime of the operation into emergency. It is possible to identify the system due to approach to this or that state. Energy dissipation in the open non-linear system takes place inside some frequency spectrum.

Interval $[a, b]$ with minimum distance $(b-a)$, which contains p-% radiation level (for instance, $p = 95\%$) called p-window $[a, b]$. Inside this frequency range the energy distributions for given frequencies correspond to the state of normal work. Assemblage of the centers of gravities of frequency diagram form clusters specified for normal and emergency regimes of the work of the system.

The analysis of the statistic structure of the cluster allows to find two-dimensional laws inside any cluster, to form a decisive rule of identification of belonging of the investigated system to either regime.

RESULTS OF INVESTIGATION

To form clusters for «normal» and «emergency» work of the system there considered the vector of observation $\bar{x}(t)=\{x_1(t), x_2(t)\}$, which is subordinated to the two-dimensional law:

$$\varphi(x)=\frac{1}{2\pi\sigma_1\sigma_2\sqrt{1-\rho^2}}\exp[-\frac{1}{2(1-\rho^2)}((\frac{x_1-m_1}{\sigma_1})^2-$$
$$-2\rho(\frac{x_1-m_1}{\sigma_1})(\frac{x_2-m_2}{\sigma_2})+(\frac{x_2-m_2}{\sigma_2})^2)],$$

where: m_1, m_2 – mean value expectation, and σ_1 и σ_2 – dispersion.

It is known that the density of the normal law of distribution keeps normal values on the ellipses:

$$\lambda^2=\frac{1}{2(1-\rho^2)}((\frac{x_1-m_1}{\sigma_1})^2-2\rho(\frac{x_1-m_1}{\sigma_1})\times$$
$$\times(\frac{x_2-m_2}{\sigma_2})+(\frac{x_2-m_2}{\sigma_2})^2),$$

where: λ^2 – ellipses of probability. It was proved that the probability of hit of the vector $\bar{\xi}$ of such a ellipse is equal to $P=1-e^{-\frac{\lambda^2}{2}}$.

The centers of two clusters are found as the centers of two ellipses. The point of tangency is found from the system solution of two equations of the second order.

The system determining the point of the tangency of the ellipses is the following:

$$\begin{cases}\frac{1}{(1-r^2)}\left(\left(\frac{x_0-a}{S_1}\right)^2-2r\left(\frac{x_0-a}{S_1}\right)\left(\frac{y_0-b}{S_2}\right)^2\right)=\frac{1}{(1-\rho^2)}\times \\ \times\left(\left(\frac{x_0-\alpha}{\sigma_1}\right)^2-2\rho\left(\frac{x_0-\alpha}{\sigma_1}\right)\left(\frac{y_0-\beta}{\sigma_1}\right)+\left(\frac{y_0-\beta}{\sigma_2}\right)^2\right); \\ \frac{\sigma_2}{\sigma_1}\frac{\rho\sigma_1(y_0-\beta)-\sigma_2(x_0-\alpha)}{\sigma_1(y_0-\beta)-\rho\sigma_2(x_0-\alpha)}=\frac{S_2}{S_1}\frac{rS_1(y_0-b)-S_2(x_0-a)}{S_1(y_0-b)-rS_2(x_0-a)},\end{cases}$$

or

$$\begin{cases}0=F_1(x,y);\\0=F_2(x,y).\end{cases}$$

The solution of the system determines the point (x_0, y_0).

The equation of the general tangent to the ellipses is written in this way:

$$F(x,y)=y-y_0-k(x-x_0).\,.$$

This function is the criteria while checking the belonging of the current point to either cluster.

If

$$F(x,y)\cdot F(a,b)>0\,, F(x,y)\cdot F(\alpha,\beta)<0\,,$$

then $M\in K_1$ (where K_1 – the first cluster).

If

$$F(x,y)\cdot F(a,b)<0\,, F(x,y)\cdot F(\alpha,\beta)>0\,,$$

then $M\in K_2$ (where K_2 – the second cluster).

The value of the boundaries of the window defines the band where the system (acoustic, electromagnetic) «sounds».

CONCLUSIONS

There grounded a methodologic approach to the choice of frequency range and creation of the data bank of normal and emergence regimes of the system operation. Organization of the data renewal allows to solve scientific and practical problem of diagnostics of the technical state in the regime of real time.

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ОБОСНОВАНИЕ ВЫБОРА ЧАСТОТНОГО ДИАПАЗОНА В СИСТЕМЕ КОНТРОЛЯ ОПЕРАТИВНОЙ НАДЕЖНОСТИ ТЕХНИЧЕСКИХ СИСТЕМ

Дмитрий Марченко

Аннотация. Обоснован выбор частотного диапазона в системе оперативной надежности технических систем, основанный на приложении вероятностно-статистического метода.
Ключевые слова: мониторинг, эллипс рассеяния, кластер.