

CRITERIA OF TAKING DECISIONS AT TECHNICAL OPERATION OF BUILDINGMACHINERY IN CONDITIONS OF THE CONSTRUCTION PLANT

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Abstract: In the article on the basis of similarity functioning the technique of getting and using the criteria of taking decisions at technical operation control, modernization and replacement of the elements of building machinery in conditions of the construction plant is considered.

Keywords: similarity, functioning, criteria, technical operation, and modernization.

INTRODUCTION

The issue of quality management of technical operation (at maintenance service, repair, and also modernization, technical state control, solving problems of refused elements, units replacement, etc.) of building machinery in conditions of the construction plant remains quite acute, inspite of positive experience of its solving in stationary conditions.

Methods and means of solving the problems mentioned above available and used in the world practice are only suitable for conditions of stationary specialized repair - diagnostic firms and building industry enterprises. Therefore at practical solving of the specified problems in conditions of the construction plant they are guided by the available operational experience and the employees' opportunities. Such kind of methods (tests and mistakes) at the building machinery diagnostics, analogues selection instead of the replaced or refused original elements and systems at modernization obviously results in reduction of operational and technological opportunities of the machinery as a whole. It basically happens because of the discrepancy of constructive and functional parameters of the compared analogues. Therefore a machine or a unit will be represented as though another technical system that should be adjusted in accordance with the original one some additional technical or technological measures (adjustment, a mode change, etc.) are needed.

Engineering methods of taking decisions in the specified conditions should be based on the system and, if possible, include typical techniques of calculations, procedures of taking decisions. As a result of engineering calculations criteria of the discrepancy allowable, criteria of similarity compared (initial and received) systems and a way of preset values achievement of the discrepancy should be received.

For solving of the specified problems it is possible to use principles of similarity of system's functioning representing one of new kinds and methods of research in the classical theory of similarity. This theory states that any functional dependence between physical parameters of the researched phenomenon and an object can be also expressed as dependences among the criteria of similarity made of these parameters. The features of criteria are the following: informatively, models of refusals development in the criteria form typical for similar processes of various technological systems; complex criteria of similarity - independent parameters. All these features allow to simplify models of development of machinery refusals and also to use algorithms of evaluation of its reliability, conformity which allow recalculation with their help of the initial or operational machinery parameters from one conditions to the others.

The procedure of estimation of the elements of the machine, the degree of the adequacy of functional characteristics and the physical processes carried out at various stages of the physical and moral obsolescence, and also the order of elimination of their possible mismatch runs as following:

- To reveal in and out parameters of the technological process carried out by a system or a machine;
- To reveal determining parameters of the carried out physical process and the parameters describing the work capacity and design for the analyzed element;
- To form criteria of similarity of functioning describing the constructional features and the physical processes carried out for the research element, a subsystem; containing it and a machine as a whole;
- To establish the dependence of criteria of the machine on the dependence of the elements, subsystems;

- To define the numerical values of similarity criteria at the initial and the researched moments of operation (for example, before and after the replacement of an element with the analogue), and also the accuracy of reproduction of the given technological process;
- To take decisions according to the specific purpose at the insufficient accuracy of the reproduction of the preset values of the parameters of the technological process by an element on the similarity criteria of functioning.

Let us admit that the “out” physical parameters of the technological process carried out by the machine, are y_1, y_2, \dots, y_n and the “in” specifying and revolting influences, the physical process and the constructional features of the element are determined by parameters x_1, x_2, \dots, x_m , and at least one of y_i parameters is connected with x_i , i.e.

$$y_i \in \{y\} = f(x_1, x_2, \dots, x_m). \quad (1)$$

The choice of those or other parameters x_i is defined by a specific task of research of the technical system and by the following taking of decisions.

Let us accidentally admit that the quantity of parameters x_i is equal to 7 and they are

$$\frac{y_i}{x_3^{\alpha_y} x_4^{\beta_y} x_6^{\gamma_y} x_7^{\delta_y}} = \Phi \left(\frac{x_1}{x_3^{\alpha_1} x_4^{\beta_1} x_6^{\gamma_1} x_7^{\delta_1}}, \frac{x_2}{x_3^{\alpha_2} x_4^{\beta_2} x_6^{\gamma_2} x_7^{\delta_2}}, 1, 1, \frac{x_5}{x_3^{\alpha_5} x_4^{\beta_5} x_6^{\gamma_5} x_7^{\delta_5}}, 1, 1 \right) \quad (3)$$

where dimensions of the denominators and numerators should be equal.

Substituting the complexes of expression (3) with the dimensions of the appropriate parameters x_j , by known from the theory of similarity methods which numerical values are designate accordingly a_j, b_j, c_j, d_j .

The criteria of similarity will finally become:

$$\begin{aligned} \pi_1 &= \frac{x_1}{a_1 b_1 c_1 d_1}; \\ \pi_2 &= \frac{x_2}{a_2 b_2 c_2 d_2}; \\ \pi_3 &= \frac{x_5}{a_5 b_5 c_5 d_5}; \\ \pi_{y_i} &= \frac{y_i}{a_y b_y c_y d_y}. \end{aligned} \quad (4)$$

characterized by four units of measurements: time T, weight M, length L and temperature θ . According to the theory of similarity and dimensions, the number of criteria of similarity will be equal 3 (the general number of parameters minus the number of the independent dimensions). These criteria will be defined by the method of zero dimensions. Let us conventionally take x_3, x_4, x_6, x_7 as the key parameters. The determinant made for these parameters from parameters of degrees of their dimensions, should be different from zero, i.e.:

$$\Delta = \begin{vmatrix} \mu_3 & \lambda_3 & \tau_3 & \eta_3 \\ \mu_4 & \lambda_4 & \tau_4 & \eta_4 \\ \mu_6 & \lambda_6 & \tau_6 & \eta_6 \\ \mu_7 & \lambda_7 & \tau_7 & \eta_7 \end{vmatrix} \neq 0$$

(2)

This term means, that taking parameters are really independent. Symbols $\mu_i, \lambda_i, \tau_i, \eta_i$ in the determinant (2) correspond to the exponents at dimensions of weight M, lengths L, time T and temperatures θ for the taken parameters x_j .

As the criteria of similarity represent sizes of zero dimension the expression (1) should be written down in the dimensionless way:

Depending on the physical meaning of the received criteria of parameters included the separate criteria will characterize geometrical similarity of the elements - analogues, others - similarity of physical processes occurring in them. Accordingly the first ones should be used for selection of elements - analogues at their constructive replacement of the refused elements, and others - for correcting of the technological parameters carried out by the

machine. Thus it means, that the received criteria of similarity can be accidentally divided or multiplied thus forming new criteria of similarity suitable for solving of specific tasks. In particular, it is possible to form the special criteria for y_i out parameters of systems' functioning. These criteria include "in" influences and internal parameters of the systems, the so-called criteria of similarity of elements functioning, the systems of building machinery.

Generally criteria may have an area of the admitted values as constructional or the technological parameters of the element of the machine are given with the accuracy in certain limits. Therefore values of criteria i of the element - analogue π_{ia} and element - original π_{i0} should follow the term:

$$\pi_{ia} = \pi_{i0} \quad (5)$$

where the set of values π_{i0} is restricted by bottom π_{i0} and upper $\overline{\pi}_{i0}$ limits.

According to the given technique the concrete examples of taking decisions at technical operation of the technical systems should be considered.

Thus if the analysis of interchangeability at a choice of analogue the term is broken, recalculation and the change of the rating values of the parameters carried out by the element of the technological process with the purpose of saving the value of the main, determining quality criterion of system functioning or the machine as a whole made or calculated from the condition of the given productivity, effort or other parameters is necessary. If quality of functioning is not saved after that it means that another element of the replaced element is needed. The order of taking decisions about the interchangeability of the technical objects was considered by the replacement of the refused pump adjustable on the pressure such as PVE 35 QR-1-21-CVP-JT6 by the domestic analogue.

The pump serves for maintenance of supply of the working element, carrying out of the working operation in time $t_0 = 2 \div 2,5$ sec. that corresponds to the oil submission into the cylindrical cavity $Q_c = 70-80$ l/min, and also for the shneck rotation with frequency $n_s = 120 \text{ min}^{-1}$ that corresponds to the oil expenditure through hydro motor $Q_{gm} = 55$ l/min at pressure $P = 12$ MPa. The import pump is characterized by the following rating values of parameters: submission $Q_n = 106$ l/min; working volume $q_n = 70 \text{ sm}^3/\text{vol}$; pressure $P_n = 25$ MPa; rotation frequency of the shaft $n_n = 1450 \text{ min}^{-1}$; the maximal pressure of forcing $P_{nmax} = 35$ MPa. As a working liquid oil viscosity $v_n = 46 \text{ mm}^2/\text{s}$.

The criteria of similarity made in accordance with the offered technique for the given conditions look like:

$$\begin{aligned} \pi_1 &= \frac{t_0 Q_n}{q_n} = 193,4 \\ \pi_2 &= \frac{n_{gm} q_n}{Q_n} = 0,024 \\ \pi_3 &= \frac{P_n}{P_{nmax}} = 0,75; \\ \pi_4 &= v \sqrt{\frac{F}{Q_c}} = 39,7 \end{aligned} \quad (6)$$

with F as the area of the piston.

Apparently from the first and the second criteria dependences, saving of preset values of technological parameters t_0 and n_{gm} at replacement of the pump by its domestic analogue is possible if at $\pi_i = \text{const}$ the condition is satisfied:

$$\frac{Q_n}{q_n} = \frac{Q_{n.a}}{q_{n.a}} = \text{const.} \quad (7)$$

However, taking into account, that the submission of oil in the hydro system of the machine to the hydro motor and the cylinder is adjusted and stabilized by the stream regulators, this condition basically may not be followed and the estimation of the interchangeability of the pumps should only be carried out on conformity of rating values Q and P . At the same time at an estimation of the interchangeability of the pumps adjustable by the pressure of the pumps the third criteria is of great importance as it means, finally, steepness of the static characteristic of the adjustable pumps, the time and accuracy of regulation.

The carried out analysis on the criteria of the interchangeability of the import pump by the domestic it is allowed to choose this analogue. In this case as an analogue the domestic adjustable pump RNA 1D 63/320 UHL4 with the following parameters was taken: $Q_{n.a} = 87$ l/min; $q_{n.a} = 63 \text{ sm}^3/\text{vol}$; $P_{n.a} = 32$ MPa; $P_{n.a.max} = 40$ MPa; $n_{n.a} = 1500 \text{ min}^{-1}$. The oil viscosity recommended by the factory manufacturer is $v_{n.a} = 12 \square 75 \text{ mm}^2/\text{s}$. According to this recommendation and including the fourth criterial dependences (6) oil Tp-46 GOST R 9972-74 was agreed. The value of the criterion $\pi_3 = 0,8$, is better for the given pump than at the replaced one.

Similarly an example of taking decisions at the analysis of the technical condition of building machinery should be considered. The choice and the use of these or those techniques and means of

the technical condition of machinery in terms of the concrete building enterprises depends on the following factors: constructive and repair complexity of building machinery, their quantity at the construction plant, economic feasibility of application of the techniques and means of diagnostics, their complexity and availability. Thus the engineering preparation of the testing process of the technical state is of great importance including the determining of “in”, internal and tested parameters and also their boundary condition at an estimation of the work capacity of the machinery; the grounded choice of kinds and evaluative criteria of the technical conditions and the appropriate to the evaluations recommendations on the regulations of the further operation the technical service and repair of the concrete machines.

Criteria of similarity of functioning having informatively according to the processes carried out by the machine or the mechanism obviously may be the source of information concerning the way how far the concrete technical condition corresponds with the efficient or another given condition. And if the number of the discrepancy of the initial and valid values of the criteria exceeds the preset limiting value it is possible to conclude about the disability of the machine.

The advantage of the criteria of similarity is also in the fact that they can be made of any process parameters, the phenomena connected by the functional dependence. At the control of the technical condition the criteria dependences made of the structural and diagnostic parameters are also of interest. In this case it is possible to determine the value of the structural and diagnostic parameter (which registration is complicated) using accessible techniques and means of registration of the diagnostic parameters be the criteria dependence without operations of dismantlement and without breaking the manufacturing process in which the machine is involved.

The control technique of the technical condition of the element, subsystem of the building machine consists of the following.

Accepting values of the parameters included into the expression (4) and equal to the values appropriate to the given condition of the element the initial values of the criteria of similarity are determined.

In the process the control of technical conditions having defined (by calculating) the valid values of diagnostic parameters y_i and having accepted constant value criterion i ($\pi_i = \text{const}$), according to the expressions (4) it is possible to find the valid value of structural parameter X_{ij} . On comparison of the parameter value with its boundary (the

greatest $\overline{X_{ij}}$ and the least X_{ij}) values appropriate to the given condition of the element it is possible to judge about the valid technical condition of the element and the machine as a whole, i.e., if

$$X_{ij} \in \left| \overline{X_{ij}}, X_{ij} \right|,$$

element j on parameter X_{ij} is in the efficient condition or on the contrary if

$$X_{ij} \notin \left| \overline{X_{ij}}, X_{ij} \right|$$

the valid condition does not correspond to the preset value, i.e. the element is disable.

The presented technique was tested at the evaluation of the technical condition of the hydro drive. Thus the following parameters of working capacity were considered: δ - a backlash in the interface of the pair “the piston and the cylinder”; μ - the oil viscosity; Q_0 - submission of the pump of the constant productivity.

Let us admit that the functional dependence determining the work of the hydro drive establishes the connection of time t of the turn of the working element with pressure difference on the cylinder of turn ΔP_c , viscosity μ and the module of oil elasticity E , the size of the outflow in cylinder Q_y , through the backlash δ in condensation, diameter d , length of course H and area F of the piston.

The criteria of similarity of the preset process of functioning were received, the main of them are:

$$\begin{aligned} \pi_1 &= t Q_0 \delta^{-3}; \\ \pi_2 &= \Delta P_c \delta^3 \mu^{-1} Q_0^{-1}; \\ \pi_3 &= t \mu^{-1} \Delta P_c. \end{aligned} \quad (8)$$

As measured parameters it is convenient to accept t and ΔP_c , and as seeked parameters - δ, μ, Q_0 .

According to the first and third criteria of similarity of functioning the increase of the turn time can be generally connected with the appropriate decrease of the pump submission, decrease the viscosity and the increase of the backlash of the pressure difference on the cylinder.

According to the second criterion the change of the pressure difference on the cylinder (at constant loading) may appear at the changing of the backlash, the oil viscosity and the submission of the pump.

The strategy of the control of the technical condition on the criteria of similarity can be different according to the concrete conditions of operation and construction of the hydro drive but the essence of the technique remains constant. The following strategy can be used in this case:

1. The initial values of the parameters included into the criteria dependences and appropriate to the preset condition were considered:

$$\begin{aligned} t &= (5 - 6), \text{ s}; \\ Q_0 &= (5,0 - 5,0)10^{-4}, \text{ m}^3\text{s}^{-1}; \\ \delta &= (1,5 - 2,0)10^{-5}, \text{ m}; \\ \Delta P_c &= (4,0 - 2,5)10^6, \text{ N} \cdot \text{m}^{-2}; \\ \mu &= (182 - 160), \text{ N} \cdot \text{s} \cdot \text{m}^{-2}, \end{aligned}$$

where the first ones are optimum, and the second ones - the limiting values of the parameters satisfying the preset, available and efficient condition of the hydro drive.

2. Values of criteria of similarity paid off:

$$\pi_1 = 86 \cdot 10^{10}; \quad \pi_2 = 12,75 \cdot 10^{-8}; \quad \pi_3 = 10,95 \cdot 10^4.$$

3. The valid values of the time of the turn and the pressure difference were measured:

$$t_u = 8 \text{ s}; \quad \Delta P_{cn} = 3 \cdot 10^6, \text{ N} \cdot \text{m}^{-2}.$$

Taking into account the real conditions an possibility of calculation of these or those parameters in case of their preserving at the level of initial values of the other parameters was researched. The calculation of the parameters was carried out.

Using the third criteria dependence and having assumed that the value of the backlash in the condensation and the quantity of the pump submission corresponds with the preset the value of the oil viscosity change was determined as:

$$\Delta \mu = \frac{t_u P_{cu}}{\pi_3} - \mu, \quad (9)$$

and its calculating value accepted for the valid one.

The calculating value of the oil viscosity ($\mu_p = 146, \text{ N} \cdot \text{s} \cdot \text{m}^{-2}$) is significantly less of the required one that allows to make a conclusion about the necessity of its analysis and replacement. Thus the real submission value is determined at the real viscosity value, the measured pressure difference value and the initial value of the

backlash. Similarly, the correctness of the assumption of the backlash conformity is checked.

In this case the values are within the limits and make: the pump submission $Q_r = 5,4 \cdot 10^{-4}, \text{ m}^3 \cdot \text{s}^{-1}$; the backlash in condensation $\delta_r = 1,7 \cdot 10^{-5}, \text{ m}$. It accounts for the working condition of the pump and the cylinder, and the condition of the hydro drive is disable according to "the oil viscosity" parameter.

The presence of the functional dependences in the form of the criteria of similarity of conditions after measuring of the true values of the diagnostic parameters of the elements allows to calculate the real values of their structural or some other diagnostic parameters and as a result to determine the technical condition of the tested element, the system or the machine, the unit as a whole. And this in its turn helps to form the strategy of their further operation (adjustment, repair; replacement of defective elements) without equipment downtimes necessary for these purposes earlier and without any dismantlement works.

Nowadays the caring out of the offered technique of testing of the technical conditions is quite feasible by the experts - mechanics of the building organizations.

The similar procedures of taking decisions can also be carried out at modernization of the building machinery.

It is necessary to note, that there are some ways of getting of the criteria of similarity on the basis of the preset nomenclature of the parameters characterizing the physical essence of the researched process. However the most effective is the way allowing to use the computer facilities. For this purpose some simple computer programmers are developed by the authors. The received criteria of taking of the decisions at the technical operation are typical and universal for use at the various stages of the "life cycle" of the certain class of the building machinery.

CONCLUSION

Criteria of similarity of functioning having informatively according to the processes carried out by the machine or the mechanism obviously may be the source of information concerning the way how far the concrete technical condition corresponds with the efficient or another given condition. If the number of the discrepancy of the initial and valid values of the criteria exceeds the preset limiting value it is possible to conclude about the disability of the machine.

The advantage of the criteria of similarity is also in the fact that they can be made of any process parameters, the phenomena connected by the

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