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Organizational analysis of the number of failures of integral components of the circuits – OE Spinning machine based on mechanical oscillations in observed time of their exploitation from aspect of their reliability

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Summary: Reliability of integral components of system for winding coils with finished yarn with OE spinning machine is performed analytically by showing the mathematical transfer functions through the final equation value of reliability based on the partial values of reliability.These final transfer functions are obtained based on the formed sub-methods as follows: Pre method (1) that consists in the fact that for the obtained exploitation data on failures, because of the high level of mechanical osillations, define the empirical function of density of distribution $\lambda_e(t)$ and empirical reliability function $R_e(t)$ and pre method (2) that was used for the selection of statistical reliability distribution of the analysed circuit components which corresponds best to the obtained data on failures that occurred due to the influence of high level of mechanical oscillations in the exploitation of their work. Based on these sub methods are obtained final forms of curve $f(G_{NK}(t),t)$ that determines the shape of the statistical distribution of the analyzed system reliability.

Keywords: *number of failures, OE – spinning machine, winding coils system, reliability, dependency of the reliability curve.*

I. INTRODUCTION - INTRODUCTION – DESCRIPTION OF COMPLEX FOR COIL WINDING WITH FINISHED YARN

System of power transmission of the system for coil winding with finished yarn is shown in Figure 1. and consists the following parts and components which are classified based on the spun yarn which is obtained by spinning from the rotor (turbine) and on its way to the coil on which is winding.

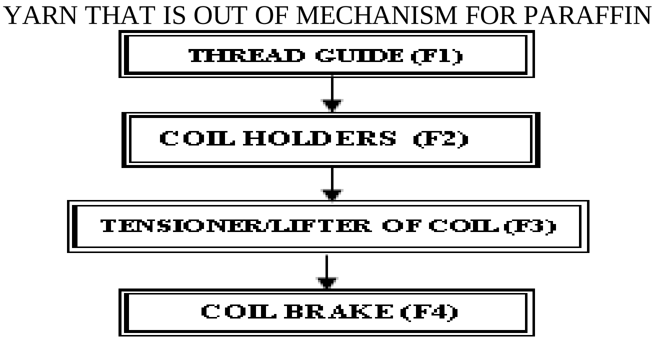

Figure (1). System of transmission for winding coils with finished yarn

THREAD GUIDE (F1) – serves for evenly and safely winding of yarn on cone coil. His movement is rectilinear with feedback gait, the number of cycles is 120/ per minute. It is made from a special type of ceramic with a metallic sheathing resistant on the occurrence of friction. Installation and removal are very simple (Fig. 2).

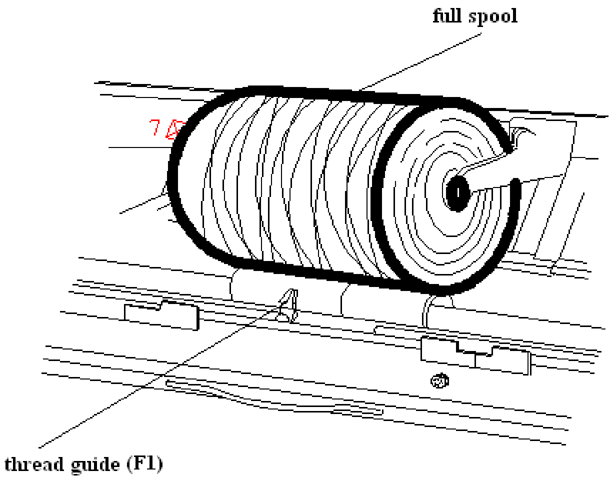

Fig. (2). System for the winding coil with finished yarn – the front part of the complex

COIL HOLDERS (F2) – serves for centering and evenly circular rotation of coil when winding. Holders are made from a special type of polymer, they are special forms placed on the rolled bearings. When bearings breakdown, because of dust in it, leads to its malfunction and fracture of the inset of coil holder (Fig. 3).

TENSIONER/LIFTER OF COIL (F3) – is system of springs and levers that is used for disposal of full coils on a conveyor belt. System of springs is unstrained at coil winding with yarn, while at the full coils the same is activated and divides the full coil from coverings on which coil leans while rolling on (Fig. 3).

COIL BRAKE (STOPPING OF COILS WHEN YARN BREAKS) (F4) – is a system that consists from roller shape coverings on which coil leans while rollin on, as well as from the lever that activates while tying the broken yarn (Fig. 3).

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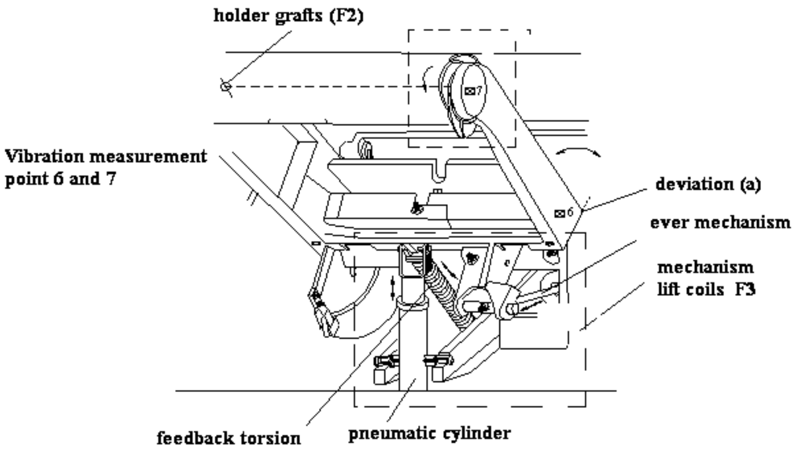

Fig. (3). System for winding coils with finished yarn – rear of the complex

COIL HOLDERS (F2) – serves for centering and evenly circular rotation of coil when winding. Holders are made from a special type of polymer, they are special forms placed on the rolled bearings. When bearings breakdown, because of dust in it, leads to its malfunction and fracture of the inset of coil holder.

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II. THEORETICAL ANALYSIS OF THE SYSTEM

Analyzed circuits at the beginning of the exploitation, did not have a big number of failures of their components, but there was a lack of precision in their installation that lead to a certain arrest, and it can be said that these are not early failures in initial work of circuits but disadvantages when starting OE – spinning machine in its exploitative work.

From established state of work of OE – spinning machine gradually came to tear of the circuit components, and in conjunction with that, to increased levels of mechanical oscillations that led to cancellation of some of their components.The first failures have occurred about 13 000 hours of work on the integral components of analyzed circuits of OE – spinning machine. From this period there is a rapid growth of failure of their integral components, and for this period can be said that it is a period of their unstable work. This can be displayed with dependency diagram of the number of failures N FAILURES (N OTKAZA) in the function of the exploitation time *t* (Figure 4.).

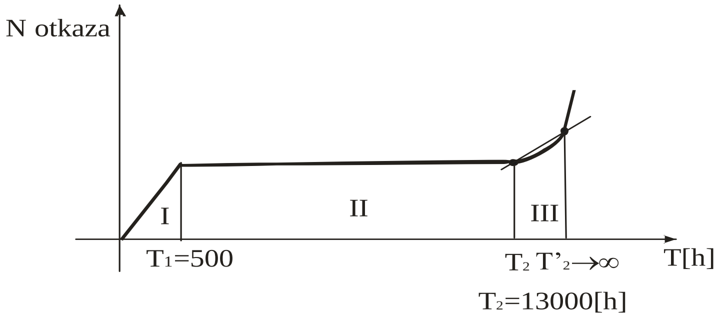

Figure (4). Dependency area of the number of failures of analyzed circuit components based on the increased level of mechanical oscillations in the function of their time of exploitation work without the use of preventive maintenance technology

On figure 4. can clearly see three areas where failures occur, as follows:

The area of initial work of the circuit $0 \div (t_1)$, *(I area of exploitation);*

The area of initial work of the circuit $(t_1 \div t_2)$, *(II area of exploitation);*

The area of initial work of the circuit $(t_2 < t'_2 < t'_2 \to \infty)$, *(III area of exploitation).*

Failure analysis of the integral components of analyzed circuits will be concentrated in the areas of their unstable work because then it come to their intensification . If with t_1 - mark the time by which the analyzed circuit was initiating his work, and with t_2 time by which the analyzed circuit had work without failure (exploitation-established circuit with the area of allowed risk of work – safe work) then each time interval after the time t_2 is interval of his unstable work $t_2' > t_2$, that is, interval of the risk.

In figure 5. is presented dependency of number of failures N FAILURES (N OTKAZA) in the function of exploitation time *t* of integral components of analyzed circuits on which were implemented procedures of preventive maintenance technology.

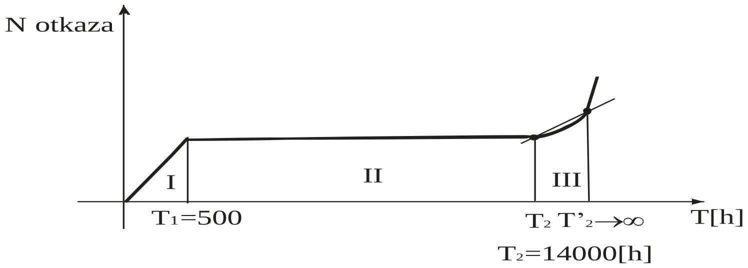

Figure 5. Dependency area of the number of failures of analyzed circuit components based on the increased level of mechanical oscillations in the function of their time of exploitation work with the use of preventive maintenance technology

III. RELIABILITY OF THE WORK OF ANALYZED CIRCUIT COMPONENTS OF OE- SPINNING MACHINE

Determination of the reliability of the work of integral components is taken as a part of the collective concept of security functioning and its performance. The starting point was the quality of service of OE - spinning machines that includes:

- Performance of use (availability and stability performance),
- Availability performance (performance of: reliability, maintainability and logical support of maintenance).

So that the listed performances could ensure safety of functioning of the work of OE – spinning machine, it was necessary to link the reliability of his work and the process of preventive maintenance technology.

To determine the reliability of the integral components of the analyzed circuit, will use the data on failures that occurred due to the impact of increased levels of mechanical oscillations (vibrations) and have been recorded from the exploitation of their work (Table 1).

Table 1. Total number of failures on integral components of the analyzed circuits on which are not implemented procedures of preventive maintenance technology and on those on which were implemented

Ordinal number	Name of the integral component of the circuit	Number of failures of integral components on which were not implemented procedures of preventive maintenance technology	Number of failures of integral components on which were implemented procedures of preventive maintenance technology
8.	Thread guide (F1)	21	20
9.	Coil holder (F2)	114	92
12.	Coil brake (F4)	2	2

IV. RELIABILITY OF WORK OF COMPONENTS OF ANALYZED COMPLEX OF OE –SPINNING MACHINE WITH METHOD OF ANALYSES OF FAULT TREE

Determination of the reliability of work of constituent components is taken as part of the collective security of functioning and its performance. Started from the quality of service of OE - spinning machines that includes:

- Performance of use (performance of availability and stability),
- Performance of availability (performance: reliability, maintainability and maintenance logical support).

To ensure the safety of the listed performance function of assembly OE - spinning it was necessary to link the reliability of their work procedures and implementation of preventive maintenance technology.

To determine the reliability of the constituent components of the analzyed complex, used the data on failures that occurred due to the impact of increased levels of mechanical oscillations (vibration) and have been recorded from the exploitation of their work.

For the analysis of data to determine the reliability of components analyzed complex, it was used the following pre methode which consists in this: that for the obtained exploitation data on failures, because of the influence of high level of mechanical oscillations, define the empirical density function $f_e(t)$, empirical function of failure intensity $\lambda_e(t)$ and empirical function of reliability $R_e(t)$.

This sub method for the determination of the main functions in the analysis of the reliability of integral parts and components of complex, were chosen based on the analysis of data on failures incurred because of increased levels of mechanical oscillations obtained in the exploitation of their work, and are the most practical way to determine the reliability of their work. As the analysis of the data of reliability, will determined density function failure $f_e(t)$, function of failure intensity $\lambda_e(t)$ and function of reliability $R_e(t)$, based on which will be determined reliability of the work of components of analyzed complexes.

For a more complete analysis of the reliability of the components of the analyzed complex, shall be determined safe function of their work.

If we have (n) connected components of complex in the system of power transmission of OE - spinning machines for which we analyze the reliability, starting from the period for $t = 0$, than at any point of time (t_i) it will be $n_i(t_i)$ of the complex that are not cancel. In this case, the empirical density function of failure $f_e(t)$, can be determined from the form:

$$fe(t) = \frac{\dfrac{n_i(t_i) - n_i(t_i + \Delta t_i)}{n}}{\Delta t_i} = \frac{n_i(t_i) - n_i(t_i + \Delta t_i)}{n \cdot \Delta t_i} \qquad (4.1)$$

where : $t_i \le t \le \Delta t_i$.

Empirical function of failure intensity $\lambda_e(t)$, is equal to the quotient of ratio of the number of failures in the time interval Δt_i and the number of circuits that are not canceled at the beginning of the interval, with the length of the time interval Δt_i.

This function is determined by the empirical formula:

$$\lambda e(t) = \frac{\dfrac{n_i(t_i) - n_i(t_i + \Delta t_i)}{n_1(t_i)}}{\Delta t_i} = \frac{n_i(t_i) - n_i(t_i + \Delta t_i)}{n_1(t_i) \cdot \Delta t_i} \qquad (4.2)$$

where : $t_i \le t \le \Delta t_i$.

The difference between the empirical density of failure $f_e(t)$, and empirical functions of failure $\lambda_e(t)$ is in the speed of happening the failure. Empirical density of the failure is overall speed failure happenings, while the empirical function of failure intensity, current speed of failure happening. Empirical reliability function $R_e(t)$ represents the probability of no failure work of connected components of analyzed complex (n) during the time *t*.

This is represented by the form:

$$R_e(t) = \frac{n_1}{n}, \qquad (4.3)$$

where:

$n_1(t)$ - number of the correct complexes or components of complexes at the end of the time interval *Δti;* $n(t)$ - total number of components of the analyzed complex.

Presented patterns in determining empirical functions: failure density $f_e(t)$, function failure $\lambda_e(t)$ and reliability $R_e(t)$, will be applied in determining the approximate reliability of the work of analyzed complex components.

Concretely computation of these functions will be shown in determining the reliability of the work of analyzed complex components on which have not been applied technology of preventive maintenance procedures and the ones on which these procedures are implemented.

V. DETERMINATION OF CORRECTION VALUES OF THE RELIABILITY OF THE INTEGRAL COMPONENTS WORK OF ANALYZED COMPLEX BASED ON THE EMPIRICAL (EXPLOITATION) DATA

Since are defined exploitation values of reliability that are expressing approximate values of reliability of integral components work of analyzed complex with maximum safety (areas of their safe work time and areas of reduction of their reliability) for their more precise determination it was used determination of their correction values.

Correction values of reliability from empirical (exploitation) data are shown in pictures from 7, and their tabular values are shown within these pictures.

Correction values of reliability are obtained by dividing the empirical density function of the empirical values $\left(f_e(t)\right)$ and function of failure intensity $\left(\lambda_e(t)\right)$ for the time interval of the exploitation work of complex components (analysis included exploitation work time of integral componentsof the complex in the period $13000 \leq \Delta t_i \leq 21000$ hours) (Fig. 7.) and is determined by the expression:

$$P_i(t) = \frac{f_{e_i}(t)}{\lambda_{e_i}(t)}. \qquad (5.1)$$

VI. DETERMINATION OF STATISTICAL METHODS RELIABILITY DISTRIBUTION OF THE ANALYZED CIRCUIT

To determine the statistical method of reliability distribution is necessary to create models and to determine transmission function of the reliability of the analyzed curcuit. For determining table of the transfer functions of the circuit for the coil winding with finished yarn $G_{NK}(t)$ correction values of reliability are used $P_i(t)$.

Formation of models included the layout of circuit components according to processing of the yarns, that is, according to the order of components in the fault tree.

The components are sequential arranged on the circut, from the thred guide to the mechanism for disposal of the coils with finished yarn at the circuit for coil winding with finished yarn.

For these reasons, the model of the block diagram is shown. In this model, approach to solving the obtaining of transfer function is reduced to reduction of the diagram blog.

Based on the obtained final expressions of transfer functions of the analyzed circuit ($G_p(t)_{NK}$ - for winding coils with finished yarn), and in it replacing the values of component reliability $P_i(t)$ for time intervals $13000(\text{h}) \leq \Delta t_i \leq 20000(\text{h})$ tabular values are obtained for significance of reliability zones, from which is constructed the curve of reliability of transfer function of analyzed circuit.

Model of the block diagram of reliability of transfer function at the circuit for coil winding with finished yarn. Model of the block diagram of reliability of transfer function at the circuit for coil winding with finished yarn is shown in Figure 6.

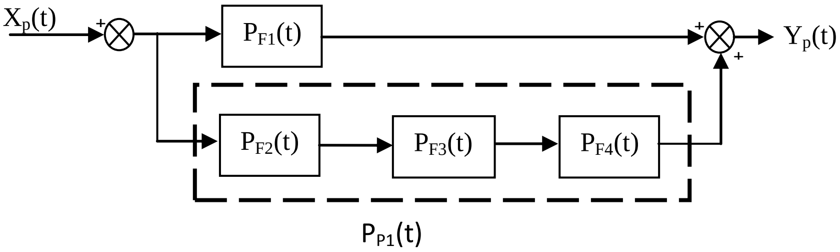

Figure (6). Initial model of the block diagram of reliability of transfer function at the circuit for coil winding with finished yarn

Step I - Determination of partial blocks of reliability $P_{P1}(t) = P_{F2}(t) \cdot P_{F3}(t) \cdot P_{F4}(t)$. (Figure 7.)

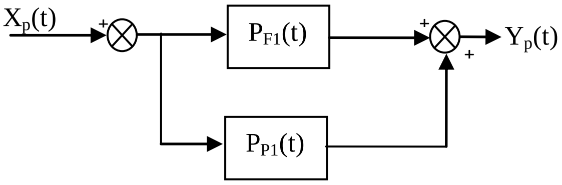

Figure (7). Picture of partial blocks of reliability

Step II – Determination of the overall transfer function of reliability of the circuit for winding coil with finished yarn:

$$\boxed{G_{NK}(t)_P = \frac{Y_P(t)}{X_P(t)} = P_{F1}(t) + P_{P1}(t) = P_{F2}(t) \cdot P_{F3}(t) \cdot P_{F4}(t) + P_{F1}(t)} \tag{6.1}$$

VII. CONCLUSION – FORMATION OF TABLE VALUE OF TRANSFER FUNCTION OF CIRCUIT FOR WINDING COIL WITH FINISHED YARN $G_p(t)_{NK}$

Tables are set up based on the final expressions of transmission functions of reliability depending on the time interval of circuits.

Based on the obtained results, a graphical representation of dependence is performed $f(G_p(t)_{NK}, t)$. (Figure 8.). Display of values of transmission function of reliability of the circuit for winding coils with finished yarn was performed in tables over constructed graphics of transfer function and is shown in Figure 8.

Remark: Shaded areas $P_i(t)$ have included values $P_i(t) \geq 0{,}5$ because values below this limit are not taken into consideration (include areas where repairs of the circuit should be made, which will be discussed in more detail in determining the value of the reliability in cases of selected statistical distribution).

Curve, $f(G_p(t)_{NK}, t)$ corresponds by its form to long-normal curves, and therefore for choice of statistical reliability distribution should be taken **long-normal distribution**.

Reliability values $P_i(t)$	transfer function of reliability for the coil winding assembly the finished yarn $G_p(t)_{NK}$	
1,0	shaded areas represent the ultimate limit of satisfactory reliability in the analysis	2,0
0,9		1,63
0,8		1,312
0,7		1,043
0,6		0,816
0,5		0,625
0,4		0,464
0,3		0,327
0,2		0,208
0		0,101

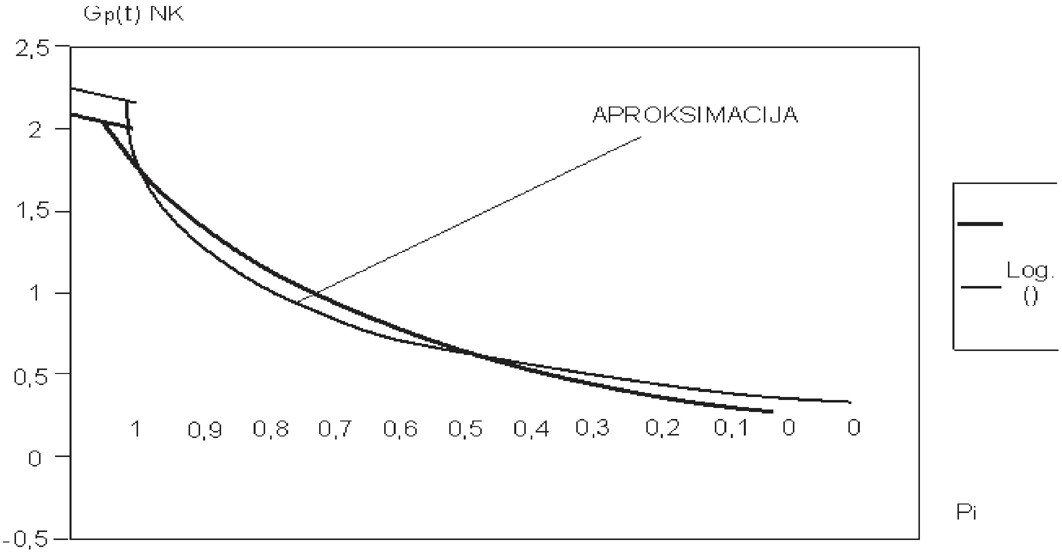

Figure (8). Graph of transfer function of circuit for coil winding with finished yarn with approximation $G_P(t)_{NK}$

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