RESERCH INTO THE CAUSES OF INACCURACIES OF COMPONENTS OF COMPLEX FOR COIL WINDING WITH FINISHED YERN AT OE

Prof. dr. Slobodan Stefanović¹, Prof. dr. Radoje Cvejić², Prof. dr. Radojko Lojaničić³, Prof. dr. Duško Kostić⁴

¹High School of Applied Professional Studies of Vranje,

²Graduate School of Operational and Strategic Management, Belgrade

³Graduate School of Operational and Strategic Management, Belgrade

⁴High Vocational School for Entrepreneurship, Belgrade, Serbia

Abstract: Analysis of tree failure showed events occurred due to increased levels of mechanical oscillations. The values of failures were used to determine reliability of the work of constituent components of analyzed complex. Based on them are determined areas of time of reliable (safe) work, as well as the areas of reduction of their reliability.

Key words: Tree failure, mechanical oscillations, reliability, system for winding yarn, OE - spinning machine

I. 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 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.

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.

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.

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.

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.

II. RESEARCH INTO THE CAUSES OF INNACURACIES OF COMPLEX COMPONENTS FOR COIL WINDING WITH FINISHED YARN OF OE SPINNING MACHINES – ANALYSIS OF TREE FAILURE

Integral components of this complex are very burdened in their work because they are exposed to wear process due to the large angular velocity, and with it the stochastic process of oscillation. In order to monitor the process of stochastic oscillations is necessary to make the location of measuring points for measuring oscillations in a way that the selected measuring points provide the most accurate measured data of vibration level (Fig. 3).

For this analysis were taken from two measuring points, as follows: 6-7 on the complex for coil winding with finished yarn.

All of this is chosen for reasons that analyzed circuit is one of the foundations of structures OE – spinning machine. With analysis, which includes procedures of application of the technology for preventive maintenance and methods of diagnosis, may affect around 70% of safety functioning of the complex work of OE – spinning machine.

On such a complex technical system, it was performed testing of the mechanical oscillations on the selected control points using the amplitude - frequent analysis, and based on the obtained results, it was determined the reliability of components of analyzed complex of power transmission. With application of reliability theory on the component parts of the transfer complex it was performed modeling of the system (model system included a fault tree) and given a functional connection between the basic

parameters of mechanical oscillations and reliability. It was given and their influence on the proper preventive maintenance component structural elements and components of the analysed system.

Failures that occurred on component complexes of OE – spinning machine based on the elevated levels of mechanical oscillations are recorded based on the organization of data collection that is, organization of the course of the level of mechanical oscillations measured values of stochastic signals at selected measuring points (measuring points 6 and 7). Based on all the registered failyres on analysed integral components of the complex, formed the fault tree.

Failure analysis on the complex for coils winding with finished yarn of OE – spinning machine included the use of fault tree analysis method that arise due to the effects of mechanical oscillations on the analyzed complex.

Fig. 4. Cancellations on integral components of complex for coil winding with finished due to the increased effects of mechanical oscillations

The major elements of transmission complex were analyzed and on it were chosen weak points and defined as a single weak points where the failures are repeated, and the same can be partly overcome by the introduction of technology of proper maintenance on them, that is maintaining of the level of mechanical oscillations in the planned belts (within certain limits of their impact). By continuous monitoring of failure occurrence, due to the increased activity of mechanical oscillations, there is the goal of maintaining the state, that is, with regular preventive maintenance can be reduced by exposure of the mechanical oscillations, and thus decrease the number of failure of components of analyzed complex. Fault tree analysis shows that intensive monitoring of the failures leading to the discovery of the weak points on technical complex, which in this work is done.

Failure analysis is presented with a deductive technique in which are specified unintended consequences arising from the impact of mechanical oscillations (vibrations) that appear in the process of exploitation of the analyzed complex of OE – spinning machine. The analysis included character of the causes of failure of the main elements of the complex and the ways in which that cause leads to the failure.

The results of the number of failure of poor points obtained in exploitation conditions, will be used in analyzing the safe functioning of work of the analyzed complex (determination of the percentage of failure) and to determine their reliability.

It should be noted that the analysis included failures that appear most frequently in the exploitation of the work of analyzed complex of OE – spinning machine, and were obtained by continuous level measurement of mechanical oscillations, whose increased levels lead to them. Failures are analyzed to clearly show the ultimate consequences of the inability of the work of components of

analyzed power transmission of OE – spinning machine.

In Fig. 4. shows the most influential power transmission failures in the components of the complex for coil winding with finished yarn, due to increased levels of mechanical oscillations.

III. 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:

1. Performance of use (performance of availability and stability),
2. 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 analyzed 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:

$$f_e(t) = \frac{\frac{n_i(t_i) - n_i(t_i + \Delta t_i)}{n}}{\Delta t_i} = \frac{n_i(t_i) - n_i(t_i + \Delta t_i)}{n \cdot \Delta t_i} \quad (1)$$

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

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:

$$\lambda_e(t) = \frac{\frac{n_i(t_i) - n_i(t_i + \Delta t_i)}{n_i(t_i)}}{\Delta t_i} = \frac{n_i(t_i) - n_i(t_i + \Delta t_i)}{n_i(t_i) \cdot \Delta t_i} \quad (2)$$

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

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:

$$R_e(t) = \frac{n_1}{n}, \quad (3)$$

where:

$n_1(t)$ - number of the correct complexes or components of complexes at the end of the time interval Δt_i ; $n(t)$ - 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.

4. RELIABILITY OF THE WORK OF THE COMPLEX FOR COIL WINDING WITH FINISHED YARN OF OE – SPINNING MACHINE, DETERMINING DENSITY FUNCTION $f_e(t)$, FUNCTIONS OF FAILURE INTENSITY $\lambda_e(t)$ AND FUNCTION OF RELIABILITY $R_e(t)$ FROM THE EMPIRICAL DATA

The procedures were applied to determine the reliability of the work of components are related to the technology of preventive maintenance of the work of analyzed complex components. They include: basic maintenance by the operator - technical surveillance, preventive periodic examinations (without the participation of special instruments), determining the state of complex using special equipment to measure levels of mechanical oscillations on selected measuring points, preventive replacement of components of a complex (time that includes overhauling state of the assembly), repair and renewal of worn components of a complex, periodic preventive repair (including replacement parts that were made in the areas of risk) and general overhaul of the complex.

In Fig. 5 are presented basic procedures for preventive maintenance technologies that were implemented in the analysis of safety functioning of analyzed complex integral components.

The sequence of analysis of the integral components of the complex will be done according to pre-established order of power transfer of analyzed complex. View of values of obtained density function failure $f_e(t)$, failure intensity function $\lambda_e(t)$ and function of reliability $R_e(t)$ from empirical data for each analyzed component of the complex on which are not implemented procedures of preventive maintenance technology and on which these procedures are carried out, are shown in picture 5.

On Picture 5. are shown polygons - diagrams of reliability of the work of integral components of the analyzed complex based of which are determined the area of reliable (safe) components work as well as the field of its reduction.

The sequence of analysis of the integral components of the complex will be done according to pre-established order of power transfer of analyzed complex. View of values of obtained density function failure $f_e(t)$, failure intensity function $\lambda_e(t)$ and function of reliability $R_e(t)$ from empirical data for each analyzed component of the complex on which are not implemented procedures of preventive maintenance technology and on which these procedures are carried out, are shown in picture 5.

On Fig. 6. are shown polygons - diagrams of reliability of the work of integral components of the analyzed complex based of which are determined the area of reliable (safe) components work as well as the field of its reduction.

5. 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.

Fig. 6. Diagram of the reliability from the exploitation conditions for integral component thread guide - F1, coils holder - F2, wheel for keeping yarn - F3, brake of coils - F4

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 ($f_e(t)$) and function of failure intensity ($\lambda_e(t)$) for the time interval of the exploitation work of complex components

(analysis included exploitation work time of integral components of the complex in the period $13000 \leq \Delta t_i \leq 21000$ hours) (Fig.7.) and is determined by the expression:

$$P_i(t) = \frac{f_{e_i}(t)}{\lambda_{e_i}(t)}. \quad (4)$$

VI. CONCLUSION

From the obtained diagrams of the reliability $f(R_{e_i}, t)$ for exploitation conditions of the integral components work of the analyzed complex, it can be determined the field of their time of reliable (safe) work, as well as areas of reducing their reliability (linear form reliability fall).

From the form of the correction curve values of reliability of integral components of analyzed complex $P_i(t)$, that is, according to the curve slope, can be analytically predicted reliability intervals that would later be used as a basis in determining the reliability authoritative.

The analysis revealed the following conclusions:

Fig. 5. Basic procedures for preventive maintenance technology on integral components of the complex of OE – spinning machine

I) Analysis of reliability of work of integral components of analyzed complex without implementation of preventive maintenance technology procedures:

- Maximum reliability in work have an integral component F3, whose reliability is at maximum and is $P_{F3}(t)=1,0$ and lasts in time interval over $\Delta t_i \geq 20000(h)$

- Based on the shape of the curve $f(P_i(t),t)$, that is, according to their inclination in Table 1. shows the sequence of reliability values and operation time of the components. The analysis included reliability intervals after the first smaller value than the maximum.

Table 1. Values of interval of correction reliability depending of the analyzed time interval of integral components work of analyzed complex on which are not implemented procedures of preventive maintenance technology

Integral component mark	Time interval of analyzed work of integral component $\Delta t_1 \leq \Delta t_i \leq \Delta t_2$	Interval of reliability for analyzed time interval $\Delta P_{i1} \leq \Delta P_i \leq \Delta P_{i2}$
Complex for coil winding with finished yarn		
F1	13000 ÷ 14000	1,0 ÷ 0,752
F2	13000 ÷ 14000	1,0 ÷ 0,5662
F4	14 080	1,0 ÷ 0,626

II) Analysis of reliability of work of integral components of analyzed complex with implementation of preventive maintenance technology procedures:

- Maximum reliability in work have an integral component F3, whose reliability is at maximum and is $P_{F3-0}(t)=1,0$ and lasts in time interval over $\Delta t_i \geq 20000(h)$.

- Based on the shape of the curve $f(P_{i-0}(t),t)$, that is, according to their inclination, sequence of reliability values and operation time of the components during these reliability, is shown in tables (Table 2). The analysis included reliability intervals after the first smaller value than the maximum.

Table 2. Values of interval of correction reliability depending of the analyzed time interval of integral components work of analyzed complex on which are implemented procedures of preventive maintenance technology

Integral component mark	Time interval of analyzed work of integral component $\Delta t_{1-0} \leq \Delta t_{i-0} \leq \Delta t_{2-0}$	Interval of reliability for analyzed time interval $\Delta P_{i-01} \leq \Delta P_{i-0} \leq \Delta P_{i-02}$
Complex for coil winding with finished yarn		
F1	13000 ÷ 14100	1,0 ÷ 0,899
F2	13000 ÷ 14000	1,0 ÷ 0,568
F4	13000 ÷ 14200	1,0 ÷ 0,6026

Fig. 6. Diagram of correction values of integral components reliability

7. REFERENCES

- [1] **B. Blanchard, W. Fabrysky**, *System engineering and analysis*, Prentice Hall Inc., New Jersey, 1981.
- [2] **Dimenberg, F. N., Kolesnikov, K. S.**, *Vibracii v tehnike*, Spravočnik tom 3, Mašinstroenie, Moskva, 1980.
- [3] **L. Brehmer**, *Technische Diagnostik in der Flugzeuginstandhaltung*, Information der zivilen Luftfahrt 11, 1975.
- [4] **P.M.Connor**, *Structured analysis in desing technique*, Sisteems analysis and designa foundation for the 1980, Norht_Holland, New York, 1981.
- [5] **S. Cvetkovic, S. Stefanovic**, *Methods of measurement and control of parameters affecting the appearance of the causes of adverse events*, Symposia with international participation "PREVING" Belgrade, 2001.
- [6] **S. Stefanovic**, *DETERMINATION OF THE VALUE OF SELECTED OSCILLATION FREQUENCY MEASUREMENT POINT ANALYZED PARTS OE SPINNING - On theboxspinning*, PRIYANKA RESEARCH JOURNAL PUBLICATION, India, 2012.
- [7] **S. Stefanovic**, *The influence of mechanical vibration on the occurrence of functional safety circuits in the power transmission system of textile machines*, Ph.D. Thesis, University of Novi Sad, 2006.