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AN APPROACH FOR DETERMINING THE PERIODICITY OF REGULATION WORK OF RISK TECHNICAL SYSTEMS

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Abstract: *The estimation of the regulation work periodicity of the risk technical systems is an extremely important moment for its technical service. Many scientific publications concern this problem but most of them deal with a service process for an infinite technical exploitation period. In the present paper a solution of the problem for a limited interval of technical exploitation is suggested. A reliability model of the observed process is developed as the intensity of the failure flux is chosen for a reliability criteria.*

Keywords: - *Regulation works periodicity, risk technical systems, technical service*

1. INTRODUCTION

Flux failure intensity $\omega(\Delta t)$ for a final technical exploitation interval Δt is estimated on the basis of BDS [1] according t_0

$$\omega(\Delta t) = \frac{\sum_{i=1}^{N} r_i(\Delta t)}{N_{RTS}(\Delta t).\sum_{i=1}^{N} \tau_i(\Delta t)}, \qquad (1)$$

where $N_{RTS}(\Delta t)$ is the number of risk technical systems (RTS) operating system of the same type for the observed interval Δt; $r_i(\Delta t)$ - number of failures i of RTS for the observed interval Δt; Δt - the observed period of time (1 year for the Bulgarian RTS); $\tau_i(\Delta t)$ - life on the i - th RTS for time Δt.

Flux failure intensity approximation is done through the constant function of time *t* for observed interval Δt represented as a polynomial in formula (2) according to [2]

$$\omega(\Delta t) = \omega_0 + a_1.t + a_2.t^2 + ... + a_m.t^m, \qquad (2)$$

where $a_1, a_2, ..., a_m$ are coefficients determined by concrete points in the flux failure intensity function for t_i ($i = 0, 1, 2, 3,...$) according t_0 [2].

The complete equipment statistics RTS and (2) make possible the approximate reliability model of flux failure intensity through a linear function (after an initial moment t_0) in the regulation work interval [3]:

$$\omega(\Delta t) = \begin{cases} \omega_0 & for\ t = t_0; \\ \omega_0 + 2V.t & for\ t > t_0. \end{cases} \qquad (3)$$

where ω_0 is the interval amount of flux failure intensity of moment t_0; $V = d\omega(\Delta t)/dt$ is the velocity of flux failure intensity increase for the observed interval Δt.

The model (3) makes possible the optimum regulation work periodicity θ_{RWopt}, estimation which provides RTS reliability for the observed period with least regulation works expenses. For that purpose we consider RTS worked out regularly over a certain period of time with periodicity θ_{RW}. During the regulation work the necessary expenses amount to C_{RW} and expenses for current repairs C_{CR}.

For the time between the regulation works when the total reconstruction of the RTS is done the leading function of the failure flux $H(\Delta t)$ can be expressed by the following formula according to [1]

$$H(\Delta t) = \int_0^{\theta_{PP}} \omega(\Delta t).dt . \qquad (4)$$

We consider the expenses for the technical exploitation of the equipment for the period of the regulation work in the folloing two cases

- E_{CR1} - expenses only for current repairs.
- E_{CR2} - expenses for regulation works and current repairs.

Having in mind the above mentioned and [4, 5, 6] we can calculate savings from the technical exploitations S_{TE} of the RTS

$$S_{TE} = E_{CR1} - E_{CR2} = C_{CR}\begin{bmatrix} H(\Delta t) - mH(\theta_{RW}) \\ - H(k_{RW}.\theta_{RW}) \end{bmatrix} - C_{RW}m \qquad (5)$$

where m is the number of regulation work for the observed period of time.

The number of regulation work for the whole period of technical exploitation is defined according to [6] from

$$m = \frac{t}{\theta_{RW}} - k_{RW}, \qquad (6)$$

where k_{RW} is the number of regulation work periods for the time *t*.

In formula (5) member $k_{RW}.\theta_{RW}$ is life in the final interval on the RTS for work under the condition $(0 < k_{RW}.\theta_{RW} < T_{RTE})$, where T_{RTE} is the technical resource till the end of the technical exploitation.

Equations (4) and (6) are used for (5) investigation if only the current time parameter will be in time limit . We get the following

$$S_{ER} = C_{CR}\left[\omega_0\Delta t + V(\Delta t)^2\right] - \left(\frac{\Delta t}{\theta_{RW}} - k_{RW}\right)\left[C_{CR}.\omega_0.\theta_{RW} + C_{CR}.V.(\theta_{RW} - t_0)^2 + C_{RW}\right] - C_{CR}.\begin{bmatrix} \omega_0.k_{RW}.\theta_{RW} + V. \\ .(k_{RW}.\theta_{RW} - t_0)^2 \end{bmatrix}. \qquad (7)$$

After investigating equation (7) we get the following differential equation

$$\left(C_{RW} + C_{CR}.Vt_0^2 + C_{CR}V\theta_{RW}^2\right)k'_{RW} - 2C_{CR}V\theta_{RW}^2 k_{RW}. \\ .\,k'_{RW} - 2C_{CR}Vk_{RW}^2\theta_{RW} + 2C_{CR}V\theta_{RW}k_{RW} - \\ - C_{CR}V\Delta t + \frac{C_{CR}V.\Delta t.t_0^2}{\theta_{RW}^2} + \frac{C_{RW}.\Delta t}{\theta_{RW}^2} = 0\,. \qquad (8)$$

There is no solution to (8) so we do:

$$u = C_{CR}.V.\theta_{RW}^2.k_{RW}^2 + \begin{pmatrix} C_{RW} + C_{CR}.V.\theta_{RW}^2 + \\ + 2C_{CR}.V.t_0^2 \end{pmatrix}.\,k_{RW}\,. \qquad (9)$$

Filling (8) with (9) we get the following equation:

$$u' + \frac{C_{RW}.\Delta t}{\theta_{CR}^2} + \frac{C_{CR}.V.\Delta t.t_0^2}{\theta_{RW}^2} - C_{CR}.V.\Delta t = 0\,. \qquad (10)$$

Its solution is as folows:

$$u = C_{CR}.V.\Delta t.\theta_{RW} + \frac{C_{CR}.V.\Delta t.t_0^2}{\theta_{RW}} + \frac{C_{RW}.\Delta t}{\theta_{RW}} + C_i. \qquad (11)$$

We equalize (9) and (11) and get the algebraic equation

$$C_{CR}V\theta_{RW}^3k_{RW}^3 - \left(C_{RW}\theta_{RW} + C_{CR}V\theta_{RW}^3 + C_{CR}Vt_0^2\theta_{RW}\right). \\ .k_{RW} + C_{CR}.V.\Delta t.\theta_{RW}^2 + C_{CR}.V.\Delta t.t_0^2 + \\ + C_{RW}.\Delta t + C_i.\theta_{RW} = 0\,. \qquad (12)$$

In order to define the integration constant C_i we use $\theta_{RW} = 0{,}5.\Delta t$, from which follows $m = 1$, $k_{RW} = 1$. We use these equation (12) and we get

$$C_i = -C_{RW} - C_{CR}.V.t_0^2 - \frac{C_{CR}.V.(\Delta t)^2}{2}\,. \qquad (13)$$

Filling equation (12) with C_i from (13) we receive the final

$$C_{CR}.V.\theta_{RW}^3.k_{RW}^2 - \left(C_{RW}\theta_{RW} + C_{CR}V\theta_{RW}^3 + C_{CR}Vt_0^2\theta_{RW}\right). \\ .k_{RW} + C_{CR}.V.\Delta t.\theta_{RW}^2 + C_{CR}.V.\Delta t.t_0^2 + C_{RW}.\Delta t - \\ - \left(C_{RW} + C_{CR}.V.t_0^2 + \frac{C_{CR}.V.(\Delta t)^2}{2}\right)\cdot\theta_{RW} = 0\,. \qquad (14)$$

Equation (14) proves the dependence of k_{RW} and θ_{RW}. Filling in it $k_{RW} = (\Delta t - m.\theta_{RW}).\theta_{RW}^{-1}$ we get the algebraic equation which is the link between θ_{RW} and m. It is the following

$$\left(C_{CR}Vm^2 + C_{CR}Vm\right)\theta_{RW}^2 - 2C_{CR}.V.\Delta t.m.\theta_{RW} + 0{,}5C_{CR}. \\ .V.(\Delta t)^2 + C_{RW}.m + C_{CR}.V.t_0^2.m - C_{CR}.V.t_0^2 - C_{RW} = 0\,. \qquad (15)$$

Solving (15) for θ_{RW} we get

$$\theta_{RW} = \frac{\Delta t}{m+1} + \sqrt{\frac{(\Delta t)^2.(m-1)}{2m.(m+1)^2} - \frac{C_{RW}.(m-1)}{C_{CR}.V.m(m+1)} - \frac{t_0^2.(m-1)}{m(m+1)}}\,. \qquad (16)$$

In order to get the real quantities on θ_{RW} equation (16) is solved under the following terms

$$1 \le m \le \frac{C_{CR}.V.(\Delta t)^2 - 2C_{RW} - 2C_{CR}.V.t_0^2}{2C_{RW} + 2C_{CR}V.t_0^2}\,. \qquad (17)$$

Filling (15) with (16) we get

$$k_{RW} = k_{RW}(m) = \frac{\Delta t - m\sqrt{A}}{\Delta t - (m+1)\sqrt{A}}\,, \qquad (18)$$

where

$$A = \frac{(\Delta t)^2 .(m-1)}{2m(m+1)^2} - \frac{C_{RW}(m-1)}{C_{CR}.V.m(m+1)} - \frac{t_0^2(m-1)}{m(m+1)}.$$

2. CONCLUSIONS

From equation (16) and (18) we can estimate the regulation works periodicity of the risk technical systems. These equations make possible the estimation of the period numbers with definite regulation works for a certain technical exploitation period.

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