OPERATIONAL MODEL FOR ASSESSMENT OF OPTIMAL DURATION AND FREQUENCY OF PREVENTIVE CHECK TO TECHNOLOGICAL INSTALLATIONS

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Abstract: This paper presents a model of regular preventive check of a facility under the installation in conditions that operational status is affected by the emergence of two types of unavailability:
- Preventive unavailability due to preventive actions verification;
- Unavailability due to performing corrective maintenance works in which the equipment fails.

1. Introduction

Maintenance Service aims optimal energy facilities through preventive maintenance, predictive and corrective. These actions lead to increased reliability and performance of energy systems and components as a whole, and decrease failures. Preventive Maintenance is an action plan aimed at preventing damage equipment, designed to ensure and maintain their functioning by replacing worn components before their failure. Preventive maintenance involves periodic inspections, at intervals set by regulatory revisions or producers, exchanges of materials, supplies, lubrication, etc..

Decision on application maintenance considerations should be combining the technical and empirical aspects of scientific theory to model the availability of systems, so that the result of the maintenance will lead to optimal solution in terms of functional and cost.

2. Presentation method

Whether the total time of unavailability of a technical system plays as a random variable:

$$T^{ind} = \begin{pmatrix} T_p^{ind} & T_C^{ind} \\ p_F & p_D \end{pmatrix} \quad (1)$$

where: T_p^{ind} is the time required preventive checks,

T_c^{ind} is the unavailability of equipment during

p_F, p_D-probability conditions / defects.

It follows the average time (T^{ind}) unavailability of the system in a given period T, for example, one year equivalent to the estimated annual operating time:

$$E(T^{ind}) = T_p^{ind} \cdot p_F + T_c^{ind} \cdot p_D \quad (2)$$

In witch $T_p^{ind} = \theta f \cdot p_F$ (3)

And

$$T_c^{ind} = (T - \theta f)p_D \tag{4}$$

Where:
θ expresses the average duration of a preventive checks, in h / test,
f - frequency of testing time T, in tests per year
T - reference range for annual time;

Figure 1 is shown the time evolution of the terms of unavailability based on the frequency of preventive check:

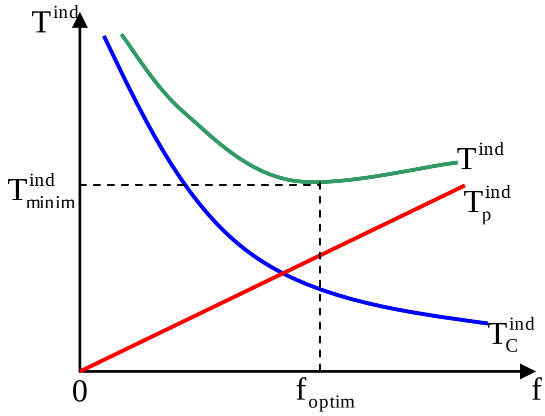

Figure 1. Unavailable time-frequency variation

Clear expression of the mean - life expectancy mathematical unavailable during T:

$$E(T^{ind}) = \theta f p_F + (T - \theta_f)p_D \tag{5}$$

$$\text{or } E(T^{ind}) = \theta f(p_F - p_D) + T \cdot p_D \tag{6}$$

Optimum condition is deduced:

$$\frac{d}{df}\left[E\left(T^{ind}\right)\right] = 0 \ \Rightarrow f_{optim} \tag{7}$$

$$\frac{d}{df}\left[E\left(T^{ind}\right)\right] = \theta(p_F - p_D) + \theta \cdot f\left(\frac{dp_F}{df} - \frac{dp_D}{df}\right) + T\frac{dp_D}{df} = 0 \tag{8}$$

It is considered a failure rate depending on the frequency of preventive check:

$$\lambda^* = \lambda e^{-mf} \tag{9}$$

where: λ * denotes the failure rate in test frequency;
λ is the failure rate of equipment and has a constant value;
m - constant regression relationship (9), determined experimentally.
Probability expressions are obtained:

$$p_F = \frac{\mu}{\lambda e^{-mf} + \mu} ; \; p_D = \frac{\lambda e^{-mf}}{\lambda e^{-mf} + \mu} \qquad (10)$$

Performing the calculation of the optimal value is derived f_0:

$$f_0 = \frac{1}{m} \ln \frac{m \cdot \lambda \cdot (T - 2 \cdot \theta \cdot f_0)}{\theta \mu} \qquad (11)$$

$$\text{but } 2 \cdot \theta f_0 << T \qquad (12)$$

$$\text{result: } f_0 \cong \frac{1}{m} \ln \frac{m\lambda \cdot T}{\theta \cdot \mu} \qquad (13)$$

compatibility condition is:

$$m\lambda T > \theta\mu \qquad (14)$$

Guideline values, obtained experimentally, of the factor m belong to the range:

$$m \in [0{,}4 \ldots 0{,}8] \qquad (15)$$

During the same period of the preventive check that θ can be interpreted for example as a managerial factor:

θ = 1 ..... 4 hours for verification preventive

θ = 5 ... 8 hours for preventive action - corrective

It stated that preventive action to verify the effectiveness of the equipment during operation becomes meaningful if it records a certain level of attrition, remediable.

Optimal maintenance strategy, in this case is the following:

- check the installation as required prophylactic inspection program - corresponding to the optimal frequency of testing;
- will be executed, possibly certain whether their work is justified.

Such a maintenance strategy is called ERP (Eventual Replacement Policy).

It is recommended for optimum use of this model „less reliable” facilities, for example, the range of reliability:

$$R(S) \in [0{,}80......0{,}95]$$

Which corresponds to percentage increases downwards played in Table 1 for an improved level of reliability, for example R (S) = 0.98.

Table 1. Percentage increases in the level of reliability.

R(S)	0,80	0,82	0,84	0,86	0,88	0,90	0,92	0,94	0,95	0,96	0,97
%ΔR(S)	22,5	19,5	16,6	13,9	11,4	8,9	6,5	4,3	3,1	2,1	1,1

3. Case study

Consider a power equipment, such as a flue gas fan, with the following parameters of reliability:

MTBF = 4500 operating hours

MTR = 280 hours of repair

Both sizes are statistically determined: Operation regular preventive check is approximately θ = 8 hours / inspection, and the average annual operating time is T = 6500 h / year. From equation (15) note the factor m = 0.6 arbitrarily.

$$\lambda = \frac{1}{4500} = \frac{1}{MTBF} \Rightarrow 0{,}00022$$

$$\mu = \frac{1}{280} = \frac{1}{MTR} \Rightarrow 0{,}00357$$

According to equation (13) resulting $f_0 = 5{,}668 \cong 6$, preventive checks per year.

4. Conclusions

- Determining the optimal frequency for checking the operational status of a preventive power equipment is to minimize the total time of unavailability.
- This model is recommended for ERP maintenance strategy – Enentual(Possibly) Replacement Policy.

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