OPPORTUNITY TO ADOPT RCM STRATEGY TO POWER INSTALLATIONS MAINTENANCE

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Abstract - The paper presents an assessment mode of average number interruptions, exclusive due to wearing of technical equipment in relation with the optimal time period regarding the preventive maintenance.
Basing on the “theory of the system’s renewing” is demonstrated the necessity to practice the reliability centred maintenance to minimize the numerous unavailability generated by the wearing phenomenon.

Key words: wearing, preventive maintenance, RCM

1. PRELIMINARIES

The method of Markov chain is one of the most familiar and important theory to study the reliability system.

The essential concept of Markov modelling is of state and of transition. So, a system or an element may be found from one of the state: operation, failure, reserve, a.s.o. [1].

The Markov process is a random process, defined by a family of random variables. To know its states at successive moments (t1, t2,….,tn), before (t) moment, by taking and processing of some information regarding the states before, contributes to know the state in (t) moment.

The Markov chain is a Markov process, defined with $\{x(t);t \in (0, \infty)\}$ variables, that may take values only with a limited state number.

In the paper is used the Markov chains theory to evaluate the state probabilities p_O^v, p_F^v for a further moment (V) characterizing “the stability in probability ”of the entity, with purpose to analyze if it is obviously or not to make the maintenance works at some elements of the ensembles.

2. CASE STUDY

Let to be an equipment of energy which temporary evolution is defined by the following three states: O – operation, W- wear, F – Failure. In figure 1 is given the graph of Markov transition, associated to operational states O and W against to F, state of unavailability. It isn’t foreseen the output of the system from the failure.

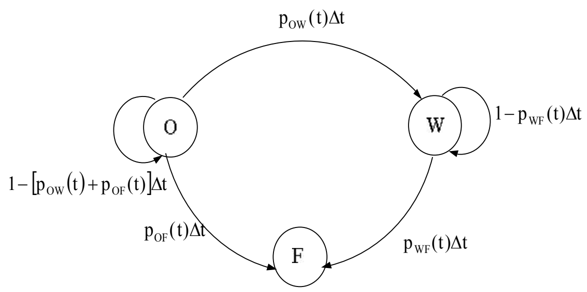

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Fig. 1. Graph of Markov chain
O, W – states of operation;
F – state of failure
$p_{OW}(t)\Delta t$, $p_{OF}(t)\Delta t$, $p_{WF}(t)\Delta t$- probabilities of transition

In the following part of the paper, will be analyzed the case when the failure is generated exclusive by the wear phenomenon, the problem of preventive maintenance.

From Operation stage O into Failure F, the evolution is excluded, because just transition is imperfect with preventive maintenance, the p_{OF} nature is randomly [2,3].

Both operation stages, O and W, are considered to be incompatible between them, because:

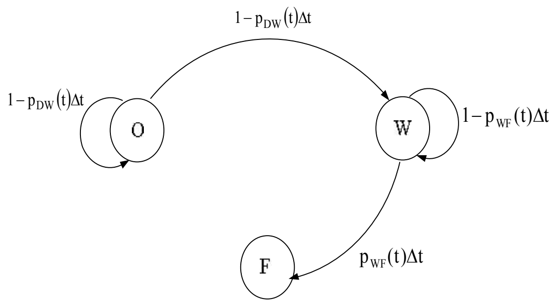

Fig. 2. The graph of transitions with hypothesis of the system failure generated by the wear phenomenon

- the system in stage O in t moment passes in the W stage in period of (t, t+Δt);
- the system is in W stage at t moment, and is maintained in this stage for period of (t, t+Δt);

In this case, the equation system with finite differences is:

$$\begin{cases} p_O(t+\Delta t) = p_O(t)[1-p_{OW}(t)\Delta t] \\ p_W(t+\Delta t) = p_O \Delta t p_{OW}(t)\Delta t + p_W(t)[1-p_{WF}(t)\Delta t] \end{cases} \quad (1)$$

The system of equations (1) as differential equation:

$$\begin{cases} \dfrac{dp_O(t)}{dt} = -p_{OW}(t) \cdot p(t) \\ \dfrac{dp_W(t)}{dt} = p_{OW}(t) \cdot p_O(t) - p_{WF}(t) \cdot p_W(t) \end{cases} \quad (2)$$

The constant transition probabilities of time are:

$$\begin{cases} p_{OW}(t) = \lambda_W \\ p_{WF}(t) = \lambda_F \end{cases} \quad (3)$$

The unused system, namely the stage F, may pass only into the stage W, when the reliability parameter is λ_W; and if it is in that stage (W) may become with λ_F unavailable, obviously $\lambda_F > \lambda_W$.[3,4].

Solving the system of differential equation (2) and taking into account the initial conditions, is obtained the relation:

$$\begin{cases} p_O(0) = 1 \\ p_W(0) = 0 \end{cases} \quad (4)$$

Through integration are obtained the state probabilities:

$$\begin{cases} p_O(t) = e^{-\lambda_W t} \\ p_W(0) = \dfrac{\lambda_W}{\lambda_W - \lambda_F}\left(e^{-\lambda_F t} - e^{-\lambda_W t}\right) \end{cases} \quad (5)$$

Because the system is in the state (O) or in (W) it is operational, the sum of the two probabilities indicates the reliability of the system:

$$R(t) = e^{-\lambda_W t} + \frac{\lambda_W}{\lambda_W - \lambda_F}\left(e^{-\lambda_F t} - e^{-\lambda_W t}\right) \quad (6)$$

The renewing functions of the system, represents the average number of such operations in T interval between two preventive H(t) actions.

To find this value, will be used the following procedure:

- the density of operational time probability f(t) is stabilized:

$$f(t) = -\frac{dR(t)}{dt} \quad (7)$$

Results that:

$$f(t) = \lambda_W e^{-\lambda_W t} - \frac{\lambda_W}{\lambda_W - \lambda_F}\left(-\lambda e^{-\lambda_F t} + e^{-\lambda_W t}\right) \quad (8)$$

or

$$f(t) = \frac{\lambda_W \cdot \lambda_F}{\lambda_W - \lambda_F}\left(e^{-\lambda_F t} + e^{-\lambda_W t}\right) \quad (9)$$

With Laplace transformer, according to the “renewing theory of equipments”, will be defined the density of renewing a system:

$$h(s) = \frac{f(s)}{1 - f(s)} \quad (10)$$

f(s) is the Laplace transform of density probability.

It is deduced that:

$$f(s) = \frac{\lambda_W \cdot \lambda_F}{\lambda_W - \lambda_F}\left(\frac{1}{S + \lambda_F} - \frac{1}{s + \lambda_W}\right) \quad (11)$$

respectively, the Laplace transformer of density of renewing is:

$$h(s) = \frac{\lambda_O \cdot \lambda_W}{S + \lambda_O + \lambda_W} \quad (12)$$

Applying the Mellin-Fourier transform (the inverse transform of Laplace) is obtained the renewing function’s density:

$$h(t) = L^{-1}(h(s)) \Rightarrow h(t) = \frac{\lambda_W \lambda_F}{\lambda_W + \lambda_F}\left[1 - e^{-(\lambda_W + \lambda_F)t}\right] \quad (13)$$

through integration of expression (13) is obtained the renewing function of the equipment:

$$H(t) = \int_0^t h(t)dt \quad (14)$$

or

$$H(t) = \frac{\lambda_W \cdot \lambda_F T}{\lambda_W + \lambda_F} + \frac{\lambda_W \cdot \lambda_F}{(\lambda_W + \lambda_F)^2} e^{-(\lambda_W + \lambda_F)T} - \frac{\lambda_W \cdot \lambda_F}{(\lambda_W + \lambda_F)^2} \quad (15)$$

Where,

T – the time interval between two preventive maintenances.

Imposing the optimum condition,

$$\frac{d}{dt}(H(t)) = 0 \quad (16)$$

results that

$$\frac{\lambda_W \cdot \lambda_F}{\lambda_W + \lambda_F}\left[1 - e^{-(\lambda_W + \lambda_F)T_0}\right] = 0 \quad (17)$$

or

$$(\lambda_W \lambda_F)T_0 = 0 \quad (18)$$

So, the optimal time interval for preventive maintenance is $T_0 = 0$.

CONCLUSIONS:

The minimizing operation of interruption number generated by the wear phenomenon, leads to the optimal solution of the maintenance: to practice the RCM strategy, hence a continuous control - monitoring the technical system. In the given calculus the preventive testing duration hasn't sense being integrated in the monitoring period of the technical equipment. The associated costs to appliance of this strategy are optimal viewing economical efficiency. The monitoring of the operation behaviour, takes into account installations with major importance in sphere of production of an economic entity.

REFERENCES

[1]. V.M. Cătuneanu, A. Mihalache, Bazele teoretice ale fiabilităţii, Ed. Academiei Române, Bucureşti, 1983

[2]. M. Cârlan, Uzura şi indisponibilitatea instalaţilor energetice, S.C. FORMENERG S.A. Bucureşti, 1995

[3]. M. Cârlan, Disponibilitatea şi mentenanţa instalaţilor energetice, S.C. FORMENERG S.A. Bucureşti,1995