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The Estimation of Reliability of Protective – Decorative Coverings

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Abstract

Provides information on the calculation of the reliability of protective -decorative coverings. The paper must have abstract.

Keywords: coverings, the probability of failure-free operation, the function of translation

Introduction

The estimation of reliability of protective - decorative coverings in process of service represents the certain difficulties connected with duration and labour input of tests. In this connection the problem of recalculation of parameters of reliability, received at forced modes of tests, on natural is rather actual. However, thus there are certain difficulties caused by something depending on intensity of working factors and a mode of tests, this or that speed of the charge of a resource (intensity of "refusal") takes place. The more intensity of external influence and rigidity of a mode of tests, the greater resource is developed by the system for the certain time interval.
Text of section 1.

Methodology

For reception of functions of recalculation we will consider two modes of tests:

1) Functioning of the covering in a normal mode of natural tests– $l_н(t)$

2) The forced tests on a cycle - 4 hours freezing at temperature-40^{0}C, 2 hours of thawing on air at a temperature 40^{0}C and relative humidity of air of 60 %, 2 hours of humidifying at a temperature 18-20^{0}C and relative humidity of air of 60-70 %- $l_н(t)$

Let's designate $\varepsilon_ф(t)$ and $\varepsilon_н(t)$ - speeds of change of size of the determining parameter (for example, of adhesion strength) in the specified modes. According to the physical principle of reliability of N. M. Sedjakina [1]

$$\int_0^t \lambda_ф(z)dz = \int_0^{x(t)} \lambda_н(z)dz \tag{1}$$

$$\int_0^t \varepsilon_ф(z)dz = \int_0^{x(t)} \varepsilon_н(z)dz, \tag{2}$$

where $x(t)$ – the converting function of time with the trouble-free operation from the $l_ф(t)$ mode to the $l_н(t)$ mode;

$\lambda_н(t)$ and $\lambda_ф(t)$ – the failure rate for natural and forced tests respectively.

In [2] it is shown that the change of properties during the forced tests is caused by acceleration of the system degradation process. The presence of the acceleration of the parameter change is a necessary condition for the distribution of time before failure of the product in different modes will be different.

Solving the system of equations (1, 2) can be found

$$x'(t) = \frac{\varepsilon_ф(t)}{\varepsilon_н(x(t))}, \tag{3}$$

$$\varepsilon_н(x(t)) = \frac{\varepsilon_ф(t)}{x'(t)} \tag{4}$$

$$\lambda_н(x(t)) = \frac{1}{x'(t)}\lambda_ф(t), \tag{5}$$

where $x(t)$ - converting function.

Thus, it is possible to predict the reliability of coverings during exploitation in field conditions on the data basis of the forced test. To do this you need to know:

- law changes is determined by the parameter mode;
- converting function;
- distribution law of time of trouble-free operation mode $l_{ф}(t)$.

Let's consider the example of calculation of reliability of protective-decorative limy coatings. A change of protective properties applied as a criterion of weather ability of coverings, valued in accordance with GOST 6992-68 on 8-mark system. In the process of the experiment it was evaluated the protective properties of coverings and adhesive strength. The total number of tests was 50 cycles of exploitation. The data obtained were compared with the data of field surveys. The results are shown in Fig.1.

Results of researches show that change of protective properties during the natural tests corresponds to the exponential function of the form

$$Y(t) = A\exp(-\alpha t) \tag{6}$$

Then speed of change is

$$\varepsilon_{ф}(t) = -\alpha \cdot A\exp(-\alpha t)$$

For a considered limy covering $A = 7{,}96;\ \ \alpha = 0{,}02.$

We consider, that at tests in the forced mode acceleration of process of change of protective properties takes place, i.e.

$$\varepsilon_{ô}(t) = -\alpha A\exp(-\alpha t) + \beta t \tag{7}$$

Then, according to (3), the converting function $x(t)$ can be determined from the expression

$$x(t) = -\frac{1}{\alpha}\ln\{\exp(-\alpha t) + \frac{\beta t^2}{2A}\ \} \tag{8}$$

In accordance with the theory of reliability, probability of failure of $P(t)$ is determined by an exponential dependence

$$P(t) = e^{-\lambda t} \tag{9}$$

However, research, carried out before, testify that in model of ageing of coverings it is necessary to take into account components which characterize the hereditary factor. In this connection we suppose that the functions, expressing parameters of reliability, also should reflect the hereditary factor. In view of above-stated, the probability of non-failure operation, in view of the hereditary factor, can be submitted by function of the following kind

$$P(t) = e^{-\lambda t - e^{\beta t} + 1}, \tag{10}$$

And intensity of refusal in the $l_{ф}(t)$ mode thus

$$\lambda_{\hat{o}}(t) = \lambda + \gamma e^{\gamma t} \qquad (11)$$

Recalculate the reliability function with the forced mode to full-scale operating conditions according to the formula (5), we obtain

$$\lambda\acute{\imath}(t) = \frac{A\exp(-\alpha t) - \beta t^2 / 2}{A\exp(-\alpha t) + \beta t / 2}(\lambda + \gamma \exp\gamma) \qquad (12)$$

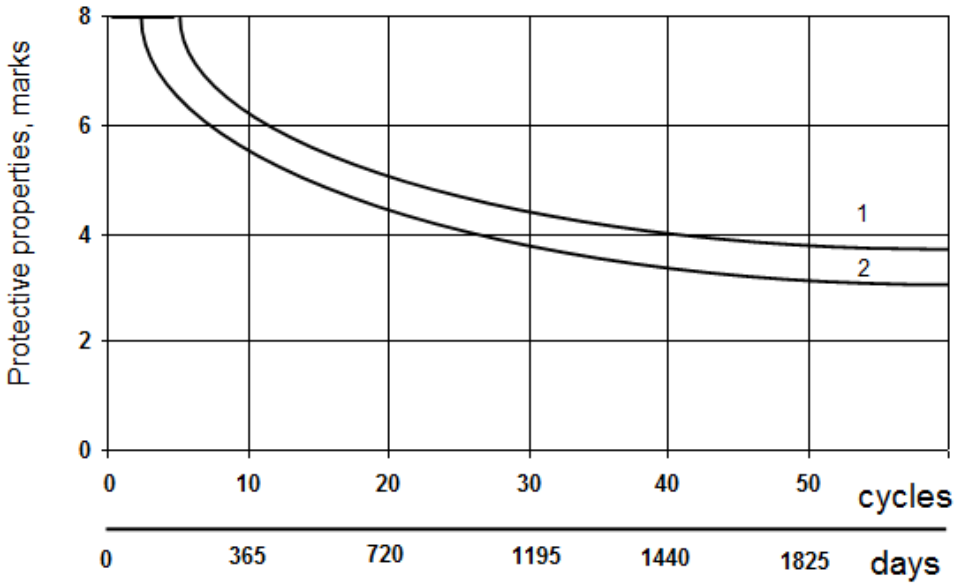

Fig. 1 Change of protective properties of a limy covering during ageing
1 - the forced mode tests;
2 – the natural tests

Tab. 1 (10) shows received data by the formula on probability of the trouble-free operation.

Table 1
Probability of the trouble-free operation of the limy covering

Day from the beginning of the operation	Probability of the trouble-free operation of the limy covering in a normal mode of exploitation	
	Calculation on experimental data in a mode $l_{н}(t)$	Calculation with forecasting according to tests in a mode $l_{ф}(t)$
100	0,896	0,895

Table 1 (Continued):
Probability of the trouble-free operation of the limy covering

180	0,801	0,796
460	0,681	0,696
1095	0,599	0,602
1825	0,503	0,507

Conclusions

Received data are well coordinated with experimental data.

References

[1] N. M Sedjakin, On a physical principle of reliability. Proceedings of the Academy of Sciences USSR. *Tehnicheskaya kibernetika*, **3**, (1966)

[2] V. A Smagin, On a model of forced testing. *Reliability and quality control*, **4** (1966)

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