TEM Journal. Volume 6, Issue 1, Pages 17-21, ISSN 2217-8309, DOI: 10.18421/TEM61-03, February 2017.

General Course of Failure Distributions at Complex Machineries

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Abstract **–In the process of maintenance management of machinery and devices there is necessity to keep in the mind "construction technologicity" (ability of construction technology). This term is used in evaluating of machinery construction, their groups and components in terms of production. The aim of management and planning maintenance of machinery is the failure-free operation in the application process. The range of machinery maintenance machines from routine one and inspection to general repairs is important to organize in a way to prevent unplanned idle time and failures or very likely to accidents.**

Keywords **– maintenance, machine, diagnostics, reliability.**

1. Introduction

Division in company is considered usually to be only a service department, which is spending a large amount of financial means, whereas its real benefit for the company is disputable. However, without a well-organized and effectively managed maintenance the main goal of every company cannot be realized, i.e. creation and increasing of profit, which is a result of reliable operation of production machines, transport equipment and other machinery that are used for producing or delivery of quality products and services in the right time and with a suitable price.

DOI: 10.18421/TEM61-03
https://dx.doi.org/10.18421/TEM61-03

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Optimisation of processes in company requires also a standardisation of maintenance approaches, background papers and information base, which offers a complex overview on maintenance. Standardisation of activities enables obtaining early and correct information about the necessary maintenance, about its duration, idling or about consumption of sources. It is useful to have elaborated a working methodology in order to perform complex activities, which are requiring a special treatment or safety rules. If there is a unified model of machinery and equipment established, it enables fast orientation and overview. The real records about operation are useful for optimisation and for correct tuning of maintenance system, as well as for analysis and statistics [2].

Multi-company approach and possibility to define own company model are the main assumptions of application in various branches and areas. They can be applied for the wide range of machines and machinery, buildings and equipment. Each of the mentioned components can be equipped with own counter as an indicator of wear-out; further a plan of operation site has to be defined together with designation of the maintenance points. Documentation has to involve relevant schemes, pictures, lubrication planes and other technical details concerning used equipment. In the figures the general course of failures on the complicated product is presented. For such products is typical cumulation of failures on end of service life or durability. According to the character of course it is a restored object then the failures are cleared during the service life of the object. In the period of normal operation, we have exponential distribution of the failures. This distribution expresses that by time, the advance time intervals between the failures are lengthened. Shortening intervals between the failures sets in till can be seen in period of the service life.

2. Course of failures on the complicated product

The course of the failures intensity for its characteristic form is marked as the „bath-tub” curve.

There is a graphic expression of three fundamental indices of reliability, the probability of working without failure R(t), the density of probability of failure f(t) and the intensity of failures $\lambda(t)$ in the Fig. 1.

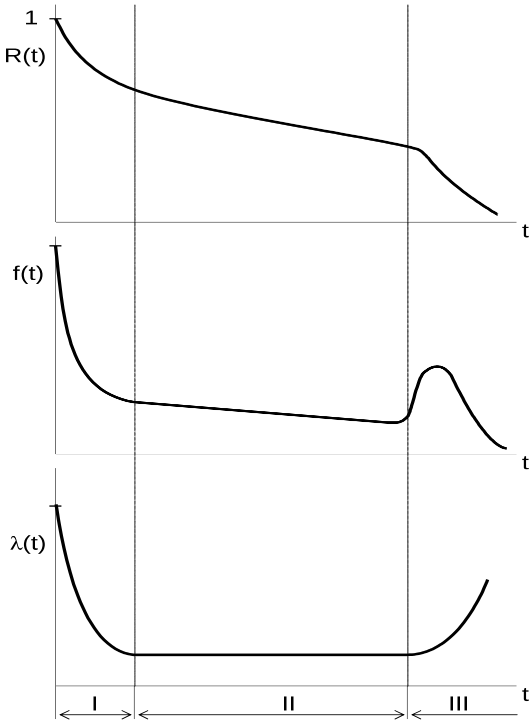

Figure 1. Basic characteristics of system element reliability

The 1st period of running-in (timely failures):

- It is shown by hidden failures of a product (the product is repaired),

The 2nd period of a normal operation:

- the failures have an exponential character of distribution.

The 3rd period of end of technical life

- strong demonstration of wear and growing old
- growing up failures density (accumulation of the failures)

The fundamental quantity for evaluation of reliability is the following of a random event that occurs in time from the beginning object working. The random event is failure and moment of an object restoration. The failure or failure before must be defined for safe distinguishing from other technical states [4, 5]. On the basis of the records from these events we derive mathematically further parameters or indicators of reliability [6, 8]. The following table shows distribution of single indicators and a relation between properties and quantities. Precondition of the test:

- elements are not restored during the test,
- two-state models of element activity (failure-free state or state without failure),
- the failures are total and independent,
- the element is watched from the time t = 0.

Table 1. The example of the measured values:

i	t_i
1	10
2	12
3	12,5
4	12,8
5	14
…….	
n	128

n - number of measured values simultaneously also total number of following objects.
t_i - temporal moment of the object failure.

We make the measurements till into the failure of all elements (objects) - the test plan is the type [*n*, *U*, *n*].

It is the most reliable measurement however in practice the most pretentious measurement timely and financially. In some cases, it is not even possible to realize this type of the test plan. We can work on the test result graphically but also mathematically as well.

3. Graphical evaluation

We divide the time axis of the test into the suitably large time sections „Δt" that we name the class interval. As follows we construct the histogram of failures distribution (Fig. 2).

We mark the number of measured failures of sum failures grown (Fig. 3) that we name the sun histogram. We choose a size of the class interval „Δt" so that the graph has the largest declaring value. If we choose too little „Δt" in the extreme case we reach maximum error rate equal to one (Fig. 4).

If we choose too large „Δt" in the extreme case, we will get in single class interval the error rate equal to n (Fig. 5)

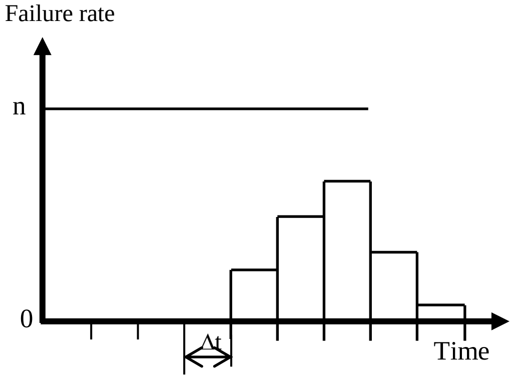

Figure 2. Histogram of failure distribution

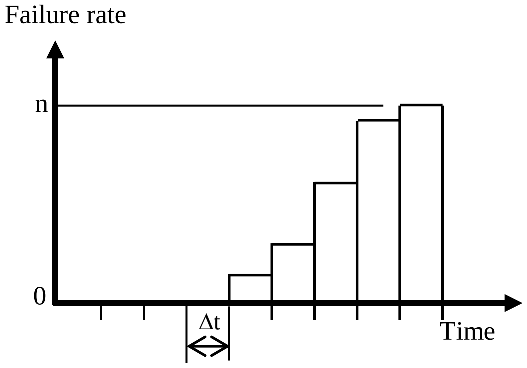

Figure 3. Histogram of failure sum growth

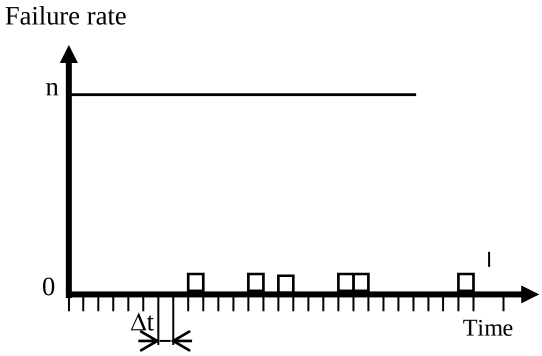

Figure 4. Extreme case we reach maximum error rate equal to one

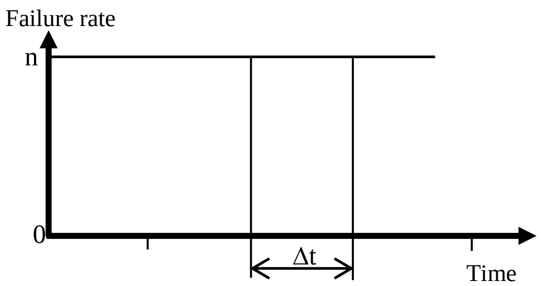

Figure 5. We will get extreme case in single class interval the error rate equal to n

4. Mathematical evaluation

Mathematical evaluation rests in the estimate of reliability indicators. We discern two methods:

- Parametric,
- Nonparametric.

At the parametric method, we suppose that measured values approach to some defined distribution of failures (exponential, Weibull's, normal, gamma …). The given distributions are defined by some time function f(t) and competent parameters that determine greatness and shape of distribution on the time axis. Exponential distribution is one-parametric, other are double parametric. We suppose no type of random distribution at the non-parametric method [1, 8]. The indicators of reliability are computed directly from the measured values.

The non-parametric method unlike the parametric method requires the record of total set of reliability tests. The point estimate is the best estimate of the indicator from the measured values expressed by one value. We do not know the parameter determination precision measure at the point estimate.

If we want to ascertain in which interval of values can be the given the parameter situated at stated probability of wrong estimate, then we perform the interval estimate. Under the point estimate we understand such an estimate of the parameter Q with help of the characteristic Vn that is expressed by one number [1, 3]:

$$Q \cong Vn$$

Q - parameter of elementary set (reality)
Vn - characteristic of accidental choice parameter (the measured value)

The mistake of estimate:

$$\Delta Vn = Q - Vn \qquad (1)$$

It is valid the consistency - the larger n is, (the number of measurements) the smaller mistake of estimate is:

$$\lim_{n \to \infty} E(|Vn - Q| < \varepsilon) = 1$$

It is valid the rule - the middle value of the measured parameters is the best estimate.

$$\lim_{n \to \infty} E(Vn) = Q$$

The best point estimate of the set middle value is the arithmetic mean $\bar{x} = \mu$

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \quad \text{(choice mean)} \qquad (2)$$

The best point estimate of set dispersion is the choice dispersion:

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2 \quad (3)$$

The interval estimate is the interval of values in that the given indicator can be theoretically found with given probability [9].

The interval estimate of the parameter Q is the number interval $\langle q_1, q_2 \rangle$ in that the estimated parameter is found with certain probability 1- α

$$P\left(q_1 \le Q \le q_2\right) = 1-\alpha \quad (4)$$

$\langle q_1 - q_2 \rangle$ – interval of reliability (the confidential interval)

α – the level of importance

(1-α) – the coefficient of reliability, the coefficient of confidence

5. Indicators and characteristics of non-restored elements reliability

1. Distribution function (probability of the failure):

It expresses the probability of it that it comes to the object failure till the moment t.

$$F(t) = P(\tau \le t) \quad (5)$$

τ - random quantity and it expresses the time till the failure of the object.

P - probability of an appearance.

P=1 - the certain appearance (all objects are broken or the given objects is broken completely).

P=0 - the certain appearance (not even an object is broken or the given objects is without failure completely),

2. Probability of operation without failure:

It presents the probability of it that in the given time interval $\langle 0, t \rangle$ the object will be in a state without failure.

$$R(t) = 1 - F(t) \quad (6)$$

3. Density of failure probability:

It expresses the value in time unit simultaneously the probability of failure origin in the small time interval.

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

Density of failures probability has the high stating value about the character of the accidental distribution of failures.

4. Intensity of failures:

It expresses the measure of failures occurrence extinction. In practical tasks it goes about the failures increased proportion to total number of already arisen failures in the given time period t

$$\lambda(t) = \frac{f(t)}{R(t)} \quad (8)$$

If it is λ (t)= const. it means that the occurrence of the failures with time expires exponentially. The intensity of the failures from mathematical reasons can grow into infinity. In practical tasks however an expressing intensity of the failures after the time moment when all objects are broken has not a sense. In this case as a matter of fact the intensity of the failures is nought [3, 7].

5. Middle period till the failure:

It expresses the average time interval after which the failure occurs. Middle period till the failure:

$$T(\tau) = E(\tau) = \int_0^\infty t.f(t)dt = \int_0^\infty R(t)dt \quad (9)$$

The higher mentioned indicators are mutually mathematically bound. It means that if we know the arbitrary course of the indicator then we know to determine also the others.

Fig. 6 expresses the typical courses of the mentioned indicators.

6. Gamma-percentage technical life:

The operation period during which the object does not reach the limiting state with the probability gamma percent. It expresses the probability of it that gamma percent of products reach the projected service life at the proposed level of reliability.

7. Dispersion of accidental quantity:

$$D^2(\tau) = E\left[\left(\tau - E(\tau)\right)^2\right] = \sigma^2 \quad (10)$$

8. Ruling deviation of occidental quantity:

$$D(\tau) = \sqrt{D^2(\tau)} = \sigma \tag{11}$$

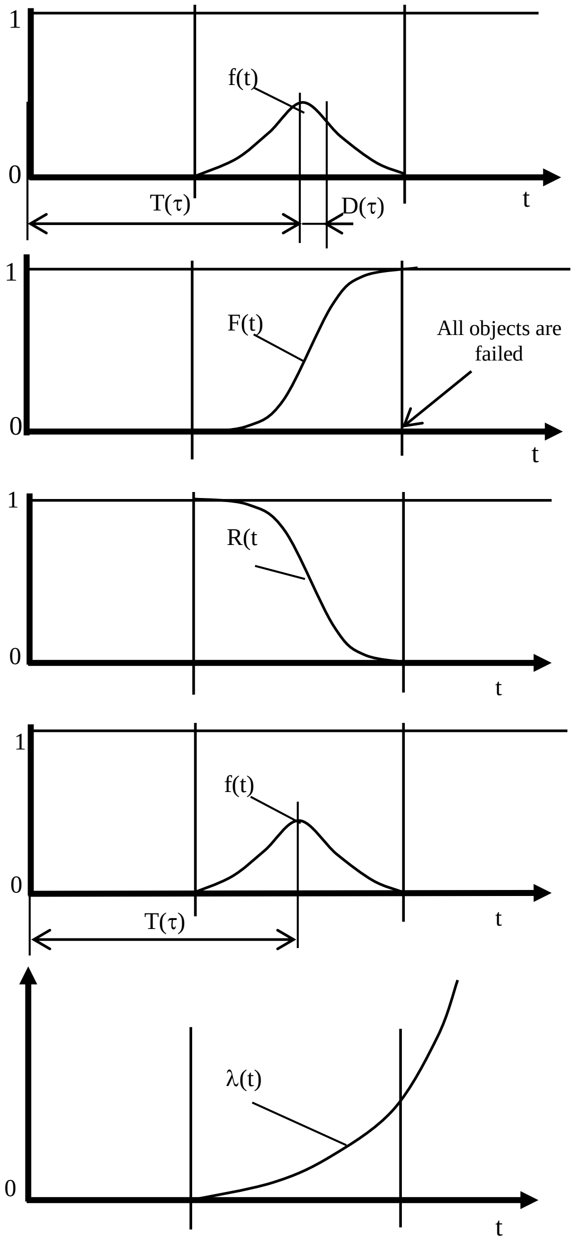

Figure 6. Typical courses of indicators

$$V(\tau) = \frac{D(\tau)}{E(\tau)} = \frac{\mu}{\sigma} = \frac{\bar{t}}{\sigma} \tag{12}$$

9. Variation coefficient:

The variation coefficient is utilized for watching various distribution marks measured in different units.

6. Conclusion

The failures on the independent equal objects arise by certain mechanism. If we assume all objects that are equal comparable operation conditions affect, then the time of failure origin is determined by many independent influences and circumstances.

In this case the failure probability density distribution will be normal. (Gauss curve) This distribution is the most natural and also other distributions at widening influences change into normal ones. If the measured distribution gives the account of diverting from normal distribution, then at creation of the failures some dominant influence is exercised. A failure of one object increases the probability of the objects failures in its proximity. Such failures occur in framework of complicated machineries with dependent failures.

The course is the demonstration of failures accumulation.

References

[1]. Sinay, J. & Pačaiová, H. & Kopas, M. & Oravec, M. (2006). Application of risk theory in man - machine - environment systems. *In: Fundamentals and Assessment Tools for Occupational Ergonomics. - Boca Raton : CRC Taylor & Francis,.* 8-1-8-11

[2]. Sinay, J. (1999) Risk assessment and safety management in industry. In: The Occupational Ergonomics Handbook. - [S.l.] : CRC Press LCC, 1917-1945. - ISBN 0849326419

[3]. Daneshjo, N. & Hlubeň, D. & Danishjoo, E. & Kopas, M. (2011). *Diagnostics, maintenance and reliability of machines manufacturing systems.* Germany, 136 p.

[4]. Daneshjo, N. & Kravec, M. (2015) System states and requirements of reactive maintance. *International Conference on Production management and engineering sciences.* 365-368.

[5]. Králiková, R. & P auliková, A.(2008). Modelling and diagnosing of mechanical engineering life cycle production process. *Chemické listy.* 399-401.

[6]. Juhás, P. & AL ALI, M. (2010) Compressed steel members with combined cross-section. *Advances and Trends in Structural Engineering, Mechanics and Computation. Taylor & Francis Group*, 615-618.

[7]. Pačaiová, H. & Glatz, J. (2015) Maintenance management system In: MM Science Journal. October p. 665-669. - ISSN 1805-0476

[8]. Valenčík, Š. (2011), Specification architecture and development of reconfigurable machine system / S. Valencik - 2011. In: MM Science Journal. No. 1 p. 232-235. - ISSN 1803-1269

[9]. Knežo, D. & Andrejiová, M. & Kimáková, Z. & Radchenko, S.(2016). Determining of the optimal device lifetime using mathematical renewal models In: TEM Journal. Vol. 5, no. 2,ISSN 2217-8309