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USAGE OF ANALYTICAL DIAGNOSTICS WHEN EVALUATING FUNCTIONAL SURFACE MATERIAL DEFECTS

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There are occurring defects due to defects mechanisms on parts of production devices surfaces. Outer defects pronouncement is changing throw the time with unequal speed. This variability of defect's mechanism development cause that is impossible to evaluate technical state of the device in any moment, without the necessary underlying information. Proposed model is based on analytical diagnostics basis. Stochastic model with usage of Weibull probability distribution can assign probability of function surface defect occurrence on the operational information in any moment basis. The knowledge of defect range limiting moment, then enable when and in what range will be necessary to make renewal.

Key words: defects, surface, analytics, diagnostics

INTRODUCTION

The goal of the technological devices maintenance is not only securing capability of production device, minimization of unprofitable factors directly influencing the effectivity of production device, idle time in consequence of preventive maintenance, which cannot be provided while device is running, idle time In consequence of failures, idle time in consequence of technological biasing of the device, lower product ability in case of worse technical conditions of the device, number of different products in case of incorrect production process and number of different products incurred in case of production start to normal condition state, but also failure states analysis and elaboration of the document how to precede theses states. [1]

Increasing of reliability of production devices as a complex can be achieved basically by three possible ways, which blend together and influence each other:

- Increasing of reliability (fail proof) of dominant non repairable parts,
- Device's construction solution, which enable significant lowering of expenses on repairs of single parts,
- Rationalization of maintenance system

System approach to rising reliability of main technological device's parts must be motivate by theoretical technical-physical disciplines synthesis involving whole complex of questions judging evaluated element as an object exposed to outer effects. Reliability models made by this way then describe in detail regularities of origin these random events, however this complex approach is rare in current practice because of time demands, volume demands, material securing demands and so on. [2]

Current methodology of creation reliability models is based on approach to the object as to the black box, which is affect by many quantitative and qualitative technical factors and factors characterizing object reliability in running operation on its output.

This type of reliability model has to be understood in basic as a component system, whom basic and unsubstitutable parts are:

Collection information system about reliability in operation,

System of quantification and reliability indicators object's elements,

System of quantification of characteristics and reliability indicators of the objects,

System for consequence technical analysis. [3]

FAULT MECHANISMS

When the failure on production device occurs it is need to localize primary faults of the lowest order object and then find out real or probable cause of the primary independent fault. From the construction, production and assembling complexity point of view can be as a lowest order object assumed elementary element represented by functional area. The elementary elements interact with physical, chemical or other processes, which can lead to fault operation. Fault mechanism can be in this concrete case very complicated combination of component processes. This processes can be by its outer exposure responsible for loss of device's required

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function. In metallurgical devices can be distinguished following primary fault mechanisms:

Abrasion – understand in manner of CSN 01 5050 as a complicated physical/chemical process, caused usually by friction, based on physical and chemical changes of surface layers when its mutual treatment,

Corrosion – undesirable and harmful surface reaction of metals and theirs alloys and theirs devaluing by chemical and electrochemical effects from surrounding environment,

Fatigue of material – undesirable decreasing of solidity characteristics of the material caused by dynamic straining which changing its direction, sense and size. This straining can be caused by mechanicals and temperatures changes,

Material aging – package of inner material processes which can cause undesirable and usually permanent solidity changes or other material's features independently on object usage, only dependent on time,

External mechanical effects – overloading can cause plastics macro deformation of the material,

Heat material degradation – radical decomposition of material caused by heat energy. [4]

These processes, which lead to origin of primary fault, proceeds with unequal speed and that's mean, that outer effects of these fault mechanisms (functional areas defects – D) are changing in time also with unequal speed, so is valid next formula:

$$\frac{\Delta D_i(t)}{\Delta t} \neq konst. \qquad (1)$$

There are several causes and effects. Between most severe belongs constructional, production and operational factors. The speed variability of fault mechanisms development causes, that in current time is not possible to express technical state level of the device. The issue is, that this level, means ability of the object perform in current time required functions, is necessary to evaluate at restricted quality of acquired information. From economical and technical reasons is necessary to maximally prevent dismantling of the devices, which are not only expensive, but also it leads to worsen of technical state of the each interconnection. The possibility to prevent dismantling is in that manner, that inner state of elements is derived from indirect outer symptoms and from analytical diagnostics. [5]

STATISTICAL MODEL WITH USAGE OF WEIBULL PROBABILITY DISTRIBUTION

The important element of this rationalize approach is analytical expression of proper theoretical model of stochastic quantities characterizing reliability of monitored object's types, i.e. such model, which assign to the object in any time probability of fault occurrence. This theoretical model of stochastic quantities has much narrowed meaning, than previously mentioned complex reliability model of whole device. Reliability evaluation of complex mechanisms, where can be assigned also metallurgical devices, shows, that optimal theoretical model is Weibull model, because it is able to cover almost all possible running of random quantities, which can occur when solving reliability of production devices. [6,7]

Common Weibull distribution of random variable t, in literature referred as Freudenthal - Gumbel distribution, or minimum value distribution is defined as three parameters with parameters a, b, c, but in theory of reliability is often used two parameters expression. It means that area parameter c is considered as 0 and final distribution is given by two parameters

t_0 – scale parameter

m – shape parameter. [8,9]

The distribution function is then described by

$$F(t) = 1 - e^{-\frac{t^m}{t_0}}. \qquad (2)$$

Weibull distribution has wide possibilities at analytical expression. By Weibull distribution can be substituted (approximate) basic probability distribution used in reliability, it means exponential, normal even lognormal distribution and it by this distribution can be used to expression of many faults. The basis of this expression is determination of shape parameter (m), which can be determined by iteration method from equation:

$$\frac{\sum_{i=1}^{n} t_i^{\bar{m}} \cdot \ln(t_i)}{\sum_{i=1}^{n} t_i^{\bar{m}}} - \frac{1}{n} \cdot \sum_{i=1}^{n} \ln(t_i) - \frac{1}{\bar{m}} = 0 \qquad (3)$$

Where

$\bar{m}$ – is shape estimation of Weibull distribution

n – number of observations,

t_i – value of i-th observation of random quantity t.

Reliability evaluations proofs (Figures 1 to Figure 3), that to express Weibull distribution can be utilized value of variation coefficient of selective observation file expressed as in

$$V(t) = \frac{\sigma(t)}{\mu(t)} \qquad (4),$$

where

$\sigma(t)$ – standard deviation of random file

$\mu(t)$ – mean value of random file

On (Figure 3) are presented relevance areas of each probability distributions. From these running and from prior knowledge of each probability distributions which are commonly used in reliability results, that determination of variation coefficient of random quantity selective file time to fault can be determined shape parameter of Weibull reliability model in Table 1. and determine nonexact description of fault mechanism in Table 2. This concept shows to be more effective than approach, when they the parameters determined from the values of selective file. Then is tested kind of probability distribution. Percent deviation of variation coefficient at size of selective file over 30 items is under 5 %. Pro-

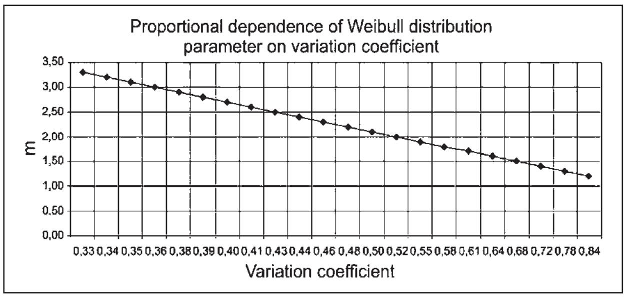

Figure 1 Linear dependence of parameter m on variation coefficient

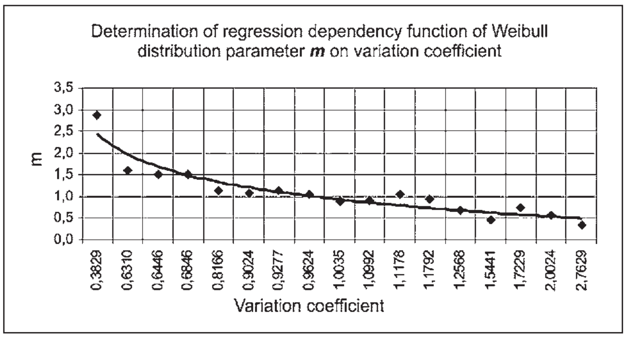

Figure 2 Logarithmic dependence of parameter m on variation coefficient

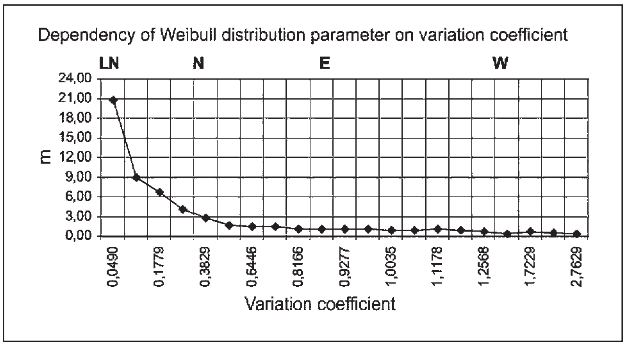

Figure 3 Experimental dependency running of parameter m on variation coefficient

Table 1 **Relationship of variation coefficient between shape parameter and probability distribution**

Variation coefficient value	Shape parameter value	Probability distribution
0,010 ÷ 0,050	> 10,00	Log-normal distribution
0,050 ÷ 0,700	1,50 ÷ 10,00	Normal distribution
0,700 ÷ 1,000	1,12 ÷ 0,90	Exponential distribution
> 1,000	<0,90	Weibull distribution

Table 2 **Determined fault mechanisms on the variation coefficient value basis**

Variation coefficient value	Fault mechanisms
0,010 ÷ 0,050	Fatigue of material
0,050 ÷ 0,150	Material abrasion with minor fatigue share
0,150 ÷ 0,700	Material abrasion and corrosion
0,700 ÷ 0,900	Material aging with major corrosion and abrasion share
0,900 ÷ 1,000	Material aging
1,000 >	Faults caused by constructional or technological irregularities

posed model is for now tested only n laboratory environment and this year are introduced the first semi operational tests. [10,11]

CONCLUSION

From the reliability evaluation point of view are the faults of device's parts are understand as a random events (also situations concerning theirs elimination). Theirs occurrence time can't be determined ahead, but if it is known theirs origin and evolution mechanism it is possible to predict probability of theirs occurrence. Knowledge of this moment allow decision making when and in what range will be need to make renewals and thus reduce effects of incoming faults, so:

- Make preventive renewal in beyond the shift and precede the idle time,
- make preventive renewal, to precede occurrence of catalectic failure and then precede occurrence of subsequent failures,
- be able to quick react to removal of defects in manner of technological and organizational way.

On the other side, understanding the cause of the failure, respectively its mechanism must be used to make corrective actions and thereby precede to failures and increasing reliability and effectivity of production device.

Proposed statistical model of technical failure rate analysis is a part of complex reliability evaluation model in term of reliability of technological devices.

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