COMPLEX INDICATORS OF AT RELIABILITY, CLASSIFICATION OF POTENTIAL METHODS OF RELIABILITY ANALYSIS

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The topic of the article is to point out certain categroies of failures, their coefficients, indicators of reliability, suggested and potential methods of aviation equipment reliability analysis..

K e y w o r d s.: coefficients of reliability , methods of computation

1 INTRODUCTION

When developing technical equipment, appart from the rest of computation, one has to reckon with the influences of operational conditions under which they are expected to function. The influences can be expressed by coefficients defining the ratio of technical (theoretical) parameters of reliability to the parameters of reliability of the monitored equipment [1].

2 INDICATORS OF RELIABILITY

- **Mean time to failure - a**verage length of time untill the first failure occurs.
- **Mean time between failures -** average length of product operational time between two failures.
- **Mean time of faultless operation -** at non-renewable products is understoood as an average time unitll failure, at renewable products as the average time between failures.
- **Technical life** - product operational time (in hours, cycles) till the moment of a boundary status, defined in technical specifications. It is an indicator that determines technical life of a product taking into account the effect of operational load and is measured in hours or cycles of load (e.g. number of landings). Technical life can be distinguished into:
  - Technical between repairs (till Overhaul 1; till Overhaul 2.; etc.),
  - Overal technical life (till phasing out of operation).
- **Stated technical life** - product of operation (in hours, cycles), at which its operation must be terminated independently of its status.
- **Time of use** - calendear time of the product use from putting it into operation till the occurence of the boundary status defined in technical specifications. It is an indicator, which helps determine the product service life in terms of the time factors involved and is measured in years, months, days. It is distinguished similarly to technical life.
- **Determined time of use** - calendar time of the product used from its putting into operation when its operation must be terminated independently of its status.
- **Time of guarantee** - time of product operation (in hours, cycles, calendar time), during which the manufacturer, provided operational conditions are ensured, guarantees a high reliability of faultless operation and product status meets technical requirements. It is a commercial – technical indicator, which is determined by method of the theory of probability considering the economical risks of both the suplier and the user.
- **Stated time of storage** - calendary time of storage or transport of the product under stated conditions, on the expiration of which, the product reatains faultless condition with high probability.

3 COMPLEX INDICATORS OF RELIABILITY

- **Coefficient of readiness** - probability that the product at any arbitrary moment will be capable of operation, appart from the planned time when the product is not expected to be used to the purpose.
- **Coefficient of technical use** - ratio of

mathematical assumption for the time, during which the product is capable of operation for a certain time of operation and the sum of mathematical assumptions for the time, during which the product is capable of operation, period of downtime, as conditions of maintenance and period of repair for the same period of operation.

- **Coefficient of operational readiness** – probabiálity that the product found in the mode of readiness (standing by), will be capable of operation and starting with the moment it will function without failures during the given time interval.
- **Mean total work of maintenance** – mathematical assumptions of the total number of work hours at maintenance for the product during a certain period of operation.
- **Proportional total work of maintenance** – proportion of the mean of total work of technical servicing to the mathematically assumed total time of product operation during one and the same period of operation.
- **Mean total work of repair –** mathematical assumptions of the total number of hours spent working during all kinds of repairs for a certain period of operation.
- **Proportional total work of repairs** – proportion of the mean value of total work of repair to the mathematically assumed product operation during on and the same period of operation.
- **Proportional total costs of maintenance -** proportion of mean values of total costs of maintenance to the mathematically assumed total time of product operation during one and the same period of operation.
- **Mean total costs of repair** – mathematical assumptions of the total costs for all the kinds of repair during a certain period of operation.
- **Proportional total costs of repair** – proportion of mean total costs of repair to the mathematically assumed total time of operation during one and the same period of operation.

4 SUGGESTED METHODS OF RELIABILITY ANALYSIS

Computing reialibility of an equipment, system or an element is meant to arbitrarily determine one or more numeral characteristics of reliability. Among such characteristics: probability of faultless operation during a certain time interval, intenzity of failures, density of failure, mean time of faultless operation, and the like [5,6].

Method of reliability analysis provides us the possibility to obtain characteristics (parameters) of reliability, which are based on the equipment desing. The influence of operational conditions is not present on them. Condition of applying this method is in knowing the basic interconnection of elements and the types used [3].

Basic interconnection of the elements of the equipment, at which putting one of them out of operation causes failure to the entire equipment, is used for various types of complex equipments at which no back-up of elements is assumed. Based on the interconnection, the equipment is divided into separate functional areas, and thoose then into separate parts or levels. At each level, the elements and parts of the design parts are ascribed to groups with equal intensity of failures. Data on the intensity of failures are obtained from catalogues of manufacturers of the given elements (spareparts).

Let us assume, that the failure at an element is a random and independent phenomenon. As failure of one element results in the failure of the entire equipment, we will be interested in the putting out that element out of operation, independently of the fact whether the rest of the elements of the entire system remain capable of operation or not.

Based on the stated above the probability of faultless operation for the entire equipment in time t (R_S) will be equal to the multiple of the reliability of falultless operation of elements (R_1, R_2, R_3, ..R_i...R_n), the equiment is composed of:

$$R_s = R_1.R_2.R_3....R_n \qquad (1)$$

Probability of faultless operation of element in time t $R_{i(t)}$ can be expressed by means of the intensity of failures using the mathematical formula of:

$$R_{i(t)} = e^{-\int_0^t \lambda_i(t).dt} \qquad (2)$$

Then, the relation (1) can be expressed as follows:

$$R_S(t) = e^{-\sum_{i=1}^{N}\int_0^t \lambda_i(t)dt} \qquad (3)$$

Mathematical formulation of expression (3) is rather general and enables determination of the probability of faultless operation for complex equipment until the first failure at any behaviour of the intensity of time dependent failures.

This relation can be used in various applications of practical importance for computation of reliability.

If the intensity of failures at all elements is a constant, then it holds that intensity of failuers at an equipment equals to the sum of intensities of failures of the separate elements, making up the equipment. It means that the reliability of faultless operation is exponentially decreasing depending on time.

Practice has proven that computations of reliability of faiultless operation solved on the basis of exponential law of reliability are often in agreement with the exponential data.

From the exponential law of probability, the following conclusion follow:

a) Reliability of a complex equipment and elements is decreasing with time by the exponential law.
b) The more complex the equipment, the larger the number of elements, of which the equipment is made up and thereby the lower the reliability of the equipment.
c) Reliability of the equipment depends on the reliability of elements of which it is made up.

5 CLASSIFICATION OF THE METHODS OF RELIABILITY ANALYSIS

In total, we distinguish reliability analyses:

- in the stage of projection (prognostical),
- in the stage of operation and research (principal application) [2,4].

Raliability analyses can be further distinguished into:

- partial,
- functional (parametrical computations),
- investigation of one type of failure (abrupt, complete, gradual, partial, inerruption, short-circuit etc.),
- reliability analyses of simple equipments (with back-up, with no back-up, without renewal, with renewal...),
- reliability analyses of complex equipments (systems of control and thosethat ensure handover and imaging of information).

Of the following classification in Figure 1 it is obvous that there exist lots of different ways of reliability analyses. Not all of them are stated in the classification. Among the mostly used are partial computations, which take into account one form of failures (abrupt, total). Among the less sophisticated are the functional analyses of reliability investigating the nature of failures (especially those of self-remedial type), but also complex equipments and systems of control and information transfer.

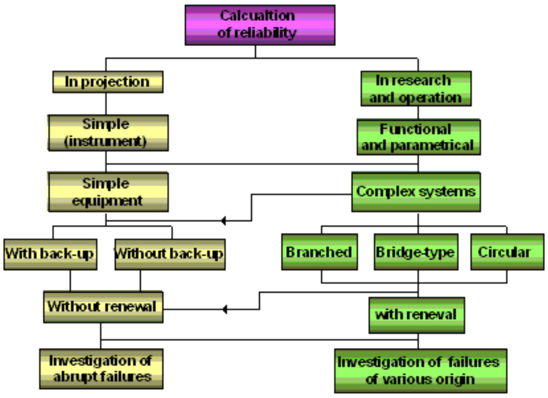

Figure 1 Methods of reliability analyses

In the theory of reliability, quite frequently, the characteristics sought-after are not so obvious for the lack of the necessary information.

Characteristics of reliability is considered positive, if its increase will correspond to the increase in reliability. If we assume that α is a positive characteristics of reliability, then the form $\alpha \geq \overline{\alpha}$ is termed as optimistic and form $\alpha \leq \overline{\alpha}$ as pesimistic.

The optimistic form is increasing reliability of the elements and vice versa, i.e. the pesimistic form will reduces it.

Let us assume that the time of faultless operation of the element is a random variable ζ and ζ_t is the time remaining to the end of the service life of the element, which has worked without failures untill time t. A certain period of time after, the elements is getting worn out – ageing, with its reliabiálity decreasing. It follows that its time remaining ζ_t reduces as its time t increases. Ageing is the typical feature of both technical system, and living organisms, practice proven by plenty of statistics.

Methods of reliability analyses based on ageing of the elements assume that the elements are subjected to gradual wear. They are based on the knowledge of a sufficent number of data that can be obtained from the results of tests performed on the selected equipments

6 CONCLUSION

Professional literature describe four classes of ageing distribution. Within the theory of reliability, the most important class is marked with S_o, for the reason of a simple physical aspect, namely local reliability with time (given by the intenzity of failures $\lambda(t)$) can only reduce. The majority of distributions applied in the theory of reliability belongs to the class of S_o. With the help of mathematical computations, it is easy to prove that exponential and normal distributions, similarly as some other types, belong to the class of S_o .

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