Estimation Methods of Unique Devices Reliability

FEDIK I. I., GOLUBEV M. P.
Scientific Industrial Association 'Lutch', Moscow, USSR

1 INTRODUCTION

In the present report we shall give the results of aprobation and choice of methods of probability analysis of service life and reliability estimation of unique products, atomic power plants (APP) among them.

2 METHODS

In practice we see that information on APP elements and assemblies, their properties are very ununiform. To perform elements tests and investigation of all kinds of influence is usually impossible. There are data on particular tests, e.g. a reactor cassette, on some service life tests of fuel elements (besides, having a different time-table of the company), on fuel tests with deviations, on uncompleted tests, on fuel element deformation measurement, on cladding strength, etc. There are also data on analagous tests.

The aim of this work is development of a methodological approach and an effective algorithm of processing of these different data for reliability estimation of the product at the stage of design and development.

Let us consider the following typical situations.

1. Separate fuel elements and other elements are tested on service life (less or more than demanded).
2. Some elements are tested on all processes leading to breakdown (PLB), the others are partially tested.
3. There is a quantity information of a number of product parameters or a quality information of their being within tolerances.
4. The tested elements have construction differences.
5. Test conditions differ from each other, there are accelerated tests, etc.

The authors approved more than one hundred different methods of data and their combinations processing on the basis of numerical experiments. As a result of investigation we chose a number of methods which (in dependence of initial data combinations their number changes from 5 to 35) form the adaptive algorithm allowing to use practically all the information at research and development stages.

SMiRT 11 Transactions Vol. M (August 1991) Tokyo, Japan, © 1991

Effective use and processing of the information are performed in the following way:

1. Description of the development object (APP) by means of structural functional configuration (SFC) and obtaining the structural formula.

2. Separation of all the data (quantitative and qualitative) according to objects of prediction (product - assembly - element) into "portions". The data portions were given the corresponding attributes vector (AV).

3. SFC elements and portions are given the attributes (from AV) corresponding to the processes taking place in them and leading to breakdown. Attributes are: a breakdown type, full or partial influence of PLB, test conditions, product construction variants, data types (operating time, probability, a physical parameter).

The above-mentioned differences are described by the attributes vector for every data portion.

Then data processing and union take place:

1. Sorting and formation of "n"-data files according to the attributes vector.

2. Control of unhomogeneity, definition of its type and choice of the method (formula) for data portion union (from the matrix).

3. Choice of the SFC level and operating time for obtaining final estimations. Detection of missing data, estimation of final estimations sensitivity to the missing data.

4. Estimation extrapolation on the demanded service life and the object on the whole. Processing of the calculation results. Detection of "critical" elements (from the point of view of sensitivity maximum, information absence, load-strength relations, etc.). Making a list of necessary tests and investigations.

The main features of the proposed algorithm:

1. Algorithm adoptation according to the information being in the disposal.

2. Use of particular methods (in the algorithm structure) in the range of automodelity and the greatest effectiveness.

3. Use of information having a different physical nature.

4. Simultaneous use of qualitative and quantitative information, temporary halts, etc. (e.g. deformation measurement, etc.).

5. Creation of physical statistic models according to the investigation results of check specimens, service-tested elements, etc. allows:

- to unite, e.g., investigation results of pipe-lines, welds, kinetics of crack development, etc.;
- to obtain a probability predictions of parameters, to estimate sensitivity coefficients, etc.

6. Use of concepts on processes leading to breakdown, ranges of parameter change.

7. Simultaneous and independent estimation prediction with subsequent union according to:

- SFC elements;
- PLB;
- breakdown types.

In addition, the above-mentioned peculiarities practically allowed to eliminate the systematic prediction error and to decrease a casual one of all probability characteristics.

The present approach has been used for three types of

nuclear power plants and gave a good result.

Nowadays the work on creation of a unique program package for calculating a reliability function for IBM PC is being performed.

REFERENCES

Golubev,M.P., Nikolaev,Yu.V. (1990). Estimation methods and providing no-failure operation of thermionic converters and nuclear power plants on their basis. In: Collected reports of Conference "Nuclear power in space", Obninsk, p. 76-82.

Golubev,M.P., Lapochkin,N.V., et al. (1990). Development of a high-voltage reactor. Ibidem, p. 123-129.

Golubev,M.P., Silkin,V.I. (1989). About standardization of reliability estimation methods on the basis of multicensored samples. "Nadyozhnost i kontrol kachestva", N 1, pp. 42-47.

Golubev,M.P. (1989). Calculation model for investigation of developing leakages. "Defektoskopija", N 8, pp. 76-79.

Procedure of structural functional analysis and normalization of demands to reliability to PP and their elements
Procedure of a probability analysis of processes leading to failure of PP and their elements
Procedure of bench development design of PP elements
Procedure of experimental data processing and reliability of unique PP
Procedure of quality evaluation while manufacturing PP elements

PP - power plants; SFC - structural functional configuration; PLF - processes leading to failure

Fig. 1. Methodological provision of quality and reliability of energy power plants at the stage developments

ALLOWS:

To compare and choose the highest possible reliability SFC of PP
To find the least reliable PP elements
To investigate mutual influence of PP elements failure, taking into consideration SFC
To normalize demands to PP elements reliability
To determine the highest possible reliability of PP
To define the main directions of PP SFC improvement

Fig. 2. Procedure of structural functional analysis and normalization of demands to reliability to PP and their elements

ALLOWS:

To make structural functional configuration and to unite data of different levels (element, assembly, PP)

To process cenzored data

To unite data of different types (statistical, physical, attributive)

To process data of a very small sample (bootstrap meth.)

To consider reliability data of PP elements prototypes

To process data of heterogeneous samples

To unite different types tests of PP and their elements

To predict PP reliability

To estimate PP reliability according to the results of their elements tests

Fig. 3. Procedure of experimental data processing and reliability estimation of unique PP

ALLOWS:

To create physical statistic models of PP elements PLF
To reveal the main operational, constructional and technological factors of PLF
To summarize heterogeneous test data
To determine influence of the main factors range on PP life and reliability range

Fig. 4. Procedure of a probability analysis of processes leading to failure of PP and their elements

ALLOWS:

To organize development of evaluation test with minimal risk
To take into consideration information ability of test bench
To minimize time and cost of reliability tests using information criteria

Fig. 5. Procedure of bench development design of PP elements