THE COMPUTER ANALYSIS OF FAULTLESSNESS TRANSFORMERS OF POWER SUPPLY SYSTEMS

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ABSTRACT

Algorithms of methods of an estimation of faultlessness transformers resulted at the set version of distinctive attributes and classification park transformers on groups with statistically various parameters of faultlessness. Algorithms serve one of distinctive features of the automated information control system developed by authors as reliability of transformers a power supply system

Perfection of a control system by reliability of the equipment of power supply systems represents important and, simultaneously, a difficult problem. Importance of the decision of this problem mainly caused increasing (in process of ageing the equipment) by cost of technological tests and restoration of deterioration (repair), consequences of damage of the equipment. Difficulty of the decision consists that modern methods of the statistical analysis of retrospective data assume realization in the form of computer technologies and exclude an opportunity the manual account owing to the complexity and bulkiness.

One of the basic directions of overcoming of these difficulties is development and application of the specialized automated information systems (AIS). The universal computerization of the power enterprises of power supply systems allows realize successfully in practice information support of a management and technical officers at the control execution of rules of technical operation, the decision of problems of maintenance service and repair of the power equipment. Experience of practical use such AIS testifies to their high efficiency [1].

Among properties of reliability most studied is property of faultlessness. At the same time, insufficient objectivity of quantitative estimations of parameters of faultlessness (PF) and absence of specifications of faultlessness demands the further researches. So, for example, if to calculate PF under the collected information on refusals of all transformers of a power supply system (further: on a final data set - FDS) we shall receive an estimation which analogue will be «average temperature on hospital». Attempts to concretize this estimation for the set version of attributes (VP) lead to that the number of statistical data about refusals is sharply reduced and, despite of an observable divergence of initial and «specified» values PF, the hypothesis about their casual divergence often does not contradict statistical data. It is possible, certainly, «closed eyes» on these features (that more often occurs), to speak only about an observable divergence of estimations PF, «to explain» the reasons of a divergence and to recommend ways of elimination of these reasons. The methodology of overcoming of the specified difficulties is developed by authors and approved in AIS estimations of a technical condition of power transformers and autotransformers (further: transformers), called as AISTR.

General characteristic AISTR.

To basic features AISTR concern:

1. The system focused on the organization of maintenance service and repair of the transformer (TR) depending on their technical condition;

2. Existing systems, as a rule, are intended for processing statistical given refusals TR, or processing of results of test (for example, data of chromatography analysis of the gases dissolved in transformer oil), or data about the revealed defects at surveys and scheduled repairs TR. Considering interrelation of these data developed AISTR provides processing and sharing of data about non-working conditions TR, results of tests and the surveys, the given restoration of deterioration;

3. Application of the methods developed by authors:

- protection of a database against casual or deliberate distortion;
- the account of casual character of estimations PF, calculation PF with optimum accuracy (width a confidential interval) and reliability (with the minimal sum mistakes of the first and second sort);
- estimations of optimum confidential area of change PF in time or other VP;
- estimations of parameters of durability according to test TP;
- planning terms and volumes of major overhauls (MO) TR on an integrated parameter which considers distinction of term of service, operating time after MO, numbers of through currents of short circuit, loading, a technical condition (data of surveys and tests), the importance consequences of refusals;
- quality assurance of restoration of deterioration;
- specifications of maximum permissible values of diagnostic parameters;

4. The opportunity the reference to the specifications and technical documentation defining strategy of maintenance service and repair TR, especially, TR, which service life exceeds normative.

Integrated block diagram AISTR resulted on fig.1.

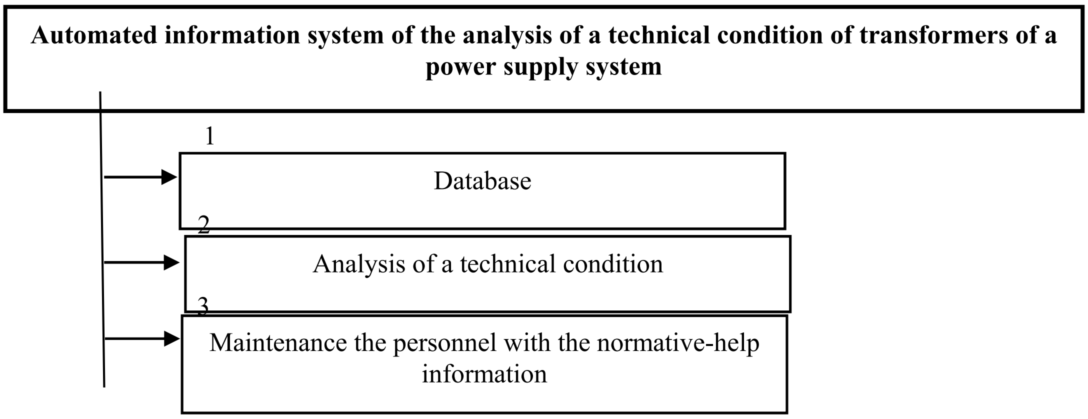

Fig.1 Integrated block diagram of modeling algorithm AISTR

On fig.2, the integrated block diagram of algorithm of a subsystem «Analysis of a technical condition» is resulted. In present clause, we consider some features of algorithm of a subsystem «analysis of faultlessness». The integrated block diagram of algorithm of this subsystem is resulted on fig.3.

Sample of data about non-working conditions on the set interval of time for concrete or same TR (block 2.2.1) is the obligatory document at the analysis of the reasons of damage TR, development of actions decrease in number and duration of not scheduled switching-off TR, the organization of maintenance service and repair. We shall distinguish following switching-off: automatic at short circuits in TR, under emergency or scheduled applications for restoration of deterioration, in a reserve and on an operating mode, false and if necessary restoration of deterioration of the adjacent equipment under the scheme. These switching-off classified on versions of the attributes set in tables of nameplate data and conditions of operation TP.

In the block 2.2.2, the analysis of a kind of switching-off TP is spent. Versions of this attribute are switching-off sudden, under the emergency or scheduled application, and compelled on a mode manually.

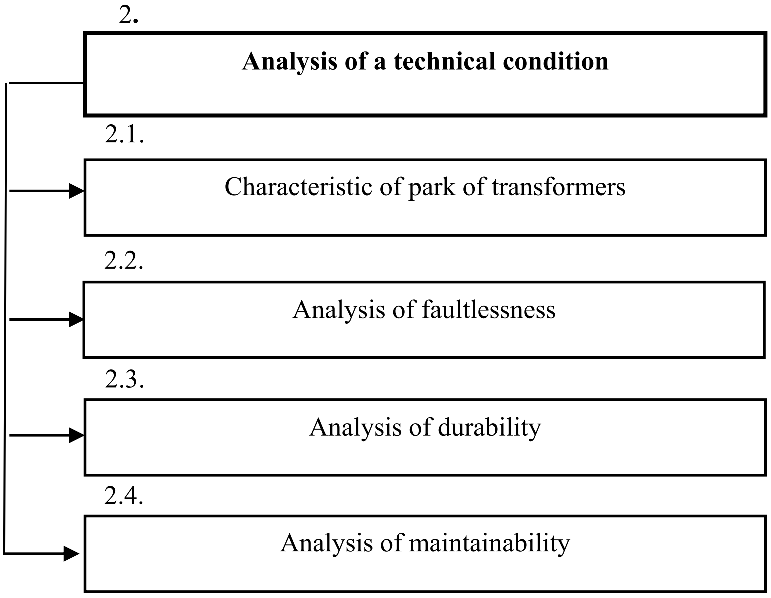

Fig.2 Integrated block diagram of algorithm of a subsystem «Analysis of a technical condition»

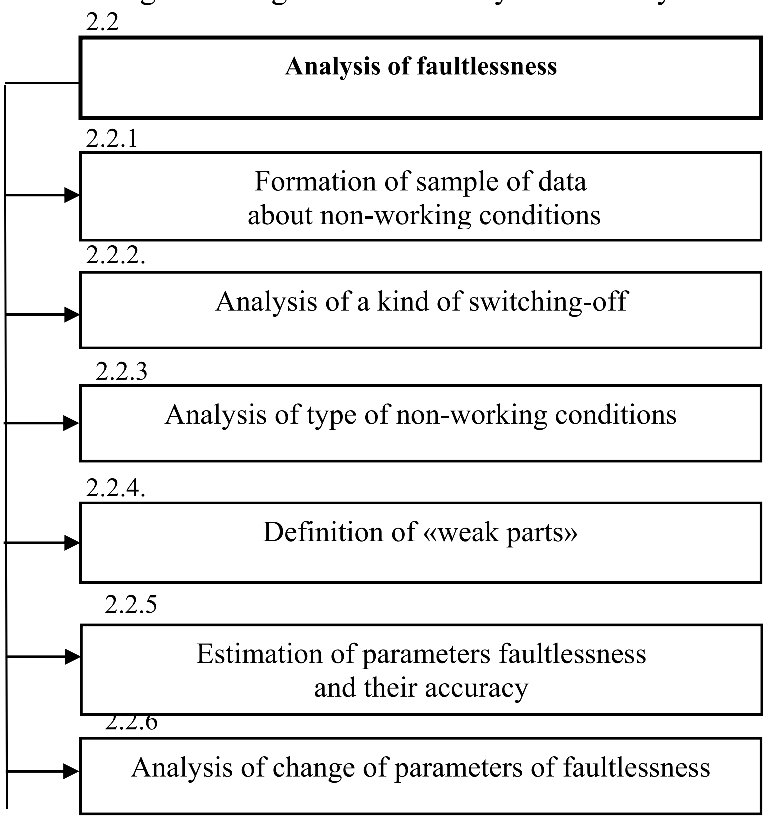

Fig.3 Integrated block diagram of algorithm of a subsystem «Analysis of faultlessness»

In the block 2.2.3 versions of type of conditions (emergency, the emergency or compelled idle time, scheduled repair) are analyzed. We shall specify distinction of these conditions. The emergency condition is the disabled condition TR connected with refusal or defect. At emergency idle, time efficient TR disconnected owing to system failure or refusal of adjacent elements under the scheme. An example of the compelled idle time is switching-off of the efficient block transformer at emergency repair of boiler installation of the power unit. Results of the analysis of observable conditions network TR for number of years of supervision on type's show that from 37% of switching-off only 26% connected with defects TR

In the block 2.2.4 «weak parts» TR defined, i.e. units, which defects most often lead to emergency switching-off TR. At classification of data by emergency switching-off TR on set VP, carried out in blocks 2.2.2-2.2.4, laws of distribution of emergency switching-off can vary. These changes include functional and statistical components. The methodology of comparison of these dependences developed by authors on the basis of methods of imitating modeling and the theory of check of statistical hypotheses allow to calculate optimum area of their change with the minimal probability of the erroneous decision.

The estimation of parameters faultlessness (block 2.2.5) at first sight does not represent any complexity. Formulas of their calculation well known. Thus, it supposed, that the information on refusals has enough for accuracy of calculations comprehensible in practice.

Actually, at attempt estimate parameters of individual faultlessness concrete TR or parameters of faultlessness of the same equipment it appears, that number of refusals and defects a little and it is necessary to solve a problem of accuracy of estimations. The matter is that the estimation parameters of faultlessness TR is not end in it self, and serves for the control non-excess as them of normative values or for comparison parameters of faultlessness of two types TR no excess. And in both cases, despite of significant distinction of parameters observable sometimes, it frequently appears casual, insignificant since is within the limits of accuracy of these estimations.

It is necessary to note, that concept of uniformity, being apprehended literally i.e. as TR one type, yet does not mean uniformity for sample of data about faultlessness these TR as conditions of operation can essentially differ (to differ with loading, service life, an operating time after major overhaul, intensity through currents of short circuit, the importance of consequences damage and so forth). Classification of the information on versions of noted attributes can lead to that, the number of refusals will be, not only it is not enough they will be absent. At the same time, it is clear, that from the point of view of faultlessness the importance of numerous attributes of distinction of nameplate data and conditions of operation is not identical. Hence, «tool» by means of which it would be possible to allocate the most significant attributes for had retrospective information is necessary.

In real conditions, usually it is necessary to solve two types of problems. The first type of problems reduced to estimation PF TR with set VP, and the second type - to ranking TR on non-failure operation.

Method and algorithm of estimation PF TR for set VP.

Includes following sequence of operations:

1. On had data about park TR of a power supply system and about emergency switching-off TR average values PF calculated. We shall consider Main principles of methodology of calculation on most often used PF - specific number of refusals $\left(\lambda_\Sigma^*\right)$ which is calculated as the attitude of number of refusals TR to number TR and duration of supervision;

2. Estimations of the same parameter for each of set VP are calculated. We shall designate these estimations as $\left(\lambda_\Sigma^*\right)$, where i - serial number of the set attributes $i = 1, n$;

3. Ranking $\left(\lambda_{\Sigma}^{*}\right)$ from $i=1,n$ in decreasing order numerical values spent. We shall designate the greatest value through $\lambda_{\max}^{*}=\max\left\{\lambda_{i}^{*}\right\}_{n}$;

4. Methods of imitating modeling and the theory of check of statistical hypotheses in view mistakes of the first and second sort check the assumption (hypothesis H_1) of a casual divergence $\left(\lambda_{\Sigma}^{*}\right)$ and $\lambda_{\max}^{*}$. If hypothesis H_1 proves to be true, it means, that the number of data about refusals is not enough, that any of set VP is not significant also classification FDS inexpedient. If the hypothesis H_1 does not prove to be true, РП for which the estimation $\lambda_{\max}^{*}$ is calculated considered essential.

5. The calculations noted items (2.4), repeat, with that difference, that as $\left(\lambda_{\Sigma}^{*}\right)$ accepted $\lambda_{\max}^{*}$, and the number considered VP becomes on unit less and will be equal (n-1);

6. If on j-that iteration the hypothesis H_1 proves to be true, it means, that from n set VP are significant (j-1), and a required estimation λ is $\lambda_{\max(j-1)}^{*}$. Usually size (j-1) is more, than more than statistical data. It is obvious, that for the others (n-j+1) VP classification of data is inexpedient. That reaches optimum accuracy (width of a confidential interval) and reliability (the minimal value of the sum of mistakes of the first and second sort).

At planning maintenance service and repair TR, the statement of specifications of safety it is important to be able to classify park TR of a power supply system on groups with differing faultlessness and VP. To generate these groups the new method offered.

Method and algorithm of classification TR on faultlessness.

The scheme of algorithm integrated the block is presented on fig.4.

Let's consider some features of calculations. For carrying out of calculations it is necessary to define (block 1): number TR, duration of supervision over their technical condition, number of emergency switching-off, number and a kind of considered attributes, number and type of versions of each of attributes. On these data, is calculated (block 2) the average estimation of specific number of refusals under the known formula:

$$\lambda_{\Sigma}^{*}=\frac{\sum_{i=1}^{K}d_i}{\sum_{i=1}^{K}\Delta T_i}=\frac{D}{M}$$

Where d_i - number of refusals of i-th TR on an interval ΔT_i; to - number TR;

In the block 3, the greatest value among set $\left\{\lambda_{i,j}\right\}_{\substack{i=1,n\\ j=1,r_i}}$ defined. For what, originally pay off $\lambda_{i,j}^{*}$ for all VP, the greatest value $\lambda_{i,j}^{*}$ among versions of each attribute $\left(\lambda_{i,m}^{*}\right)$ defined and, at last, the greatest value among all attributes $\left(\lambda_{m}^{*}\right)$ is defined.

The method of statistical modeling and the theory of check of statistical hypotheses in view of mistakes of the first and second sort checks a hypothesis (H_1) about a casual divergence λ_{Σ}^{*} and $\lambda_{\max}^{*}$. If hypothesis H_1 is true, and significant attributes are absent, calculations come to the end (block 11). If λ_{Σ}^{*} and $\lambda_{\max}^{*}$ differ not casually management is transferred to the block 5 where the number and type of significant attributes and their versions are registered.

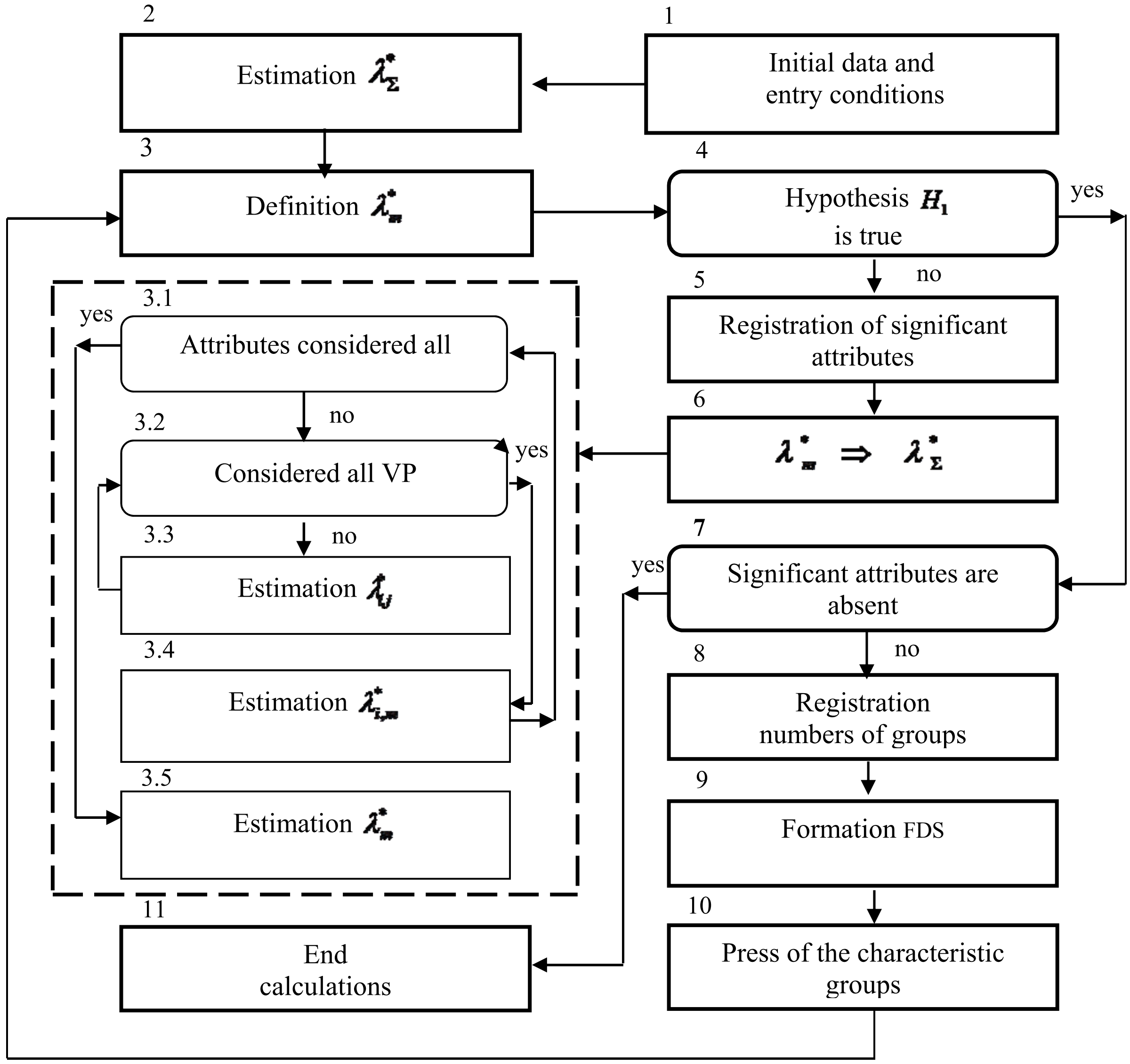

Fig.4. Integrated block diagram of algorithm of classification FDS

In the block 6, as FDS sample of data for which $\lambda^*_{i,j} = \lambda^*_m$ with i=1,n and j=1, r_i is accepted, and management is transferred to the block 3, where again, (but already for sample and (n-1) an attribute) is defined, checked λ^*_m hypothesis H_1, etc. Process of search of significant versions of each attribute comes to the end if the paritynd λ^*_m does not contradict hypothesis H_1. As group TR with distinct from λ^*_Σ faultlessness and known PF is generated, having registered it (block 8), management is transferred to the next stage of formation FDS (block 9). Its essence consists that from general number TR (M) and numbers of refusals (D) are calculated TP (M_m) and refusals (D_m) describing again generated group TR. Further are printed a serial number of this group, significant VP, M_m, D_m, λ^*_m and management is transferred to the block 3. For search of the next group of data. It can be or separate group and remained group TR as a whole.

As possible (at infinite great volume of statistical data) the number of groups equally $L=\prod_{i=1}^{n_n} r_i$, and statistically proved (at real volume of data) - is many times less, the recommended algorithm allows to allocate practically comprehensible number of groups TR with differing VP and to use them at forecasting reliability TR in view of conditions of their operation.

Casual character of distinction observed not only for estimations PF, but also for their change depending on the set combination of attributes. Most often in practice curve changes of specific number of refusals in time (on calendar years, duration of operation, a season and day) are used. However, the curves constructed on retrospective data for all TR, are poorly significant. Therefore, as a rule, classification of the information on set VP is spent. For example, curves for power transformers and autotransformers, TR various classes of a pressure, various capacity and so forth. Here in essential a greater degree are analyzed, than for estimations PF dependence on volume of statistical data is shown. The methodology of the account of this dependence offered by us in and realized in AISTR.

CONCLUSION

1. A necessary condition of an objective estimation of expediency of replacement of transformers of a power supply system, carrying out MO, modernizations, changes of loading and an operating mode, test the opportunity of an operative estimation of their technical condition is. This problem solved in the automated information system of an estimation of a technical condition of transformers developed by authors (AISTR);

2. The subsystem «Analysis of faultlessness» AISTR, alongside with traditional elements of the analysis, represents an opportunity:
- To optimize accuracy of estimation PF TR and laws of their change in time for set combination VP;
- To raise objectivity of comparison of faultlessness various TR (in other words, comparisons of faultlessness TR to various set VP);
- To divide park TR into groups on a condition of identity of their non-failure operation;

3. The analysis of the defects eliminated during switching-off TR under the emergency application, and also the defects which have caused automatic switching-off of transformers owing to of short circuit growing old TR, allows to improve type and periodicity of diagnostic check, to raise quality of scheduled repairs, to specify possible loading and operating mode TR.

LITERATURE

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