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Parametric diagnostics of gas turbine

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They are considered problems of the building of the systems diagnostics of gas swapping aggregates (GSA). Whereas, park of the turbines, using at present on territory of the Republic of Kazakhstan has greatly grown old, questions of the creation and introducing the similar systems are actual. As bases of the building of the similar systems authors are offered use the systems of the artificial intelligence, as follows systems on the base of the ill-defined logic and neuron networks.

Introduction. Technical diagnostics - is the branch of the scientific and technical knowledge, which essence makes the theory, methods and means of search and detection of technical objects defects. Before starting the discussions about problems of the creation of turbine unit technical diagnostic systems, it would be desirable to make some general observations about appointment and problems of technical diagnostics. The basic purpose of technical diagnostics consists in increase of reliability of objects at a stage of their operation. It sometimes causes objection as many consider that reliability is property of the unit. However we should remember that the readiness coefficient of turbine and the technical condition coefficient - two basic indicators of turbine’s reliability - depend on expenses of time for repair due to some refusals of equipment, and last one depends also on expenses of time for planned repair. Therefore, if using methods of technical diagnostics it is possible to reveal occurrence of defect and to predict its development it will allow to reduce quantity of refusals, to eliminate available defects during planned services and repairs, to reduce volumes and terms of repair work.

§ 1. Stating the problem of the building diagnostic systems of gas swapping aggregates

Certainly, technical diagnostics allows to reveal and eliminate and sometimes to prevent spoilage in production arising at fabrication stages and installation or in the course of repair. However such type of defects is easy to supervise using direct methods during manufacturing of this unit and not to suppose them, instead of to ascertain their post factum. All aforesaid allows to formulate the following main targets of technical diagnostics defining economic efficiency of diagnostics:

1) Detection of damages or defects at an initial stage of their development; revealing of concrete defective knots or details; definition and elimination of the reasons which have caused defect;

2) Estimation of an admissibility and expediency of the further operation of the equipment with considering forecasting of its technical condition at the revealed defects; optimization of the operation modes, allowing safely to maintain the unit with the revealed defects till the moment of its conclusion in planned repair;

3) Organization of service and equipment repair based on a technical condition (instead of procedural service and repair), maintenance of preparation and performance of qualitative repairs.

Generalizing the previous experience of engineers [1-2] in the given branch we will list the basic conceptual decisions which are necessary for creation of turbine unit’s system diagnostics. The first one is the expanded use in diagnostic systems of existing sensors and monitoring systems. That is a basic decision - not to suppose duplication, especially duplication of primary sensors if they meet the requirements of diagnostics. And only in some cases it will be useful to use additional or duplicating sensors and the monitoring systems needed for decision of certain diagnostic problems. As examples the high-frequency vibration sensors used for the control of acoustics on the exhaust parts, or the gauges of biases placed on the bearings cases or elements of the base can be resulted.

The second - is that the diagnostic system should work in "on-line time". The term "work in real time" doesn’t mean that the system should work with very fast speed, but it’s just mean that we gather the data in rate of controllable process. If it is a question of system of diagnostics intended for revealing of defects of the equipment and released from performance of problems of the alarm system and emergency protection of the equipment working in a mode of "on-line time" it is necessary to consider any system, allowing to trace and analyze all changes of the parameters characterizing
occurrence and development of defect in rate of development of this defect. The primary goal of the diagnostic systems is to give out the prevention of defect occurrence before the given defect will represent real danger to reliability of the diagnosed equipment. Hence the major element of the designing of diagnostic systems is the knowledge base about possible defects, their diagnostic signs, speeds of development of defects depending on operating modes etc.

The third - is developing of the diagnostic system named "from defects through equipment to algorithms". It is the major conceptual issue, an initial position from which the system is projected. If system developing is conducted from the concrete list of defects and their diagnostic signs which allow to reveal these defects on the basis of well-founded experience or theoretical preconditions of the developer it will allow to minimize volume of controllable parameters, to prove use of additional measuring sensors and to optimize algorithms of diagnostics. But in such system possibilities of its development and expansion should be initially put. Unfortunately usually developing of the diagnostic systems is conducted on the basis of the list of parameters which either are already supervised, or there is a possibility to supervise. If the volume of measured parameters is not proved by concrete diagnostic problems then the additional information often leads to creation of bulky and disabled diagnostic systems.

The forth is integration of the diagnostic system with control systems of the turbine. In the presence of a control system, created diagnostic systems of a turbine unit, as well as other subsystems, should be integrated with them. Certain rules of information interchange with control systems should be thus developed. So, the operative diagnostic information necessary for operation personnel, should be transferred in a control system and be displayed by its system means, is similar to other targets of the control system. On the other hand, those parameters of the unit which are registered by a control system and are simultaneously used for the decision of diagnostic problems should be transferred from a control system in diagnostics system.

The fifth is the acquisition, storage and representation of the data’s. The technique of data acquisition and volume of the stored information, ability to restore the information about the character of the process, in particular about changes of vibrating parameters, substantially define the possibilities of diagnostic systems. In general we cannot describe value of vibration as average, maximum or minimum value in hour, shift or days. It can be like some integrated condition of the unit necessary for the report documentation, but there is absolutely not enough for diagnosing. On the other hand, each measuring of vibration gives individual values and it is caused not only an error of measurements, but also some instability of the process. Therefore methods of acquisition and storage of the results of vibration measurement is characteristic feature of diagnostic systems and therefore need to search the ways to keep the significant information and, simultaneously, to avoid creation of too bulky databases which are not allowing operatively to process and represent the information. As soon as we describe main requirements for the diagnostic system we have to talk about the diagnostic methods. The diagnostics methods it is principles on which basis search and detection of defects is carried out. The analysis of vibrations is the powerful tool for an estimation of a technical condition of a turbine unit. Occurrence and development of a considerable part of defects of a turbine unit, as a rule, causes changes in its vibrating condition. These changes, as well as development of the majority of defects, usually occur during long time interval. The general reasons of turbine’s vibration is unbalance, defects in bearings, inadmissible gaps and backlashes, a deterioration, aerodynamic and hydraulic forces and etc. But for full understanding of the processes occurring in such difficult mechanism as the turbine, the knowledge as vibration parameters and regime and thermo mechanicals parameters is required. Depth of the analysis at diagnosing substantially depends on the time period on which base diagnosing is carried out that demands long time for acquisition and storage of the information used at diagnosing.

The updating time and periodicity of accumulation of the information in diagnostics systems depends not only on time of defect’s development, but also from a turbine operating mode. It is necessary to allocate at least four operating modes of system defined by operating modes of a turbine unit: start-up, a stationary mode, shutdown and cooling. The analysis of vibrating characteristics at
start-up and shutdown considerably raise reliability of diagnosing of many defects. But the vibration control on these modes demands realization of the high-speed multichannel measurement methods.

§ 2. Review of the methods of diagnostics

Diagnosing methods cannot be considered in a separation from means on which diagnosing process is realized. The most simple methods can be realized in the form of instructions or recommendations in which necessary tables are resulted, schedules, monograms, the oscillograms received on the basis of generalization of experience, allowing to estimate a current technical condition of object, to identify occurrence or development of defects on the basis of comparison of diagnostic signs. The most difficult methods of diagnosing demanding performance of a considerable quantity of calculations, mathematical modeling of object, processing of big volume of the information, are realized on computer facilities. Now for objects diagnosing the expert systems are often used [3-5].

The expert system is the system of an artificial intellect using knowledge from concrete area for the decision of arising problems and uniting possibilities of the computer with knowledge of the expert in such form that can offer reasonable council or carry out the task in view decision. In most cases this knowledge will be organized in the form of some set of the rules, allowing doing the conclusions on the basis of the initial data or assumptions. Expert systems get the increasing popularity in the decision of problems of diagnostics as allow accumulating the generalized knowledge of set of the experts, received on the basis of long-term experience. It will be useful for the experts who do not have still sufficient experience and knowledge in the field of diagnostics, and for qualified professionals. For the first expert systems serve also as a tutorial, for the second allow not to miss some details or particulars in behavior of object of diagnosing.

Diagnosing methods, anyhow, are reduced to methods of recognition of images of defects. At all variety these methods use one of following approaches or their certain combination:

1) Deterministic method;

2) Static method;

3) Probabilistic method;

The determined approach is based on logic methods of recognition, means that the methods using logic interconnections between signs and a condition of objects. Objective laws of interrelations and causal conditionality of all phenomena allow to construct only rigid scheme (a reasoning’s tree), reducing process of definition of defect to movement from a tree root to a final diagnostic branch through set of knots in which the direction of movement depending on presence or absence of any sign is established. The distinctive property of these systems is their speed and possibility of all-around automation of diagnostic’s processes. Use of statistical methods of diagnosing for the unique and individual equipment is complicated, because at rare enough occurrence of defects it is inconvenient to receive representative samples. Without stopping in detail on methods of identification of defects, we will specify only that the solving rule (a rule, leaning on which the conclusion is formulated) at use of such methods is affinity of the object having concrete defect to any standard, or an accessory of the revealed diagnostic signs of any area of signs.

§ 3. Priorities of the method of mathematical modeling, based on fuzzy logic

One of the most popular probabilistic methods is the method developed by R. Bajes. The Bajes theorem and its formula allow, using aprioristic probability of defect occurrence and some data confirming put forward position, to calculate new value of probability of that position about defect presence truly [4-5]. That the estimation of presence of diagnostic signs does not require categorical answers "YES"or "NO", and is carried out with use of fuzzy logic, for example: "POBABLY YES, THAN NO", "PROBABLY NO, THAN YES", "I DO NOT KNOW"etc.

It is a very fruitfully practically to use the fuzzy logic because sometimes we have to reveal signs on some noisy background. But the fuzzy logic is most effective when diagnostic signs are received on the basis of mathematical modeling. For example, it is need on the basis of calculations.
of the compelled fluctuations and comparison of these results with the valid fluctuations of a rotor to identify a broken blade with instructions of a place of damage on a rotor or a place and character displacement or other defects. But it is absolutely clear that results of calculations will always differ from practical results of supervision by the following reasons: firstly, any model is approached; secondly, there is an error of measurements; thirdly, there is an influence of other developing defects etc. In this case even opponents in principle of use of fuzzy logic should recognize that differently as on the basis of some criteria of similarity of theoretical and practical results, successfully to solve the given problem it is almost impossible. And the concept of similarity, naturally, means the fuzzy logic.

From all aforesaid follows that from all considered the expert system of probabilistic type is the most universal and perspective. It is least subjective also in the best way is adapted for organization "machine of conclusions", adjusted on any object, whether it be the turbine, the generator or compressor [6-10].

REFERENCES