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Shaft sensor based on modeling diagnostic signs of power unit defects

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Abstract

A perfection concept is proposed for automated control diagnostics systems used at power plants with application of shaft sensors. It is proposed a systematic approach to solve a number of practical problems related with safety and performance of power generating turbosets. Diagnostics of multi-rotor turboset technical condition are significantly improved due to "complete" set of shaft motion sensors, applied at both sides of each journal bearing. There have been given diagnostics signs of defects measured with shaft sensors and suggested some extra criteria of reliability of the shafting and supports.
To illustrate the method let us compute correcting alignments of fragment of shafting.
Using simplified 2-rotor 4-support turboset, it is shown that: corrective alignments of supports, recommended by manufacturers of turboset and generator, may be not sufficient to compensate misalignments of supports, caused by thermal deformations of turboset support system. Those corrective misalignments should be computed individually for each turboset, using real thermal deformations and real clearances of journal bearings.

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Keywords: automated control diagnostics systems, shaft sensors, journal bearings, turboset, shaft, supports, defects, misalignments, corrective alignments of supports, criteria of reliability.

1. Introduction

Automated control systems for safe money-saving real-time operation and maintenance (COMPACS®) [1,2] are used in many industries where such systems can work based on different sensors including shaft displacement ones. Shaft displacement which causes basic disturbance is sensitive to a number of defects like rotor half-coupling

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assembly defects, defects of rotor centering in the turbine setting, support malfunction, etc. At domestic thermal power-plants, where at least one pair of shaft sensors is installed in bearings on turbine units [3], the vibration experts cannot see the turbine unite adjustment without important initial information about rotor movement. However, these sensors information is processed by the existing systems within minimum scope, only for the purpose of vibration problem solution. These tasks are covered by the new GOST [4] instead of the old GOST 27165-1998. But the key information contained in the static characteristics read with shaft sensors (levitation curve, minimum clearance, etc.) and in other proper characteristics (power friction loss, misalignment, rigidity and oil film damping, etc.) is not used and not analyzed. Also, the new GOST [4] is supported with no guidance papers for defect diagnostics and for use of characteristics dependable on the bearing design and operation conditions including very important parameters of bearing capacity and friction loss.

Some foreign companies use levitation curves for diagnostics of different plants and units, but they cannot go beyond the problems covered by ISO 7917-2:2009. According to this ISO, shaft displacement sensors are installed on one side only or on the bearing transverse axis. However, it is impossible to evaluate correct technical condition of the support because of rotor journal misalignment caused by a number of factors.

It is very difficult and laboriously to discover defects using the current method support and software provided by tens of companies, so far as the main problem, defect search automaton and development of criteria for evaluation of residual defects risk or acceptability, has not been solved. As opposed to other ones the COMPACS® system can make complete diagnostics in automatic mode [1].

In such a way, the following new problems now arise:

- adaptation of the COMPACS® systems for power units with journal bearings;
- development of methodological support and diagnostic power unit failure indicators based on shaft sensors, as well as auxiliary diagnostic problems solutions;
- check and development of diagnostic signs by means of physical and mathematical modeling;
- perfection of vibration monitoring specifications and diagnostic systems for different turbine units.

This work solves in part the first two problems resulting in exemplary modeling of support misalignment and determination of correcting alignment. In [7,8] for the COMPACS® systems there are prospects of shaft sensors in full set considered for the purpose of unit rotor balancing and centering perfection. The full set of shaft sensors means installation of two sensor pairs on both sides of the rotor journal in the bearing according to [4].

2. Diagnostic signs of defects based on the shaft sensors complete system

Measurement of shaft displacement based on the complete set of sensors allows specifying the following defect diagnostic signs (see Table 1). The table also includes extra criteria of reliability. The criteria and defect diagnostic signs given in Table 1 may be grounded by the current document in part only. The rest should be analyzed and perfected, if necessary, in respect to an individual unit during the system adaptation. *Alongside with the suggested criteria, the turbine unit reliability criteria must be performed according to GOST R 55263-2012*[4].

Realization of the Table 1 criteria involves the following problems solutions in the course of monitoring ONLINE:

- calculation of minimal journal misalignment and gaps, i.e. the modes with inadmissible gaps and loss in bearing capacity;
- connection of minimal gaps and misalignment with babbit temperature for all loading conditions and rotary speeds;
- calculation of gap correlation and journal misalignment based on the data of housing absolute extension;
- calculation of static and dynamic loads in supports;

Table 1. List of defects measured or diagnosed with shaft sensors.

No	Defects	Diagnostics indicators	Remarks
	a) static defects		