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Real-time condition monitoring of thermal power plants feed-pumps by rolling bearings supports vibration

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Abstract. The report addresses the real-time condition monitoring of technical state and automatic diagnosis of auxiliary equipment for bearings supports vibration, for example, control of the feed-pump operating modes of thermal power stations. The causes that lead to premature birth and development of defects in rolling bearings are identified and the development of activities ensuring safe and continuous operation of the auxiliary equipment of thermal power stations is carried out. Collection and analysis of vibration parameters of pumping units during their operation at the operating modes of the technological process are realized by means of real-time technical condition monitoring. Spectral analysis of vibration parameters of one of the pumps showed the presence of frequency components, which mark violations in the operating practices of the pump, the imbalance development and, as a consequence, the development of defects in the bearings by long-term operation of the unit. Timely warning of the personnel on the operation of the unit with the "INTOLERABLE" technical state and automatic warning issuance of the need to change the technological process allowed to recover the estimated pump operation mode in due time and prevent further development of defects in equipment.

1. Introduction

All processes of life-support in today's world of mankind is directly dependent on the stability and quality of consumed electric power. In this regard, power companies face the task of ensuring stable and uninterrupted electric power generation process. To solve this problem real-time condition monitoring of the technical state of equipment of power plants is required. However, substantially only basic energy mechanisms that generate electrical energy - turbines - are equipped with the control and block systems. At the same time for the operation of one turbine dozens of support dynamic equipment, such as various types of mills, blowing fans, exhaust fans, pumps, cooling towers are used. Many auxiliary units operate without reserve, and their sudden failure leads to a decrease in volume and quality of generated electric power up to a complete stop the turbine.

Equipping auxiliaries of power plants with systems of automatic diagnostics and monitoring of a technical condition is a real way to maintain safe and reliable operation of power plants [1] and stability of vital mankind activity.

2. Systems for monitoring the technical condition and automatic diagnostics

Now a large number of systems of condition monitoring, diagnostics and monitoring parameters of dynamic equipment of power plants are known.

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A prominent representative of such systems is the system [2], some of the practical results of the use of which at the thermal power plant will be discussed in this article.

The test facilities are primarily a network of sensors mounted directly on the auxiliary equipment of thermal power plants. These sensors being transducers perform the conversion of the measured parameters of various physical quantities (vibration, temperature, current, pressure, etc.) into electrical signals. The electrical signal from the sensor through the cable communication lines enters the programmable interface modules for pre-treatment and further - diagnostic station for processing. Visualization of the results of measurements in real time is presented on the monitor with the values of the parameter being measured and color icons (green – ‘TOLERABLE’, yellow – ‘ACTION REQUIRED’, red – ‘INTOLERABLE’) corresponding the current technical condition of the equipment being diagnosed. Simultaneously diagnostic instructions (expert reports) are issued in the automatic mode.

2.1. Condition monitoring - Mode "Monitor"

On the "Monitor" screen the following is schematically represented: the operated equipment in the form intuitively clear to any person, the main parameters to be measured according to GOST R 53565-2009 [3], presented in the top left of the screen, but most importantly – prescriptions of automatic expert system in the upper right of the screen "Monitor" to be carried out to ensure the safe operation of equipment.

When the technical condition of the unit passes into the state of ‘INTOLERABLE’ system warns staff through verbal communication to make them perform urgent measures to ensure the safe operation of equipment. In accordance with the applicable regulations of Technology staff must comply with the recommendations of the system and the system, again in the automatic mode, controls the speed and quality meeting the requirements to change the state of assemblies and their components.

2.2. Condition monitoring - Mode "Trend"

All parameters measured by the system are stored in databases for different time intervals from 12 hours up to 9 years. The submitted four-days trend of front engine bearing acceleration shows that just over two days (figure 1, section 1) the technical condition of the working unit is in ‘TOLERABLE’ category, then there is a defect development in the bearing and acceleration increases (figure 1, section 2) and technical state of the machine goes into ‘INTOLERABLE’ category. The system automatically informs staff about the need to perform decommissioning of the unit and within 5 hours activities and the output unit of the operation are conducted with subsequent repair (figure 1, section 3).

B-104 BLOWING FANS FRONT END BEARING _ ELECTRIC MOTOR

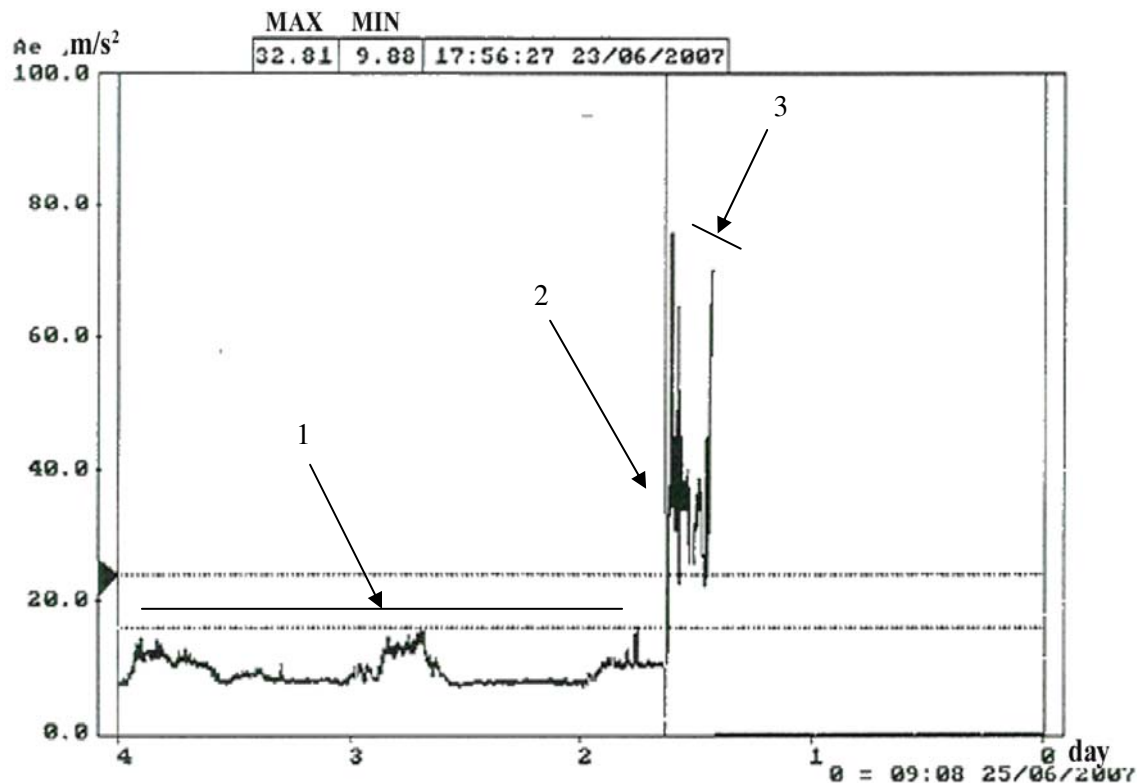


Figure 1. The trend of acceleration up to 4 days front end bearing of an electric motor.

3. The examples of equipment diagnosing

The system provides reliable diagnosing of defects in bearings, lubrication regimes infringement, technological process infringement (cavitation, hydroblows, etc.), violations of shaft alignment and of rotating parts balancing, looseness of fastening, electromagnetic and other defects[4].

3.1. Violation of the equipment operation regime

It should be noted that periodically technological personnel has to operate auxiliary equipment in modes other than given in the passport to provide the work of the power generating unit, which will undoubtedly affect the mechanical condition of the unit and its technical resources. When operating an feed-pump PE-500-180-3 at a thermal power plant staff broke the technological regime of its work which resulted in bringing pump pressure too high by about 15%, and understating the charge by 40%, which led to the transition of technical condition of the pump into a state of 'INTOLERABLE' category - rms values were: of vibration acceleration (A_e) - 33.88 m/s², vibration velocity (V_e) - 13.22 mm/s, vibration displacement (S_e) - 23.10 μ m (table 1).

Table 1. The measured parameters of a pump vibration.

Type of bearing	Direction	Ae, m/s ²	Ve, mm/s	Se, μm
Tail bearing	X - horizontal	33.88	13.22	23.10
	Y- vertical	19.72	7.43	12.82
	Z – axial	17.30	6.16	4.07
Front end bearing	X - horizontal	7.91	3.72	5.76
	Y- vertical	12.16	4.59	5.71
	Z – axial	13.68	3.27	4.66

In the amplitude spectrum of vibration acceleration (figure 2) and vibration velocity (figure 3) dominant is the blade frequency of the pump impellers 349.2 Hz (22.83 m/s², 10.39 mm/s) modulated by rotation frequency harmonics.

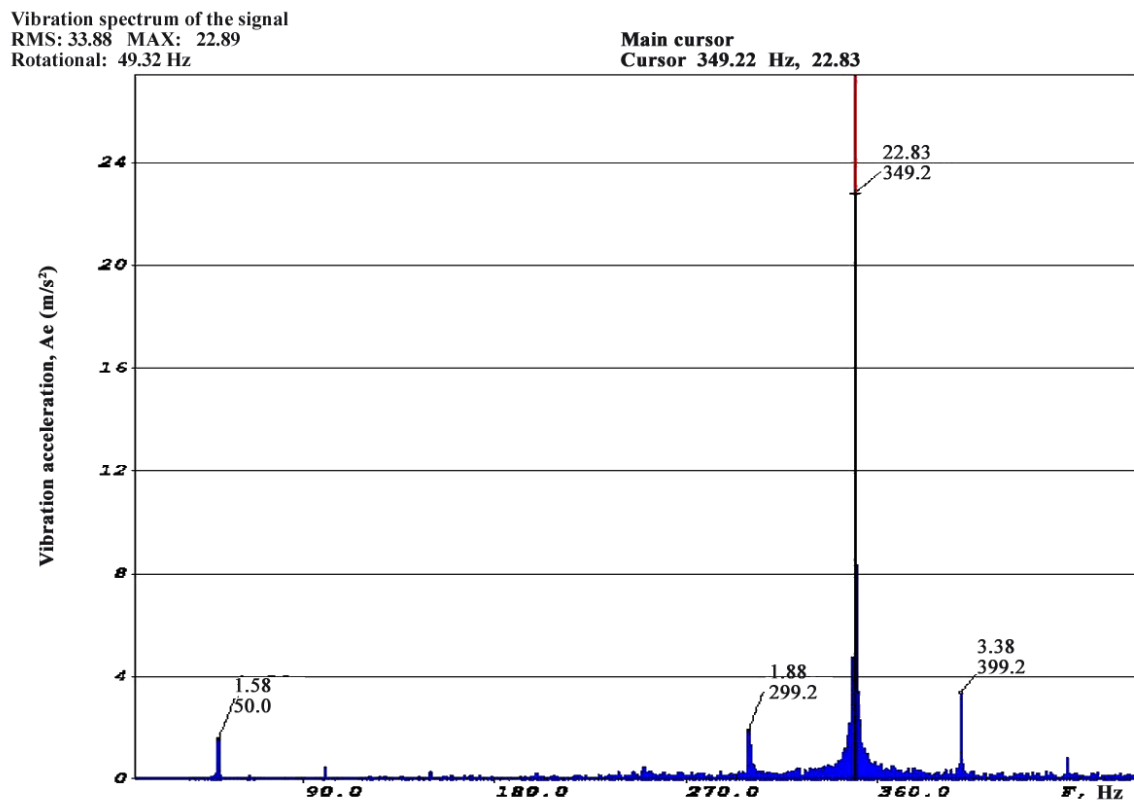


Figure 2. Amplitude spectrum of vibration acceleration from 0 Hz to 450 Hz.

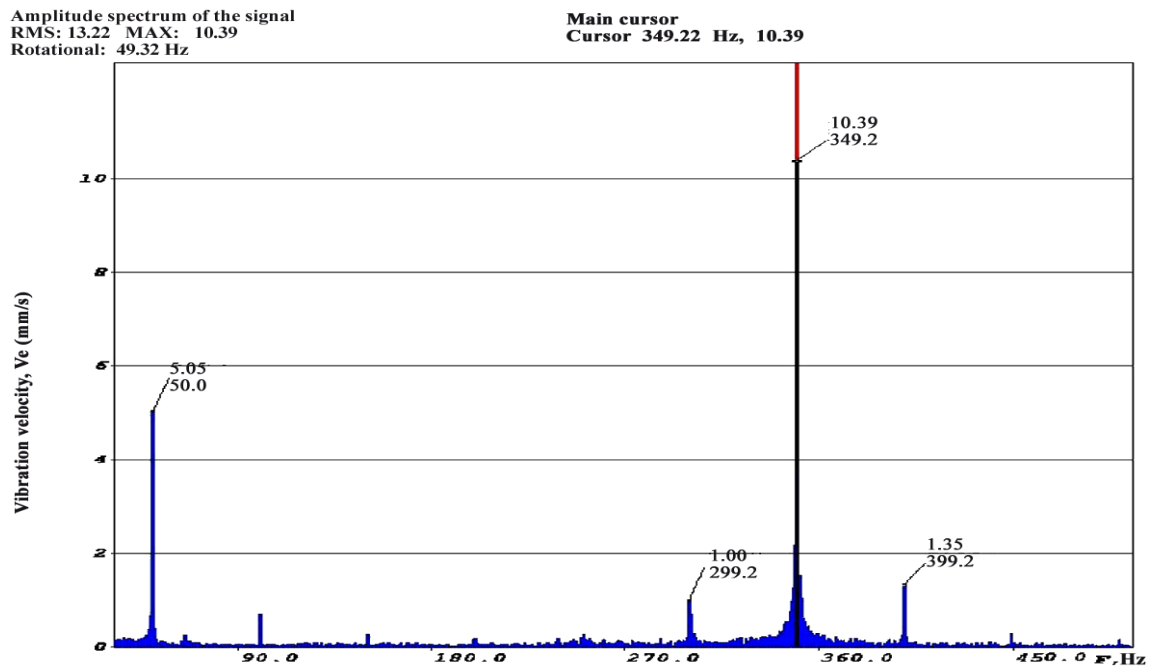


Figure 3. Amplitude spectrum of vibration velocity from 0 Hz to 450 Hz.

In the amplitude spectrum of vibration displacement (figure 4) predominant is the frequency of rotation (16.12 μm), present is also blade impeller pump frequency 349.2 Hz (4.74 μm) modulated by rotation frequency harmonics.

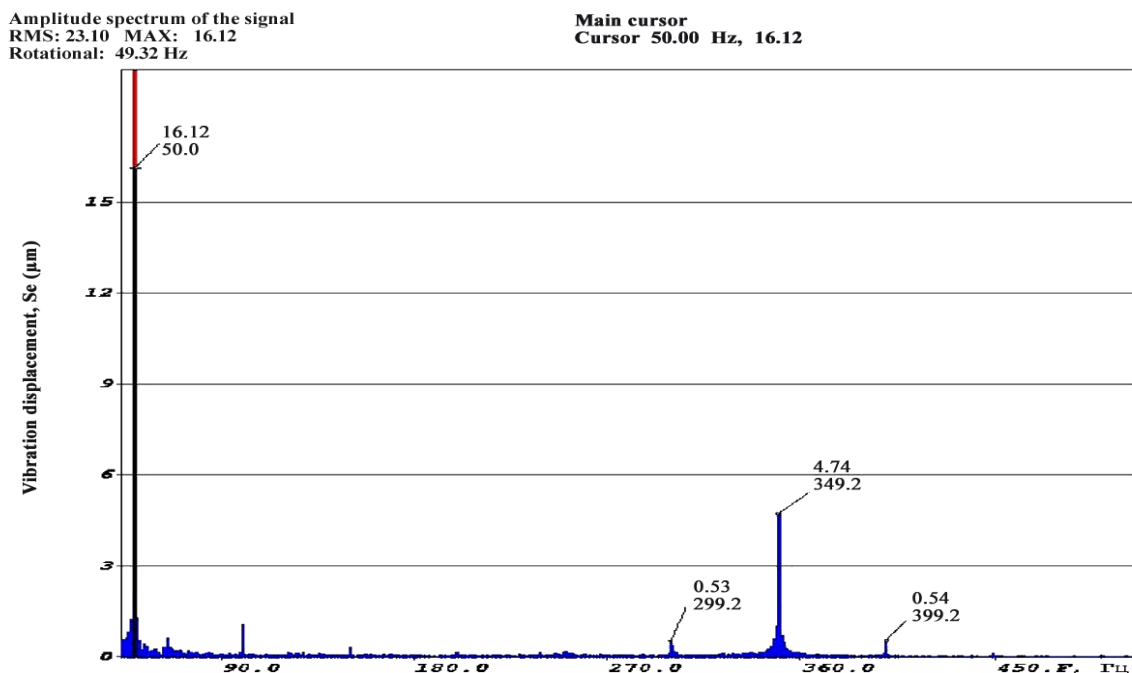


Figure 4. Amplitude spectrum of vibration displacement from 0 Hz to 450 Hz.

The fact that harmonics of rotation frequency dominates in the spectrum of vibration displacement (figure 4), and has a significant impact in the spectrum of vibration velocity (figure 3) means the presence of an imbalance in the pump. Harmonics of blade pump impeller frequency are modulated by harmonics of the rotation frequency in the spectra of vibration acceleration, vibration velocity and vibration displacement (figure 2, 3, 4). The presence of imbalance is the result of violations of the operating practices and has a hydraulic origin.

Prolonged operation of the pump with such a violation of the technological regime will inevitably lead to the development of defects in the bearings of the pump with consequent loss of working capacity of the unit.

3.2. Low quality of repair works

When accepting a feed - pump into operation after repair at a thermal power plant, a high value of vibration acceleration at the tail bearing of an electric motor was found. The analysis of the spectral components of vibration showed that the maximum vibration occurs at the frequency of passing of stator slots modulated by a binary power supply frequency and rotation frequency harmonics (figure 5).

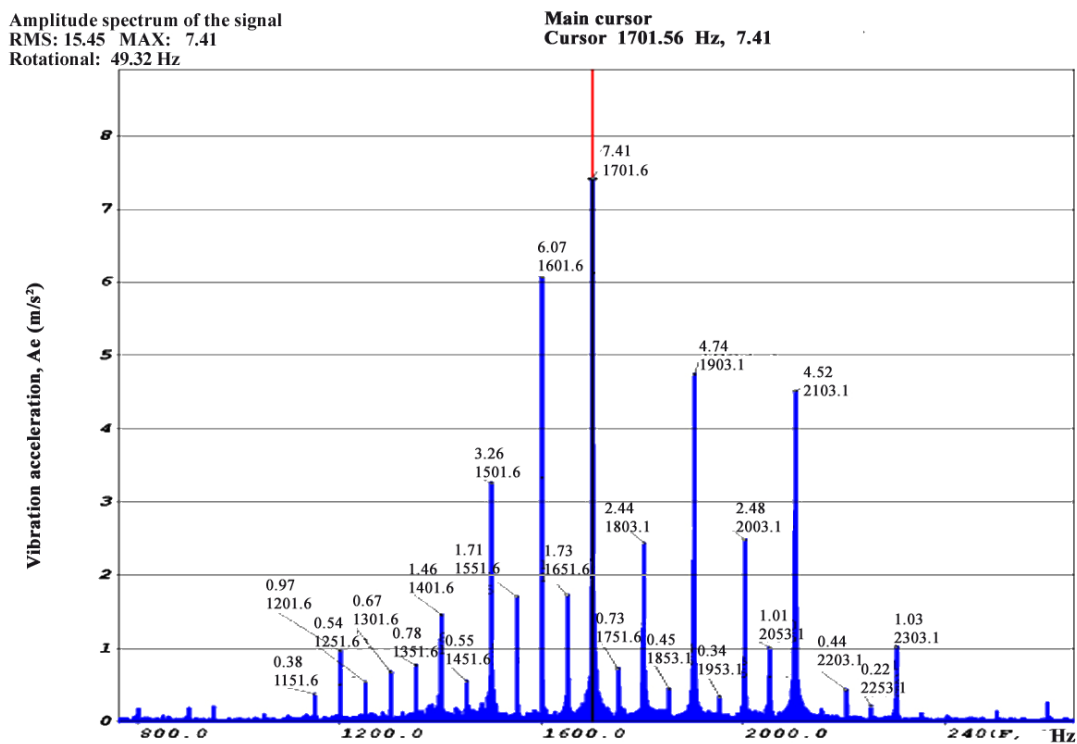


Figure 5. Amplitude spectrum of vibration acceleration from 800 Hz to 2500 Hz.

That may reveal electromagnetic defect of a motor – magnet gap eccentricity and rotor misalignment. Repeated repair was required to bring the unit to the technical condition of ‘TOLERABLE’ category.

These examples of equipment diagnostic confirm that vibroacoustic diagnostics is a very sensitive method for diagnosing equipment, which allows to trace the development of the defects.

4. Conclusion

Equipping machinery with stationary system of technical condition monitoring and automatic diagnosis eliminated the accidents, and expelled the so-called "sudden" failures. "Sudden" failures occur where there is no observability of the process of origination, development of the fault, and its growth to a critical level and then to an emergency.

Equipping auxiliary machinery of power plants with systems, and due to this, the transition to operate on the actual technical state, the planning and execution of maintenance and repair only when indicated by the system ensures reliable, safe, resource-saving maintenance of power plants.

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