MONITORING AND VIBRATION ANALYSIS OF HYDROAGREGATES

Ranko Antunović, PhD
Faculty of Mechanical Engineering,
University of East Sarajevo
East Sarajevo

MSc Nikola Vučetić
Faculty of Mechanical Engineering,
University of East Sarajevo
East Sarajevo

Milenko Roljić
Hydroelectric power plants on Vrbas
Mrkonjić Grad

Anđelko Grahovac
Hydroelectric power plants on Vrbas
Mrkonjić Grad

ABSTRACT
Direct control and diagnostic analysis of the situation turbine unit with strictly defined diagnostic methods, obtained good insight on the current state of the technical system and the actions implemented to maintain when it's really necessary. Parameters that carry the most information about the state of the system are certainly vibration parameters. Diagnostic approach lies in the fact that any malfunction machine produces a vibration predefined character. In this paper some of vibration analysis that have been done in Hidroelectric power plants on the HPP Vrbas.

Keywords: monitoring, hydroagregats, vibration analysis

1. INTRODUCTION
Carefully selected and implemented a system for monitoring hydro can help the operator to avoid the areas of work in areas where vibration, partial discharge or cavitation can cause permanent damage to the system. In addition, the system allows early detection of potential damage, places and types of errors, planning downtime required activities necessary parts, human resources and their own costs. [1..9] Control parameters are indirect individual, associated with structural parameters (vibration, temperature, gap in bed, oil pressure, etc.) And carriers have accurate information about the technical condition of the system. In general control parameters can be divided into: the parameters of the working process (power, flow, frequency of start-up, etc.), The parameters of supporting processes (parameters of vibration, noise, temperature parameters, etc.) and geometrical parameters.
According to the practice of the well-known world producers of hydro-generators, the following dimensions and parameters of controlling are monitored: temperatures of parts and assemblies of generator and cooling fluids, vibration of mechanical parts and relative displacement (orbits), stator form, rotor and generator gap, partial discharge in coils, the presence of water in the oil, the speed of rotation, the magnetic flux, the flow - the cooling water pressure, the oil level in the bearings, the control of the small rotations, the state of the magnetic stator core, the content of gases and humidity in the cooling air, the efficiency of the generator, the winding temperature of the rotor, the quality of the cooling water (distillate), noise measurements in the generator barrel, cavitation and pressures through the turbine, Fig.1.

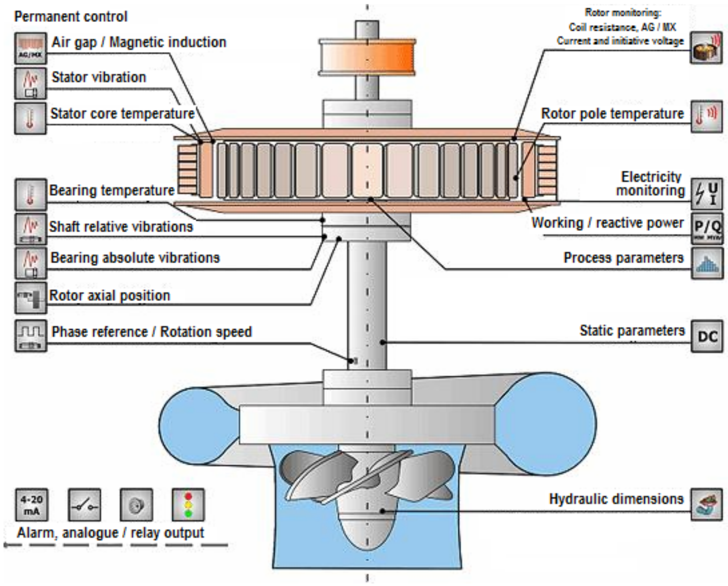

Figure 1. Measuring, monitoring parameters of hydroagregats

The main task of the control-diagnostic system turbine unit is monitoring the situation, protection of plants and early diagnosis of a malfunction of the turbine unit. Contemporary control systems and diagnosis hydroagregates, typically contain the following subsystems, control:

- Control of the vibration,
- Control of the partial discharge (PD - monitoring),
- Control of the magnetic flux generator,
- Control of the air gap (between the rotor and the generator stator),
- Controlling the temperature and process parameters necessary.

2. FAILURE ANALYSIS OF HYDRO UNITS

The most common failures with the turbine unit and the necessary measurements which we can identify the causes of these defects during the exploitation of the system are shown in Table 1.

Table 1. Overview of the possible cancellation of the hydro and the necessary measurement and analysis which can not diagnose the cause of the malfunction.

FAILURE TYPES AND REQUIRED MEASUREMENTS	**MEASUREMENT**												
	LEAD BEARING VIBRATION	AXIAL BEARING OIL FILM THICKNESS	LEAD BEARING TEMPERATURE	AXIAL BEARING TEMPERATURE	PHASE DETECTOR (IMPULS) PER ROTATION	TURBINE CAP VIBRATION	GENERATOR GAP (AIR GAP)	STATOR GENERATOR HOUSING VIBRATION	GENERATOR TEMPERATURE	PROCESS VARIABLES	GENERATOR SPARKING	POSITION OF THE MAIN LATCH	SEALING RING GAP
■ *Minimal system* ▲ *Standard system* ♥ *Recommended system*	■ ▲ ♥	■ ▲ ♥	■ ▲ ♥	■ ▲ ♥	■ ▲ ♥	■ ▲ ♥	▲ ♥	▲ ♥	▲ ♥	▲ ♥	♥	♥	♥
MECHANICAL DEBALANCE	• (1X)				•								

ELECTRICAL DEBALANS	• (1X)				•								
HYDRAULIC DEBALANCE	• (1X)				•								
CRITICAL WORKING ZONES	• (NE1X)				•					•		•	
FAILURE OF SWINGING SHAFT	• (1X)				•					•			
AXIS MISALIGNMENT	• (1X)				•								
CAVITATION						•				•		•	
CLOSING RING					•								•
LARGE VIBRATION OF TURBINE					•								•
BEARING OVERLOAD	•	•	•	•									
BEARING FATIGUE	•	•	•	•									
INCREASED BEARING	•	•	•	•									
DAMAGED INSULATION OF THE STATOR											•		
VIBRATION OF COIL IN THE STATION											•		
ROTOR RING MOVING					•		•						
STATOR CORE MOVING					•		•	•					
UNEVEN STATOR GAP					•		•	•					
EXCENTRIC ROTOR / STATOR					•		•	•					
KONCENTRIC ROTOR/STATOR					•		•	•					
STATOR BENDING					•		•	•					
LOOSELY STATOR BARS								•					
UNBALANCED FORCES IN STATOR CLEARANCE					•		•	•					
FILLED STATOR COOLING									•				
BLOCKED STATOR VENTILATION CHANNELS									•				
OVERHEATED STATOR COILS									•				

To impose updates the database for the purpose of monitoring and diagnosing a malfunction of the turbine unit, the system is set up to supervise the following modes of hydro units: 1. The unit is stopped, 2. Start, 3. Low load, 4. Nominal operating mode, 5. Stop aggregate. Most used vibro-diagnostic analysis in practice are: analysis of the overall level of vibration, spectral analysis, phase shift analysis, the vector of real-time analysis, the orbit, DC analysis, trend analysis and others. Some of these vibrational formats are shown in Figure 2,3,4 and 5. In order to be vibration analysis of hydro units, it is necessary to observe certain vibrational displays simultaneously correlated with process parameters.

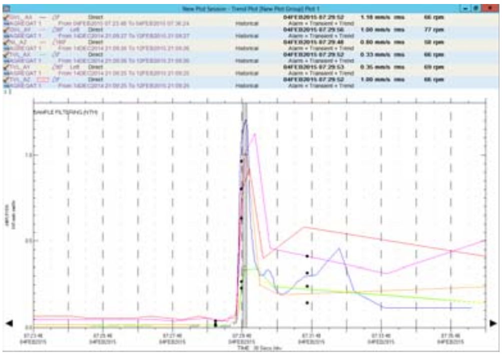

Figure 2. Analysis of the total level of vibrations at the launch of the hydroelectric power plant vibrations from bearing [11]

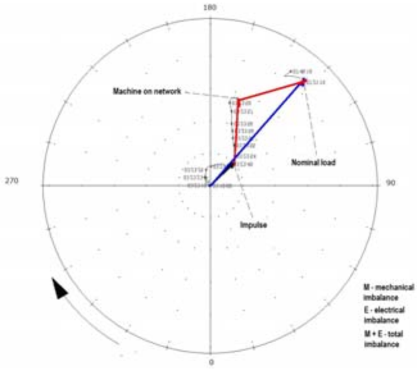

Figure 3. Trend analysis of component 1X rotor

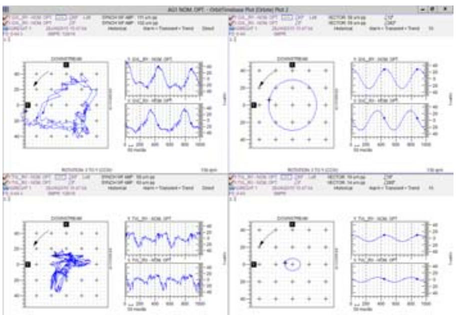

Figure 4. Analysis of the journal orbit in the bearings

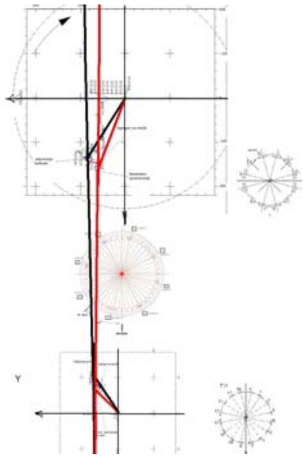

Figure 5. Analysis of the placement of the axis of the aggregate on the basis of the measurement of the journal position placement in the bearings [11]

3. VIBRATION MONITORING OF HYDRO AGREGAT HPP VRBAS

The installed vibratory-diagnostic system in HPP Bočac, COMPASS (COMputerised Predictive Analysis and Safety), is a Bruel & Kjaer computer diagnostic system (CDS) designed to monitor the mechanical condition of the hydro-aggregate and to predict potential machine errors - PFM (Potential Failure Mode monitoring).

In accordance with the measured total levels of rotor and absolute vibrations, in accordance with international standards, the condition of the HPP is assessed as acceptable for uninterrupted long-term operation. By analyzing individual vibrations, a deeper diagnostic analysis was performed.

Just some vibration views from the hydro-aggregate number 2 were shown here. They pointed to certain defects in the system. Vibration spectrum analysis shows an elevated level of vibration on the first vibration tone, 1X harmonic vibration, which is characterized as imbalance in the system, Figure 6. By subsequent analysis it could be established that this imbalance is produced by a small imbalance of the rotor of the generator and the displacement of the geometric and inertial axis of the hydro-aggregate.

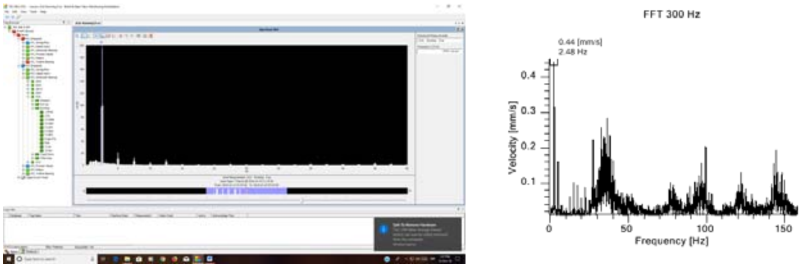

Figure 6. Rotor vibration spectra on the upper generator (left) and absolute vibrations on the bearing (right)

Also, it can be noticed that hydraulic problems are also presented, expressed as turbulence in the turbine, which is most striking at the very beginning of the machine. In Figure 7, the vibration spectrum (in the idle stroke and load) is shown where these problems are noticed.

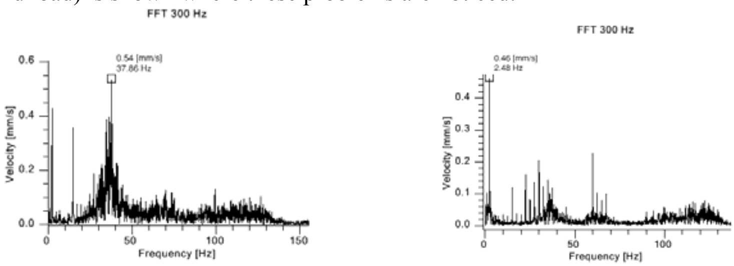

Figure 7. Vibration spectrum on idle (left) and full load hydroelectric power plant (right)

In Figure 8, the orbits or the position of the axis of the rotor are shown, where the small dynamic displacement of the axis of the hydro-aggregate is visible, which leads to the asymmetry of the magnetic field that produces additional electric force in the system, Figure 8 (right).

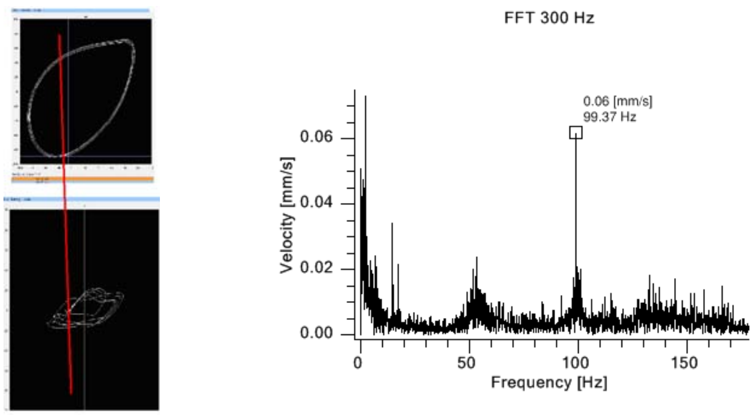

Figure 8. Position of the rotor axis of the hydro-aggregate (left) and the spectral display of absolute vibrations from the generator bearing (right)

Also, in terms of orbiting and the presence of the 2X harmonics of vibration in the spectral display, one can diagnose the clear existence of one-way forces of discrepancy that shift the axis and mainly produce this observed problem.
By diagnostic analysis of the overall condition of the hydro-aggregate it could be concluded that it works dynamically stable and that for now no destructive conditions exist which significantly affect its

exploitative readiness. The analysis was done with the aim of determining the current vibration state, as well as for the needs of further monitoring and monitoring of the state of hydroelectric power plants for the purpose of introducing maintenance of machines by condition.

4. CONCLUSION

Direct monitoring and analysis of the condition, in particular monitoring and analysis of the vibration state, provides a good insight into the exploitation state of the hydro-aggregate, and the maintenance actions are carried out when it is really necessary or based on the condition of the machine. The installed monitoring and diagnostic system in HPP Bočac proved to be a sophisticated and reliable control system. Certainly this system in some future period should be upgraded with advanced diagnostic methods with which it is possible to increase the accuracy of diagnostic methods. Such a method is based on the application of neural networks and the fuzzy logic by which multiple diagnostic parameters are integrated into one and thus increases the reliability of the entire diagnostic process, such a method of diagnosis of sliding bearings is also indicated in this paper. Also, the development of new technologies for remote monitoring of the state of machines enable the exchange of information between the two systems located in different geographical locations, which opens the possibility of greater use of telemonitoring of the machines themselves.

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