VESKi

Oreškovićeva 8j, Zagreb | Croatia | www.veski.hr

VIBRATION EXPERT SYSTEMS | CONSULTING | SYSTEM DESIGN

CoDiS protection and diagnostic system
BENEFIT EXAMPLES

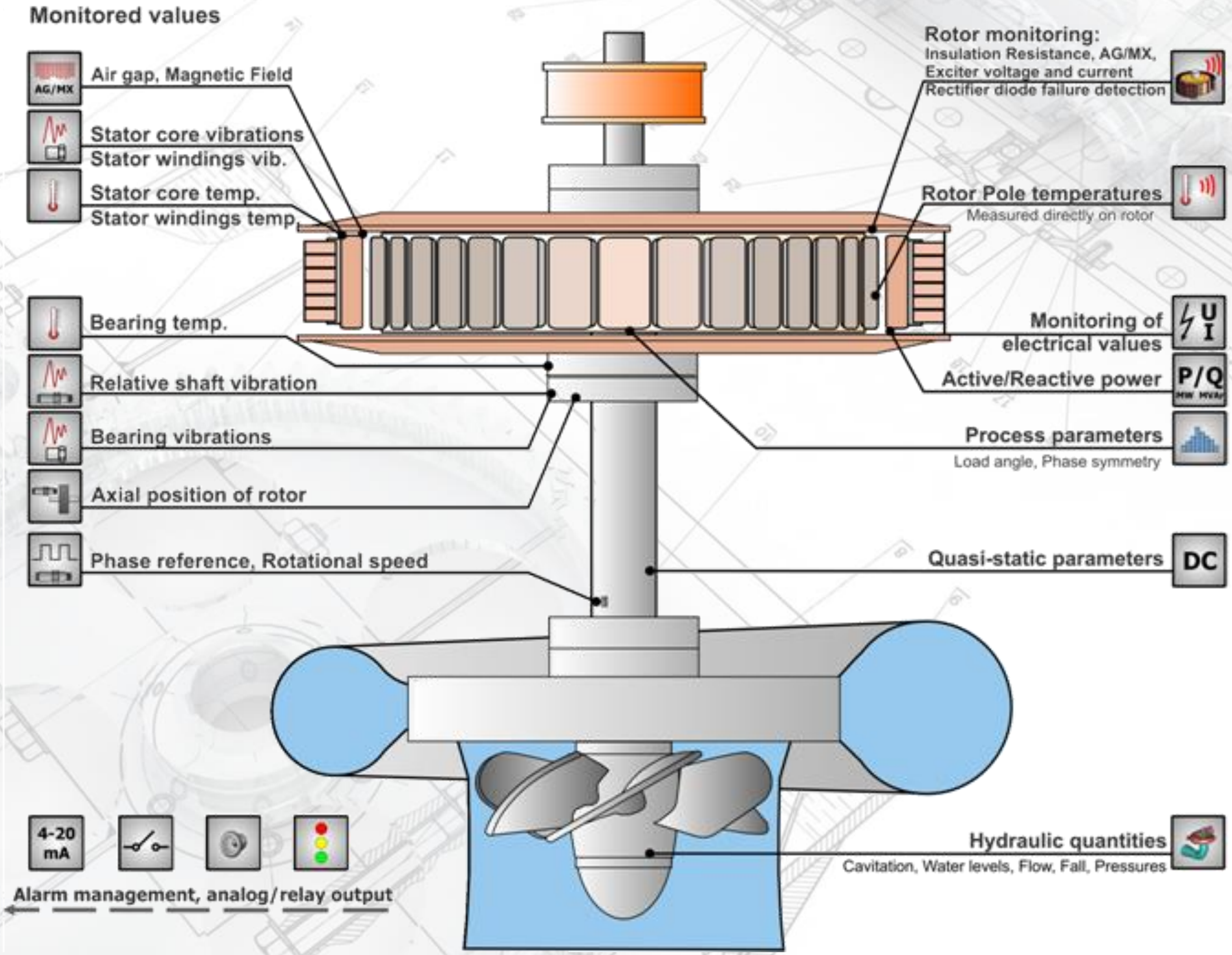
NATIONAL INSTRUMENTS Silver Alliance Partner

CoDiS Machine Condition Monitoring

Computerized Diagnostic System

Solutions only

Monitored values: CoDiS system is configured to detect faults



Fault detection– List of typical faults on hydro turbine and generator

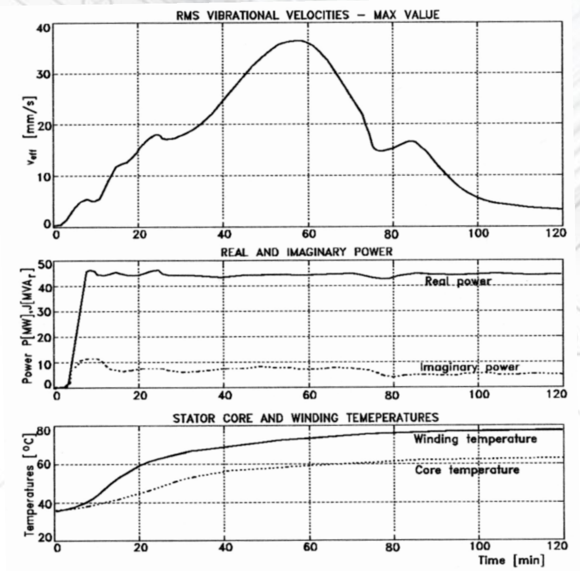
Faults	Measurement													
VESKI Fault detection and Corresponding measurements	Bearing vibrations	Relative shaft vibrations	Bearing temperatures	Turbine cover vibrations	Air gap	Magnetic field	Stator core vibrations	Stator frame vibrations	Generator temperatures	Process quantities	Cavitation	Electrical quantities	Partial discharge	Hydraulic quantities
Mechanical Unbalance	1x •	1x •												
Electrical unbalance	1x •	1x •			•	•								
Hydraulic unbalance	1x,nx •	•		•										•
Misalignment	1x, 2x •	1x, 2x •												
Eccentricity of stator and rotor		DC •			•	•								
Bearing wear	•		•											
Stator windings vibrations							100Hz 200Hz •	100Hz 200Hz •						
Insulation wear													•	
Rotor shape		•			•	•								
Overheated stator coils									•	•			•	
Phase symmetry							•	•				•		
Bearing stiffness	•	•												
Excitation problems						•						•		
Load angle detection					•	•						•		
Pressure pulsation											•			•

Data base: Data recorded to highlight some typical errors

Increased stator core vibrations – HPP /Vertical Kaplan/ 2 bearings /45 MW unit.

Problem

- High vibrations of stator core
- Vibration maximum reached at certain stator core temperature and then amplitudes reduce as the heating continues
- Temperature where maximum is achieved is becoming lower as the loosenes progrades and after few months reached the 20% of nominal



Core vibrations (upper diagram)
Active and reactive power (middle diagram)
Stator core and winding temp. (lower diagram)

Detection

- Stator core loosened after 15 years, probably due to bad assembly
- Stator core change stiffness with temperature
- Resonance of core is at 100 Hz as the core is loosened

Objective:

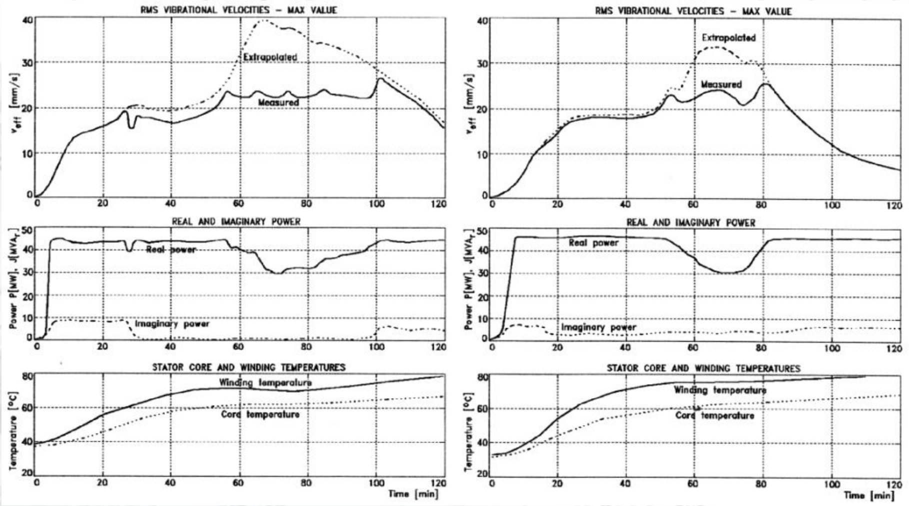
- Stator core exposure to high vibrations as short as possible

Increased stator core vibrations – HPP /Vertical Kaplan/ 2 bearings /45 MW unit.

Solution proposal

- Regulation of load level and cooling of stator using vibration feedback in order to cross over critical frequency as fast as possible and get out of resonant area

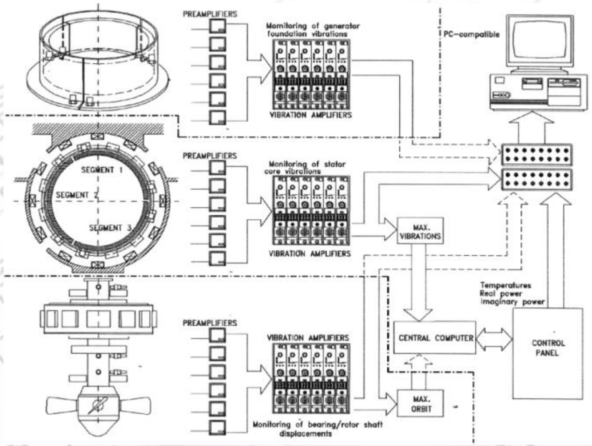
Load level regulation (measured vibration feedback) significant influence on vibration level



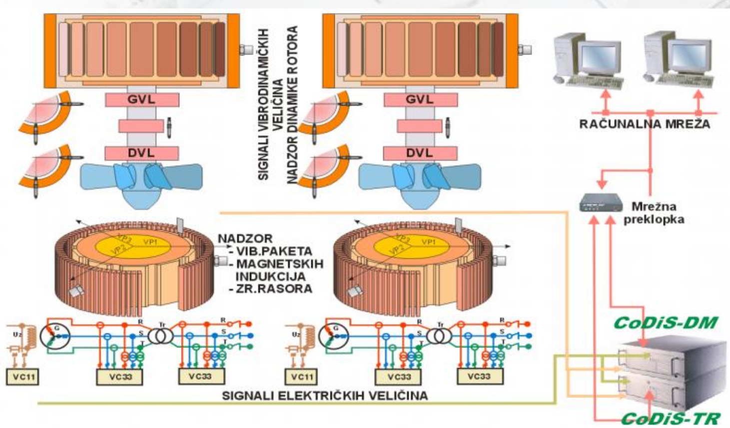
Stator cooling off
- In function of measrued vibrations
- Faster heating exposure time minimized

Increased stator core vibrations – HPP /Vertical Kaplan/ 2 bearings /45 MW unit.

Permanent solution - Dedicated stator core permanent monitoring system connected to control system (ASEA ProMaster) - **FIRST CoDiS INSTALLATION – 1993.**



2003. – System CoDiS refurbishment



BENEFITS
- system eliminated critical temperature changes
- generator was operational for following 3 years
- after three years (1996) stator core was changed due to a lightning protection failure

- total investement cost:
- expert measurements cost ~ 35,000 US$

- monitoring system 1993 costs ~ 40,000US$

- generateded energy > 350 GWh
> 9.500.000,00 US$

Quick statistical condition estimation – CoDiS-QSCE

Estimation of stationary operation conditions

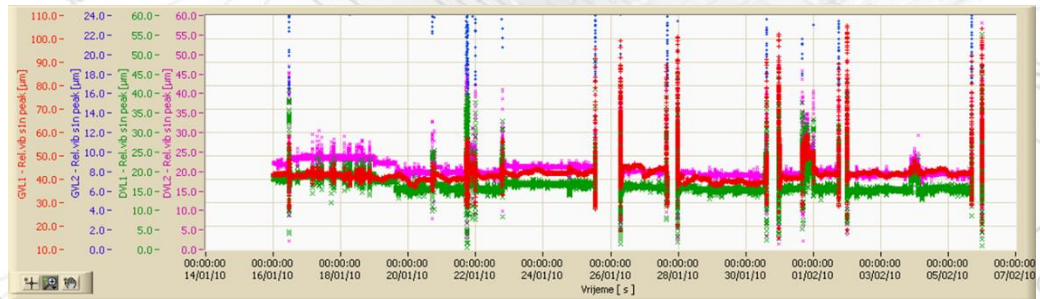
- Selecting representative period of operation (typically 1 – 2 months before and 1 – 2 months after overhaul) – evaluation of results

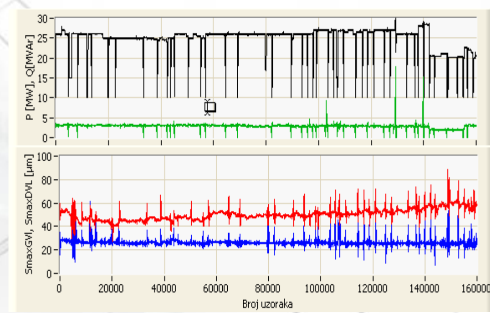
- Selecting values for analysis, significant for condition estimation (typically vibration Smax, s1n, AirGap minimum etc)

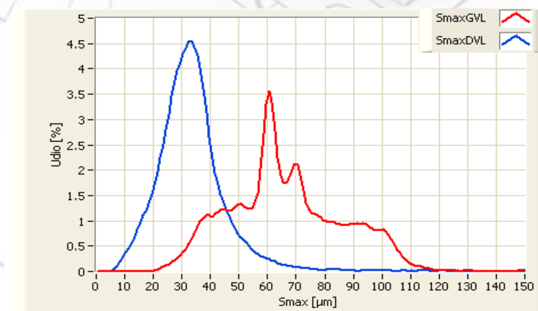
- Determining data filters (real and imaginary power levels, rotational speed, temperature etc.)

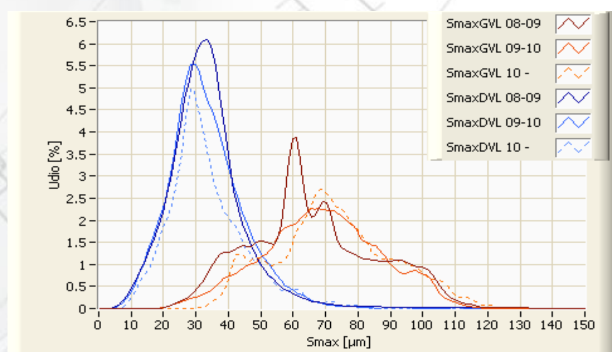
- Applying statistical data distribution analysis – histograms

- Performing histogram comparison







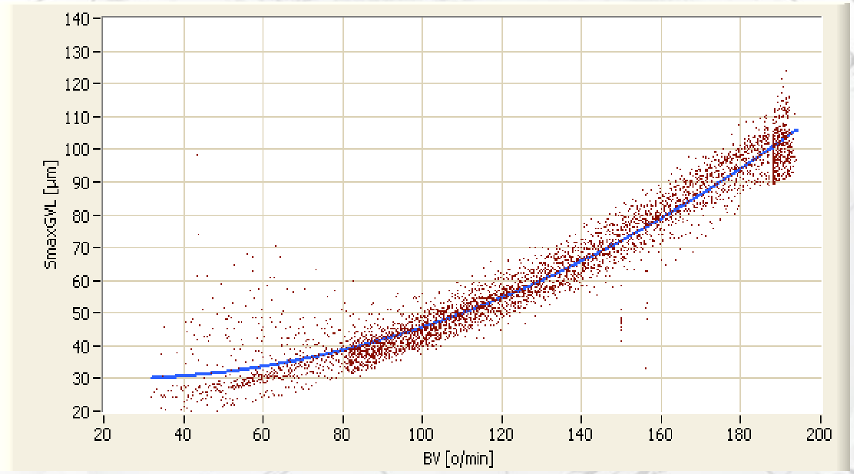


Histogram's area, x and y maximum and minimum differences are basics for condition stability estimation

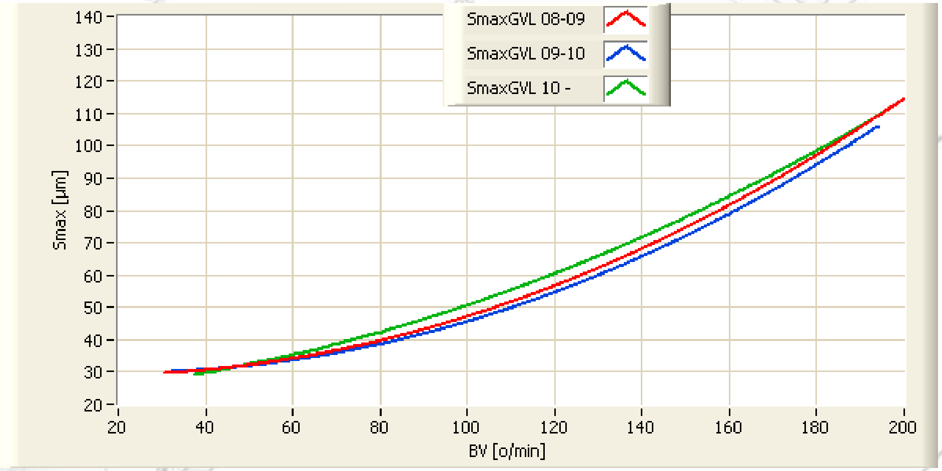
Quick statistical condition estimation module – CoDiS-QSCE

Estimation of conditions based on RunDown&StartUp data

- Behaviour repeatability during RunDown and StartUp analysis
- Selection of data significant for condition evaluation (relative and absolute vibrations – Smax, RMS, s1n amplitudes and phases)
- Data filtering – only data recorded during variable speed are submitted to analysis
- Additional to histograms regression analysis is performed
- Comparison of regression curves for various periods is performed



Smax regression analysis
(Vibration vs Rotational speed)



Regression curves comparison
(Vibration vs Rotational speed)

Quick statistical condition estimation module – CoDiS-QSCE

CoDiS-QSCE analysis results application

- applied for quick condition estimation in order to plan overhaul procedures – overhaul reduction if conditions are stable (no changes), further analysis if some fault (changes) are indicated

HPP 2x108MW – Bearing opening on condition change or every 3rd year
- overhaul reduction for ~ 15 days
- overhaul cost reduction ~ 180.000 €
- generated energy ~ 28000MWh

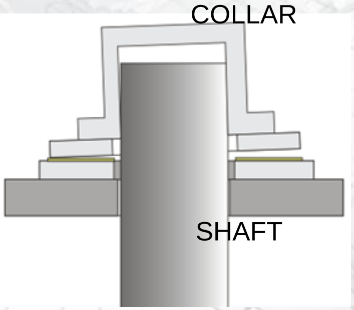
HPP 2x45 MW – Bearing opening on condition change or every 2nd year
- overhaul reduction for ~ 18 days
- overhaul cost reduction ~ 216.000 €
- generated energy ~ 8500 MWh

HPP 2x35MW – Bearing opening on condition change or every 2nd year
- overhaul reduction for ~ 15 days
- overhaul cost reduction ~ 180.000 €
- generated energy > 3000 MWh

HPP 2x 108 – Shaft alignement

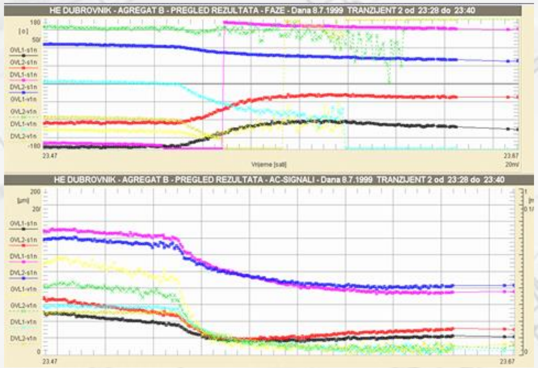
Problem

- Increased relative vibration level after overhaul measured by CoDiS system

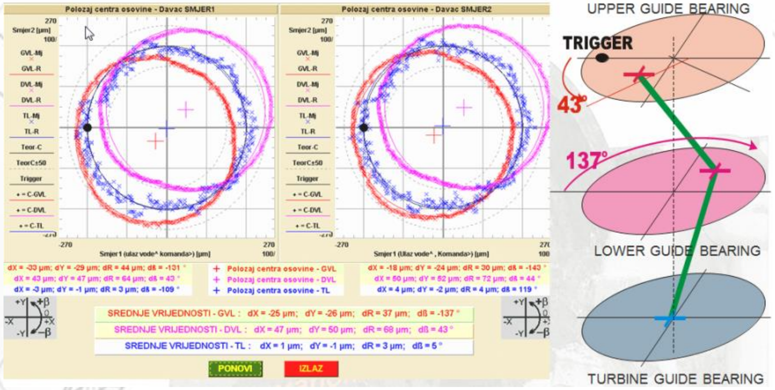


Detection

- irregular shaft centerline
- irregular shaft collar assembly on upper generator combined bearing



Run out compensation analysis



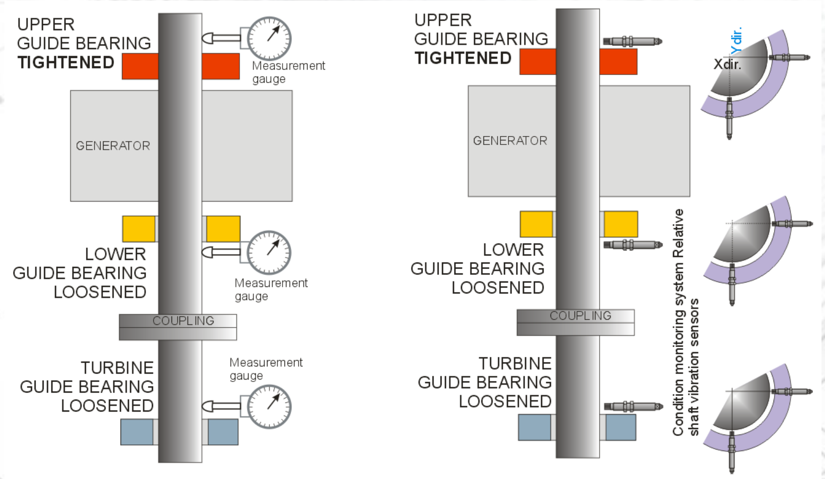
2D and 3D shaft alignement and Run-Out analysis

HPP 2x 108 – Shaft alignement

Solution

Irregular thrust collar assembly repair:
- inserting thin metal plates between thrust collar ant collar plate
- checking shaft centerline after each metal plate insertion

Traditional method
Measurement gauges



Applied - Measurement using
CoDiS sensors and modules

Result

- Reduced repair cost as OEM demanded to dismount the collar and transport 500km to the factory for repairs

Reduced downtime cost for at least 10-12 days
- 2 days for shaft centerline assembly due to automated procedure for run out detection
- 10 days for transport and repair in the factory

RESULT: Metal plates installed on site, no vibro-dynamical behaviour changes reported for 11 years of unlimited operation.

HPP 2 x50 MW, Vertica Kaplan – Turbine cover vibrations

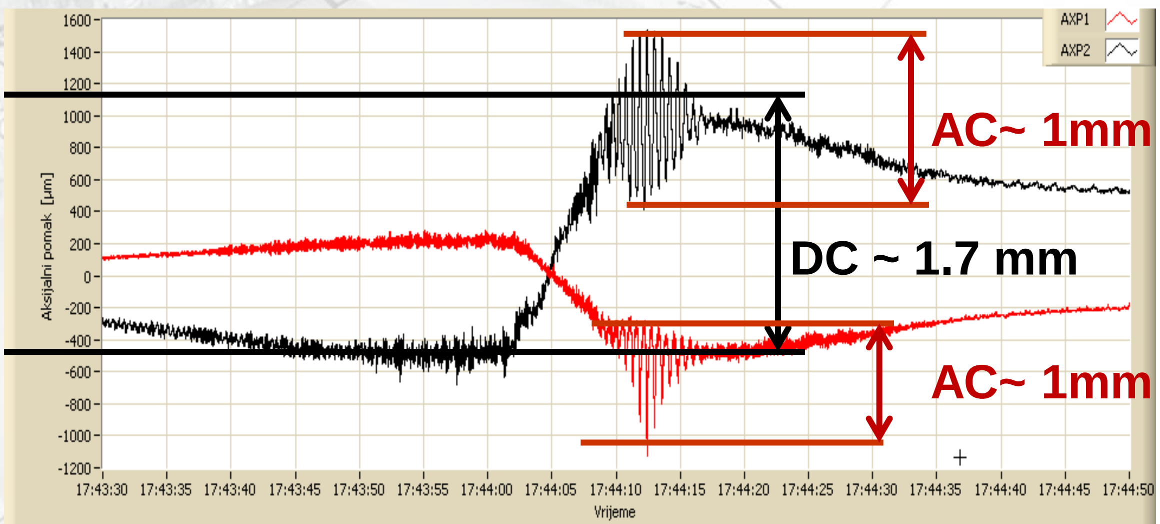
Problem

- High vibration of generator (AC) in axial direction and high statical (DC) deflection
- Unstable in operation – vibrations occur suddenly in stationary operation
- New machine was out of operation for 2 months

Detection

- Low stiffness of turbine cover

Initial state – axial displacement of rotor



Axial displacement of rotor Vs structure

Axial displacement of rotor Vs turbine cover

HPP 2 x50 MW, Vertica Kaplan – Turbine cover vibrations

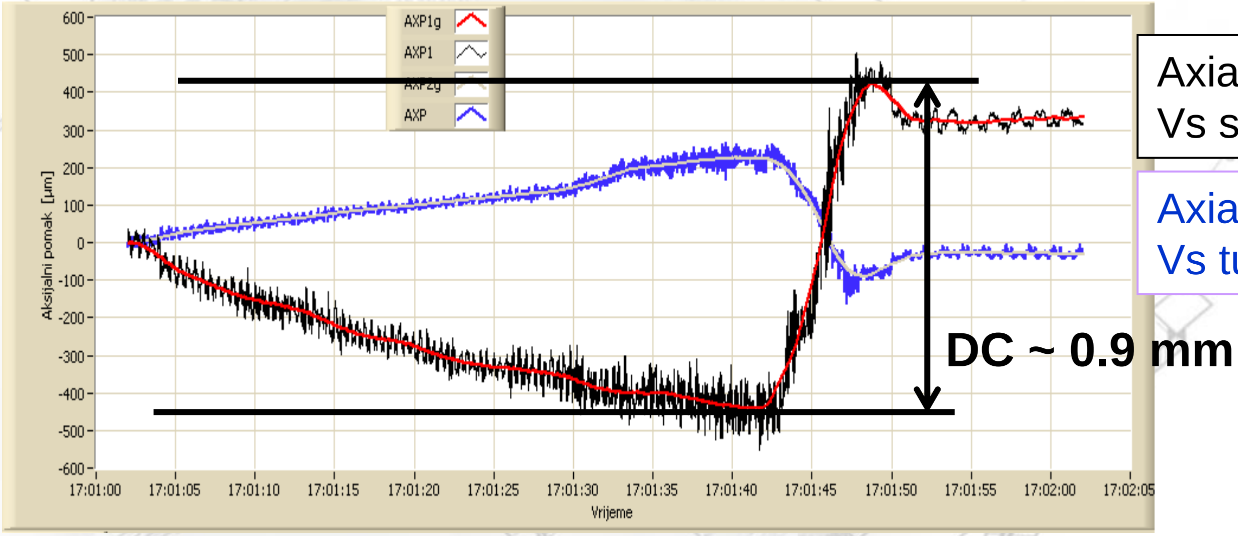
Solution

- Increase the turbine cover stiffness applying the rigid elements to the construction

Result

- Stiffness increased ~ 2 X
- Deflection reduced by ~ 2X
- No more unstable operation and AC vibrations
- **MACHINE AVAILABLE FOR OPERATION 2 WEEKS AFTER MEASUREMENTS**

After correction– axial displacement of rotor



Axial displacement of rotor Vs structure

Axial displacement of rotor Vs turbine cover

Thank you for your attention!

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Read our case study – http://sine.ni.com/cs/app/doc/p/id/cs-10016