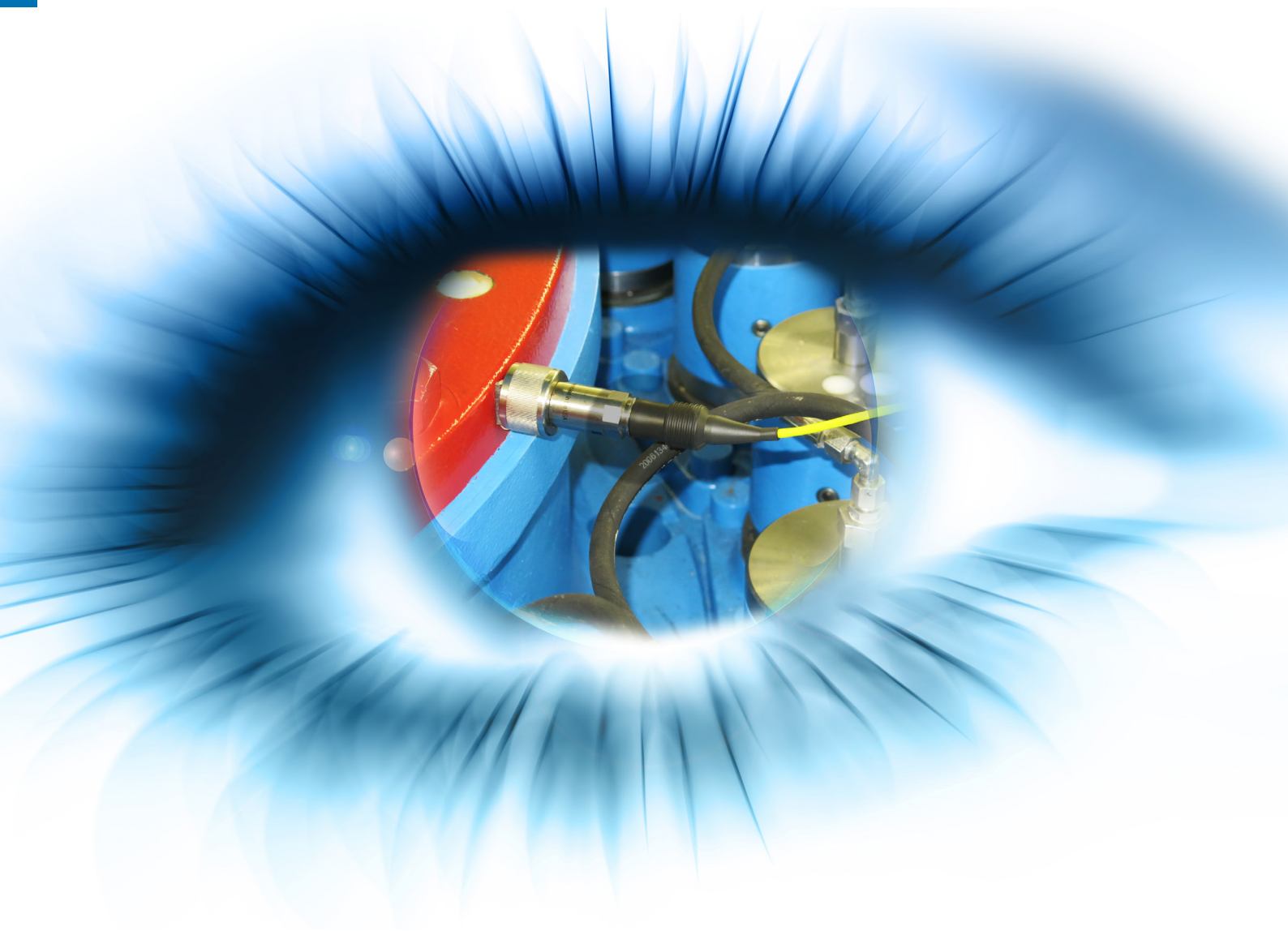
ANDRITZ Hydro

Site Measurements

Measurement – Analysis – Consulting



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ANDRITZ
Hydro
HANDY SCAN 3D

Expertise in measurement and analysis technology – a strong combination

Changing energy market dynamics require new operating concepts, more regulation, faster load changes, more frequent start-stop cycles, and even temporary overload scenarios. However, these evolving market requirements have to be met with power plants which were often originally designed for totally different demands and operational profiles.

In order to enable safe operation and minimize outages in such a challenging environment, profound knowledge of the condition of the power plant and the loading of its components is vital. ANDRITZ HYDRO gains this knowledge, which allows the operator to act on the basis of machine condition and reduces investment cost, by means of an array of available measurement methods. ANDRITZ HYDRO's know-how in the field of hydro-electro-mechanical machinery and systems, as well as its ability to execute such measurements, enables sophisticated analysis and interpretation of measurement data. This in turn allows ANDRITZ HYDRO to derive appropriate information as a means of effective maintenance, operation, and troubleshooting. All of ANDRITZ HYDRO's professional and analytical measurement engineers are specialists in related disciplines such as hydraulic layout, structural analysis, rotor dynamic analysis or the electrical layout of generators.

This combination of measurement technology know-how and an analytical background allows sustainable and comprehensive customer support, minimizing required interfaces and reducing effort. It therefore ensures a high level of reliability and safety regarding the evaluation of results.

The overall hydro-electro-mechanical comprehension and knowledge of ANDRITZ HYDRO's measurement engineers fully supports the "Three-Phase Approach" - diagnosis, analysis and therapy of hydraulic units - which for many years has been successfully applied worldwide in various service and rehabilitation projects by ANDRITZ HYDRO.

Vibration measurement

ANDRITZ HYDRO specialists conduct vibration measurements of power plants during condition assessment (fingerprint measurement), commissioning, and acceptance tests, as well as for trouble-shooting activities.

Nowadays, many hydropower units are equipped with a vibration monitoring system. This allows the analysis of signal trends with respect to unit behavior and helps optimize the planning of future rehabilitation programs.

A study based on vibration measurement of a hydraulic unit generates valuable additional information to be derived regarding transient and stationary operating points. Analytical evaluation of this data helps reveal existing issues or identify possible risks and thus avoid future problems and potential damage.

Modular data acquisition systems (up to 100 synchronous channels) enable ANDRITZ HYDRO to provide detailed evaluation of measurement data based on comprehensive instrumentation and high sampling rates with minimal expenditure. Through these systems time-frequency spectra at critical measurement points are derived and analyzed with respect to suspicious frequencies and phases. The depth of ANDRITZ HYDRO's experience in this field of application plays a decisive role in the correct interpretation of the results.

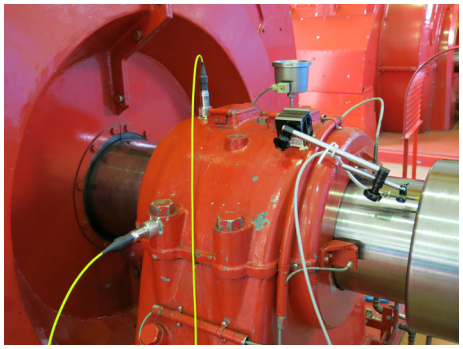
Measurements performed by ANDRITZ HYDRO are based on the DIN ISO 7919, DIN ISO 10816 and IEC 60994 standards. Furthermore, our measurement special-ists are certified according to DIN ISO 18436-2.

Measurement, diagnosis and analysis

- Comprehensive measurement of bearing and generator housing vibration, shaft vibration, pressure pulsation, and noise levels
- Assessment of overall machine behavior across the entire operating range
- Detailed measurement reports

Highlights

- Identification of critical operating points
- Root cause analysis for abnormal behavior of the unit and suggestions for improvement



Efficiency testing

For hydraulic machines the efficiency is a measure of how effectively hydraulic energy is converted into mechanical energy (turbines) or vice versa (pumps). Similarly, for electrical machines efficiency is a measure of how well mechanical energy is converted into electrical energy by a rotating generator.

Efficiency testing allows optimized operation of the power plant, a key consideration given current market requirements and energy costs. In addition, efficiency test results also enable the optimization potential of the unit to be identified with respect to a modernization or rehabilitation program. In particular, the most convenient time for service and rehabilitation of an erosion- or fouling-related decrease in efficiency can be determined.

Index efficiency testing

Index testing is an economic method of comparing efficiencies before and after rehabilitation. Instead of measuring absolute efficiencies, relative comparisons between different operating conditions are conducted. This can be achieved with relatively little effort and just a few sensors.

Besides allowing comparison of relative efficiencies, this method can also be used for optimization of double regulated units like Kaplan and Bulb machines.

In general, the index test can be used for all turbine types as a performance record.

Thermodynamic efficiency testing

Thermodynamic efficiency testing is applied to high head turbines with heads of above 100 m and serves to determine the absolute hydraulic efficiency. This method is based on the measurement of loss-induced temperature differences before and after energy conversion by the turbine.

At ANDRITZ HYDRO experienced engineers with profound knowledge of hydraulic machinery perform these efficiency tests. This in-depth comprehension of hydraulics allows optimal analysis and assessment of the turbine components and their impact on hydraulic efficiency.

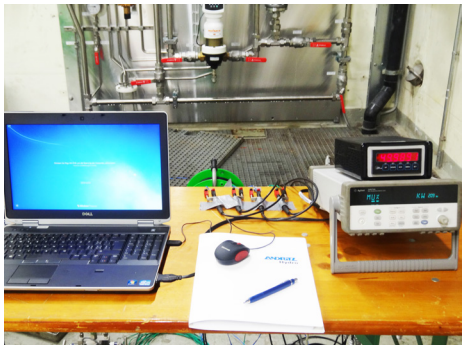
The methods used by ANDRITZ HYDRO for both the index and thermodynamic efficiency tests are specified in the internationally accredited standard IEC 60041.

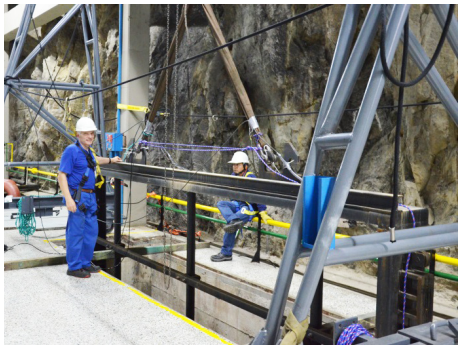
Measurement, diagnosis and analysis

- Relative and/or absolute efficiency over the defined operating range
- Identification of sub-optimal operating points
- Detailed documentation

Highlights

- Input for the evaluation of improvement potential
- Input for profitability calculations during standard operation





3D geometry measurement

Today, thanks to the development of new measurement technologies, highly effective and precise instruments are available.

ANDRITZ HYDRO has several different laser-based systems at its disposal, enabling the alignment and measurement of components within an accuracy of +/- 0.1 mm at a distance of up to 40 m.

At a time when investment funds are limited, reverse engineering of hydraulic machinery is becoming increasingly important. Turbine components can be digitally modelled based on 3D geometry measurements, optimized by means of modern simulation methods, and modified to fit the current state-of-the-art technology ideals with only moderate adaptations.

Consequently, turbine components do not have to be completely replaced and the effort and time required within the process chain is significantly reduced.

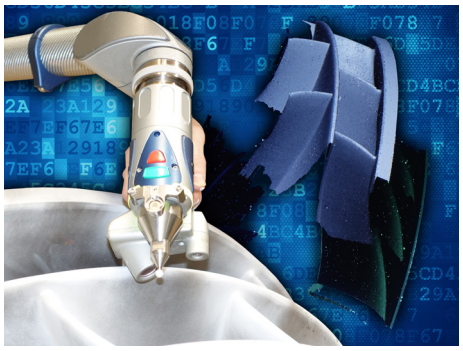
Typical examples of components suitable for reverse engineering are Pelton runners with outdated bucket geometries. Due to continuous research and development in the field of hydraulic profiles, much higher efficiencies or more robust designs are achievable. Using 3D-scanning of the existing geometry, ANDRITZ HYDRO is able to optimize hydraulic profiles with minimal effort, leading to higher efficiencies or to reductions in cavitation damage.

Measurement, diagnosis and analysis

- 3D geometry measurement of components with laser tracker, FaroArm, and surface scanner
- Definition of geometry optimization for improved efficiency
- Alignment of the unit/shaft line and possible improvements

Highlights

- Fast acquisition of the existing geometry
- Reliable basis for possible repairs and/or modernization



Strain gauge measurement

Strain gauge technology serves as a method to measure deformation of a component's surface that can be used for the calculation of local stresses. Therefore, strain gauges are applied to locations where stresses are to be evaluated. Such gauges respond to surface deformation with a change of resistance. By means of special electrical bridges, such changes of resistance can be correlated with strains, and stresses, respectively.

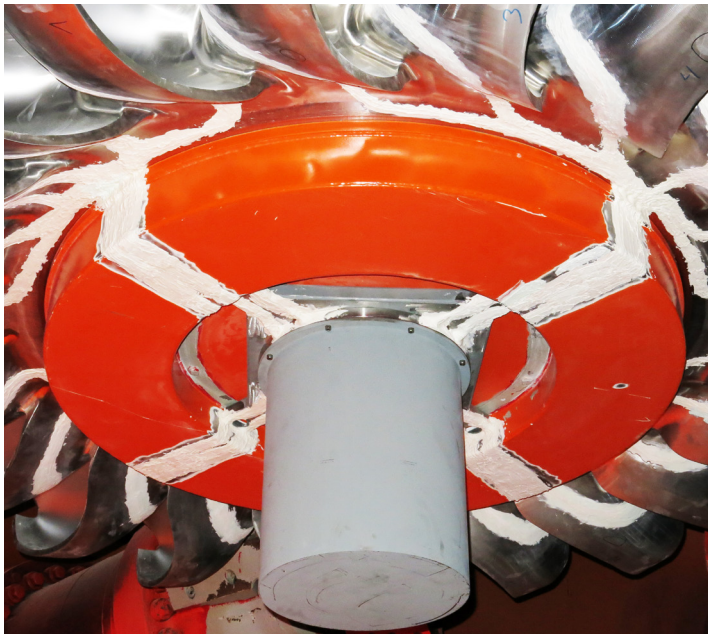
Strain gauge measurements are used by ANDRITZ HYDRO to measure static or dynamic stresses on components. These strain gauges can be applied on both stationary (e.g. housing, distributor, penstock, stator housings) and rotating (e.g. shafts, runners, pole cores) components. For measurements on rotating components both data loggers and telemetry systems are used for data acquisition. Qualities such as axial thrust, stress amplitudes on runner blades/buckets or pole fixings, or even stresses which occur during pressure testing of a Pelton distributor are measured. Accurate measurement of stresses and strains are a very important input parameter for the analysis of residual life assessment of components.

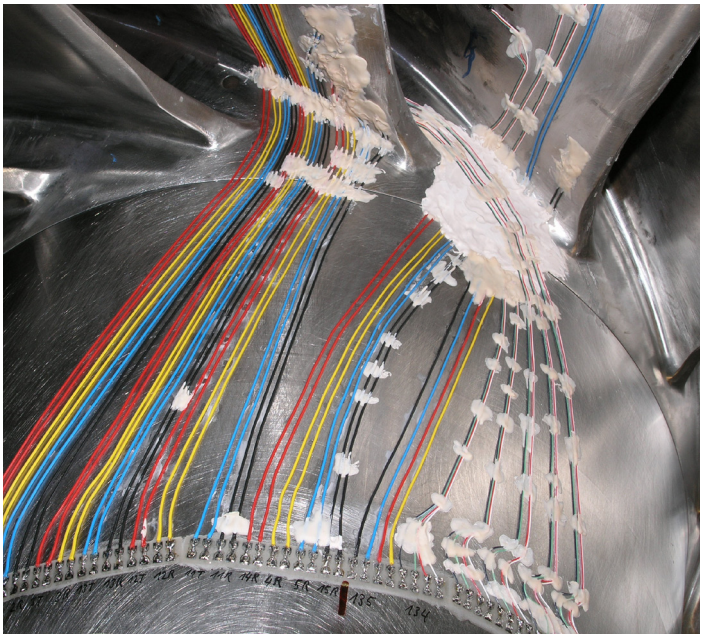
Measurement, diagnosis and analysis

- Measurement of static and dynamic stresses during operation
- Important input for finite element calculations
- Detailed documentation
- Experimental stress analysis

Highlights

- Effective stress analysis
- Input for the residual lifetime analysis of components





Winding diagnosis

A condition-based, rather than scheduled, maintenance strategy is the modern creed. New operating concepts suitable for modern market requirements demand more frequent regulation, faster load changes, more start-stop cycles, and even temporary overloads. In such a challenging operating environment, detailed knowledge of the current condition of the units, as well as their loading, is crucial in order to enable safe operation and minimize outage times.

ANDRITZ HYDRO's winding diagnosis provides the plant operator with the necessary information to plan the optimized operation of the unit, as well as its timely maintenance. Regular execution of winding diagnoses allows insight into the aging process. The findings and resulting forecasts help prevent the power plant from severe damage, larger repair works and unplanned production downtimes.

The specific assessment of the complete unit enables the plant operator to define and improve the maintenance plan. Forward-looking investment decisions can thus be made and the lifetime of the unit can be prolonged.

Following data analysis, the corresponding maintenance and repair works are planned and defined in consultation with the customer.

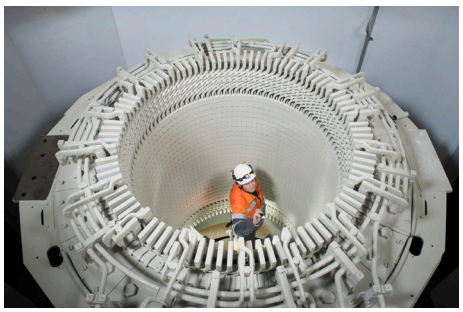
Depending on the requirements, standardized diagnosis packages are available, which can not only be customized as needed but may also be combined with customer-specific measurements.

Measurement, diagnosis and analysis

- Electrical measurements and tests, as well as visual inspection, depending on the accessibility of the corresponding components
- Analysis of measurements, comparison with empirical values from units of similar design
- Action plan with consideration of strategic importance and operational mode of the unit

Highlights

- Diagnosis report, including indication of the status of the unit
- Trend analysis with respect to the aging of the windings



Thermo-diagnosis of generators

Windage losses account for a considerable proportion of the total losses from a generator. With more modern approaches a significant reduction in these windage losses is possible through minimal measures.

ANDRITZ HYDRO uses calculation methods and thermo-diagnosis to identify windage losses. Thermo-diagnosis is a comprehensive measurement of ventilation and temperature distribution within a generator. It can be a part of a general diagnosis or performed prior to a planned modernization or rehabilitation program. The measurement is executed on the unit operating under full load. It yields a detailed overview of the actual temperatures and the distribution of cooling air within the generator, possible alarm and shut down values, as well as the possible potential available from optimization. Based on the measurement results of the thermo-diagnosis, electromagnetic calculations allow improvement potentials to be precisely evaluated.

By means of this measurement, hot spots can also be detected which may accelerate the aging process in the long run and which are not registered by standard temperature monitoring systems.

Measurement

State-of-the-art pressure and temperature sensors are used for thermo-diagnosis. In addition, by using an infrared camera ANDRITZ HYDRO provides the opportunity to visualize the temperature distribution and any hot spots.

Thermo-diagnosis measurement requires the machine to be thermally stable. This is typically achieved after about four to eight hours of operation. Hence, very little effort is needed for such an important measurement to be conducted.

Results

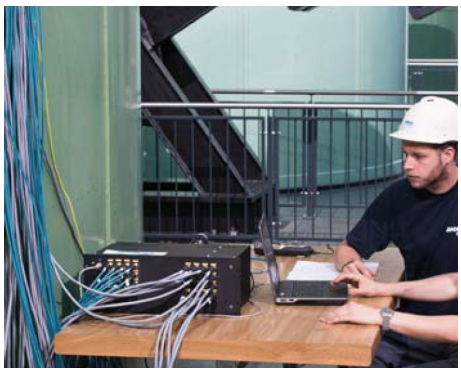
The results show possible potentials with respect to reducing losses or aging effects and indicate by which (mostly minor) means these potentials may be achieved. At the same time, these measurement results yield information regarding possible power increases.

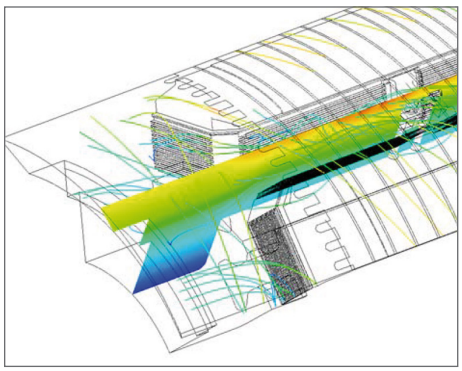
Measurement, diagnosis and analysis

- Comprehensive measurement of pressure, temperature and flow rate
- Best possible basis for site assessment of the generator or definition of optimization potential or preparation for rehabilitation
- Detailed documentation
- Presentation and discussion of results

Highlights

- Identification of critical locations and/or hot spots
- Definition of measures for reduction of losses through future generator rehabilitation





Special measurements / project examples

Axial thrust measurement

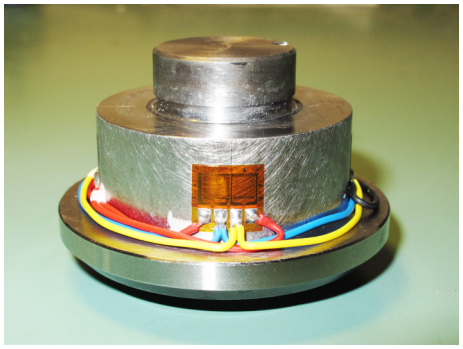
The thrust bearing of hydraulic units must withstand the hydraulic axial thrust, which is the result of all axial forces acting on the runners of pumps or turbines. For vertical units, the mass of the whole shaft line also has to be added to the hydraulic forces.

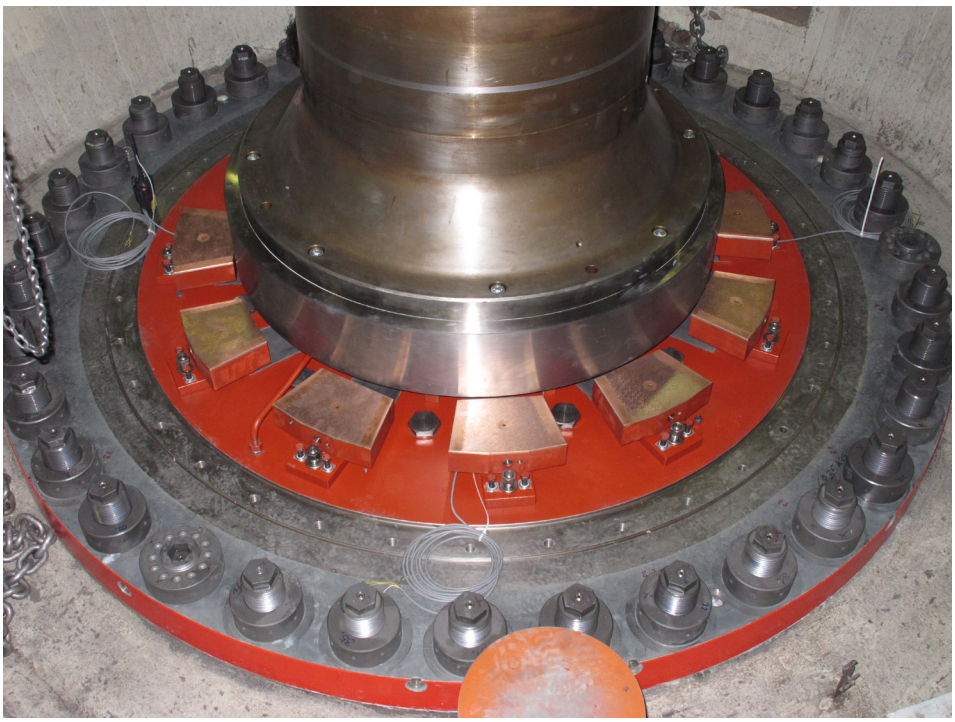
There are different methods of gauging axial thrust. A well-proven and very accurate method is measurement with strain gauges, either applied directly to the shaft or on the thrust bearing. ANDRITZ HYDRO's measurement engineers provide tailor-made measurement solutions - from single measurements using temporary sensors to permanent monitoring using specifically-built sensors.

Foundation stiffness measurement

Analysis of foundation stiffness plays a central role in the course of a rehabilitation project as it is an important input for dynamic analysis of the rotor shaft line.

During foundation stiffness measurement the foundation or individual components are excited by an imbalance. Through the measurement of this excitation and the response in the foundation components, the transfer function is evaluated. This serves as a basis for calculation of the foundation stiffness. For new power plants in particular, but also for rehabilitation programs, this measurement provides an important input for the dynamic analysis of the rotor. Measurement of the natural frequencies of the foundation is also possible using this method.





Experimental modal analysis

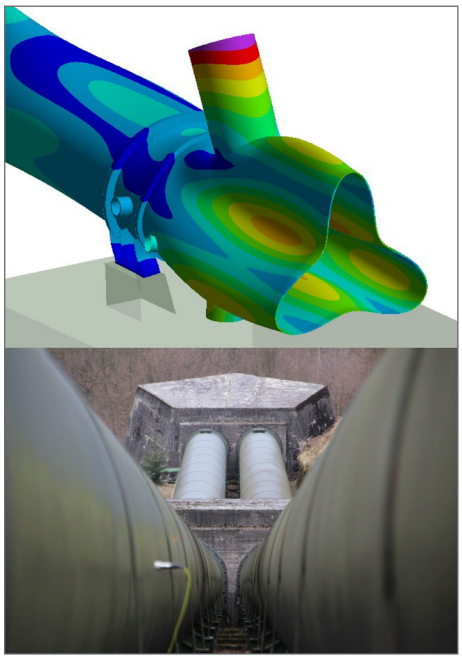
Due to the complex interdependencies within a hydro-electromechanical system, unexpected vibrations at unpredictable locations may occur. Experimental modal analysis helps identify these vibration modes, facilitating further assessment - such as numerical modal analysis - in order to develop improvement measures and proposals for solutions.

Using this method has enabled numerous vibration problems to be solved. A very successful example is seen in vibration measurement and simulation of the penstock of the hydropower plant Waldeck 2 in Germany.

Natural torsion and bending frequency measurement

Continuous advancements in manufacturing technology is allowing the production of lighter and thinner components which enhance hydraulic efficiency. This trend of reducing component weight - and thus changes in the mass and moment of inertia of rotating parts - results in a change in the critical speeds. This phenomenon may be simulated through dynamic analysis of the rotor.

The natural torsion and bending frequencies can be measured in order to calibrate these calculations. Several measurement methods are available to ANDRITZ HYDRO for the measurement of these geometry-related natural frequencies.



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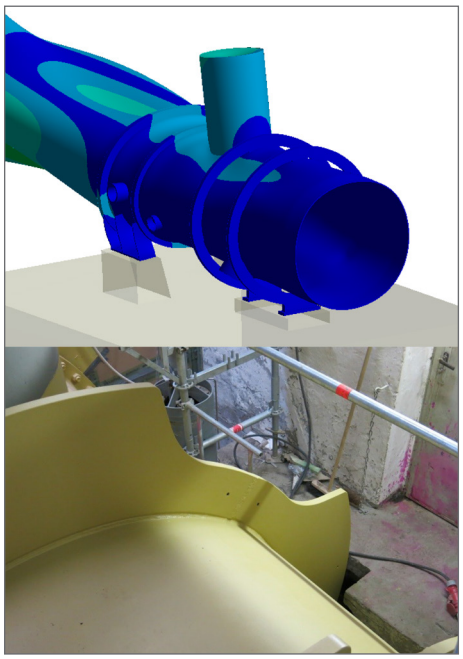

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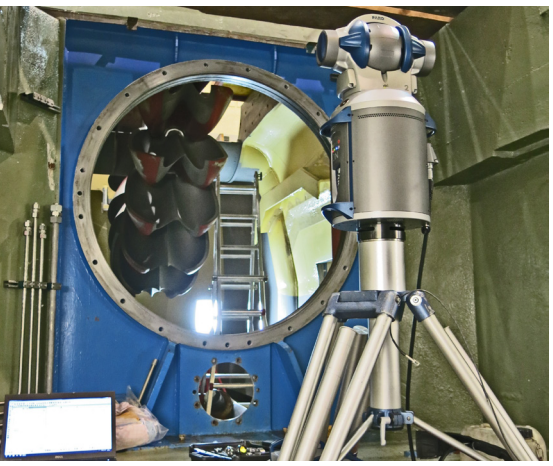
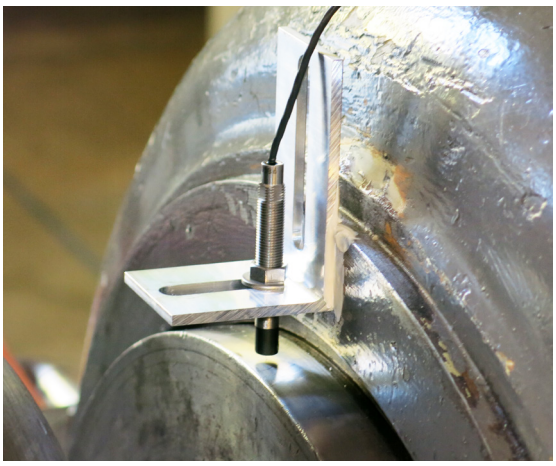



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