



HydroNet

Modern Methodologies for the Design, Manufacturing and Operation of Pumped Storage Power Plants

Co-financed by CCEM and swisselectric research

Scope of project

Electricity production in Switzerland relies heavily on hydro power plants, which face new challenges due to the strong increase in short-term energy trading.

Modern power plants are expected to operate at variable speed in a wider range of output power with improved efficiency, flexibility and safety. To address these challenging issues, our network aims to converge towards a consistent standardized methodology for design, manufacturing, operation, monitoring and control of pumped storage power plants in order to give new impulsions in the hydropower technology.

The focus is put on operation and maintenance with respect of the new economic environment. Besides the generation units, civil engineering and sedimentation issues as well as economical aspects are considered.

Goals and activities

Modeling and simulation of rotor stator interaction in pump turbines

In this task, we started the preparation of the experimental setup for the flow velocity survey in the Hydrodyna pump turbine model. The Laser Doppler velocimeter has been upgraded and tested in the high speed cavitation tunnel at LMH/EPFL. A new plain runner has been manufactured with glass windows to allow access for the laser beams to the rotor stator interaction zone.

The measurement campaign starting mid February 2008 covered different operating conditions in pumping mode.

Prediction of flow instabilities taking into account the hydro acoustic

A new test rig specifically designed to investigate hydro acoustic phenomena is underway. Hydrodynamic instabilities are produced by a flow past a semi cylinder. A set of piezo resistive pressure sensors will be installed all along the circuit to allow for pressure waves monitoring. At the same time, numerical simulation of the



Reservoirs of a Pumped Storage Power Plant

flow taking into account hydro acoustics is also underway, using EPFL Simsen software.

Fluid structure interaction in pump turbines

We have investigated the instrumentation for the measurement of dynamic forces acting on a hydrofoil in the LMH high speed cavitation tunnel. An existing 5 components balance, initially designed for the measurement of static forces was modified to allow for dynamic forces measurements. A new conditioning electronic has been made and successfully tested. Preliminary measurements on a 2D hydrofoil revealed a complex behaviour of the measurement device.

Main Investigator
Mohamed Farhat, EPFL

Project Partners
EPFL
Empa
Eawag
HSLU/HTAL

Numerical simulation of rotating stall in pump turbines

To prepare the numerical simulation of the flow field in the pump turbine, the following steps were made:

- Grid generation of pump turbine completed (full 3D with spiral casing, moving guide vanes, 360 deg. runner, draft tube).
- Tools for transient analysis of data (energy and momentum fluxes in individual channels, force and torque on elements) have been developed.
- Validation of simulations in steady operating point in pump and turbine mode has been successfully accomplished.
- Transient simulations at runaway are in progress.
- The pump turbine has been delivered to the HSLU.

Non intrusive monitoring of pumped storage power plants

In a meeting at KWO Oberhasli with the Grimsel owner the possibility to instrument their power plant for remote monitoring purposes was investigated. A specification of desired measurement locations was presented and discussed. KWO has agreed to give access to the power plant together with technical assistance.

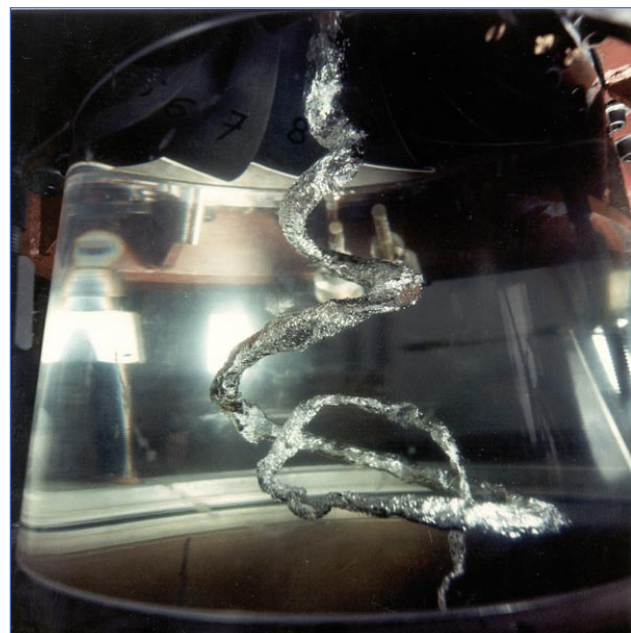
Control of variable speed pumped storage units

The following steps were achieved:

- Literature review
- Investigation of two control strategies of a pump turbine in generating mode and one control strategy in pumping mode.
- Development of a method for identification of optimal surface of speed and opening with respect to the machine efficiency.
- The control strategies are being applied in a real case study (Muju power plant) for validation.

Pressurized shafts and tunnels, prediction methods for sedimentation in pumped storage plants and downstream ecological effect of particles

These tasks have just started with a literature review.



Vortex rope at a Francis turbine outlet.



Instrumented pump turbine runner.