Hydro-Clone

Innovative Real-Time Simulation Monitoring System for Hydro Power Plant Transient Survey

Real-Time Simulation Monitoring (RTSM)
Ahead of Time Simulation Monitoring (ATSM)
Detection of Hydraulic / Electrical Anomalies
Anticipation of Power Plant Damages
Hydro-Clone

User-friendly interface

Hydro-Clone PC Simulation, Acquisition, Data processing

Data (Modbus)

f_{sample}=10Hz

Power plant PLC

Real-time measure/simulation comparison

based on existing measurements - no additional sensor required -

Alarm system

Type 1: Exceedance of the admissible limit of a measured quantity

Type 2: Exceedance of the admissible limit of a non-measurable quantity:
  - Minimum or maximum pressure throughout the penstock or the headrace/tailrace tunnels
  - Discharge throughout the system
  - Extreme torque in the coupling shaft
  - Extreme current or voltage in electrical system

Type 3: Divergence measurements/simulations:
  - Unexpected gate or valve closures
  - Unexpected air admission from air-valves
  - Flow obstruction by external body
  - Head loss increase
  - Water column separation
  - Conduit breakdown
  - Surge tank sediment deposit
  - Electrical fault
Hydro-Clone – Real Time Simulation Monitoring System

• A calibrated SIMSEN model of the HPP, operated in Real-Time and using in-situ measured boundary conditions including:
  - Hydraulic circuit: galleries, surge tanks, valves, pressure shaft, pumps and turbines (Pelton, Francis, Pump-Turbine, Kaplan)
  - Mechanical inertia and coupling shaft
  - Electrical system: motor-generator, transformer, circuit breakers, transmission lines
• A real-time monitoring system performing the following tasks:
  - Real-Time acquisition and transfer of in-situ measured boundary conditions and quantities to the digital clone
  - Data processing and diagnosis of the power plant health
  - Provide pre-defined appropriate alarms based on both real-time (RTSM) and ahead-of-time (ATSM) analysis
  - Communication with archival storage system
• A tailor-made archival storage and related database system enabling:
  - To archive simulated and measured quantities
  - To display and analyse previous results
  - To log alarms
  - To update and enhance the clone functioning

Features

Purposes

• Real-time Water Hammer/Surge Tank/Unit transient Survey
• Detection of abnormal pressure transients prior to reach admissible limit:
  - Significant deviation between measurement and simulation
  - Identification of unappropriated sequence settings
  - Identification of possible hydroacoustic resonances
• Detection of anomalies:
  - Air admission
  - Unexpected valve closure
  - Flow obstruction by external body
  - Water column separation
  - Transducer failure/dysfunction
• Monitoring of non-measurable quantities:
  - Pressure and discharge in headrace/tailrace tunnels
  - Pressure and discharge along the penstock
  - Torque, current and voltages
• Deviation of hydropower physical characteristics:
  - Head losses increase
  - Turbine/generator efficiency drop
  - Closing law drift
• Ahead-of-time projections of the state of the system (Decision Support tool, Alert Awareness, what-if...?)
• Anticipation of potential power plant damage:
  - Fatigue evaluation
  - Buckling risk

European Patent application EP 2 801 879 B1, “Hydroelectric power plant real-time monitoring system and method”
Simulation of a hydro plant by ‘cloning’ makes it possible to detect undesirable phenomena, such as penstock or gallery overpressures, head loss increases, decreases in efficiency, surge tank limits, start-up and shut-down issues, unexpected cavitation and possible water column separations, air intake, and unwanted valve closures. Furthermore, a digital clone is able to minimize the risk of potential imminent harmful behaviour of the plant, by generating so-called ‘ahead-of-time simulation monitoring’ (ATSM) alarms, based on a series of instantaneous simulations of any potential near-future behaviour of the plant. By combining RTSM and ATSM in real-time the Hydro-Clone system constitutes indubitably a valuable numerical asset for hydro plant owners to improve powerplant safety.