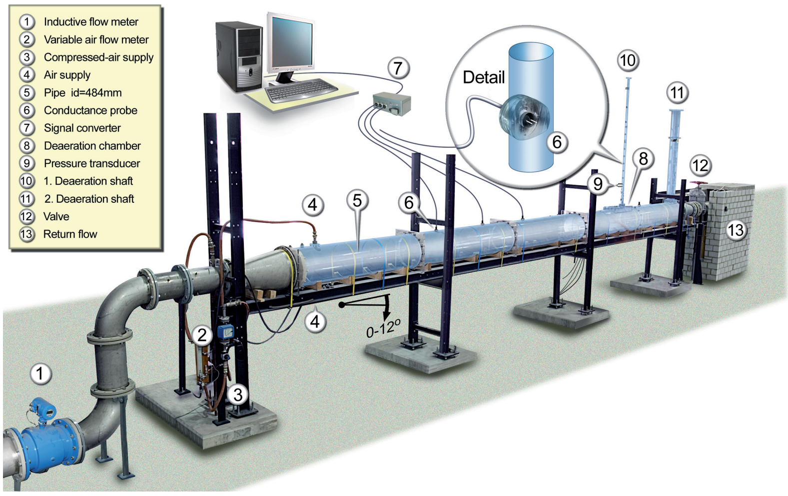
# Phd - De-Aeration of large Conduits (2008)

Air in the pressure system of hydropower plants may have negative effects on their operation and energy production as well as on the structure itself. These negative effects include an increase of the friction pressure drop, pressure fluctuations and high pressure pulses. Furthermore, the trapped air results in a reduction of the efficiency of turbines and pumps. For this reason hydropower plants are designed so that no air is entrained into the system. Nevertheless this cannot completely be achieved in practice, either due to design limitations or construction costs. This problem appears to be increasing in the future because of the rising demand of energy and a more flexible operation, in terms of peak power production.




main experimental setup

The air can be evacuated from the pressure system by means of structural deaeration device. These consist of a deaeration chamber at the ridge of the tunnel, separating the air from the water and a pipe or drill hole on top of the chamber, evacuating the air. The experience of the last years showed that there is a lack in specific knowledge of air-water flow in pressure tunnels, in deaeration chambers and in deaeration pipes for the design of such deaeration devices. This thesis intends to close this gap and to develop design guidelines for structural deaeration device.

To carry out large scale model tests, two experimental rigs were built at the Laboratory of Hydraulics, Hydrology and Glaciology (VAW) at ETH Zurich. These allowed the investigation of the air-water flow in horizontal and downwardly inclined large conduits (D = 0.484 m), in deaeration chambers as well as in standpipes.

The flow pattern of the air-water flow in conduits mainly depends on the flow rate of the two phases and the inclination angle of the pipe. For each investigated air- and water flow rate and inclination angle of the conduit a different bubble size distribution are observed. In downwardly inclined pressure pipes air bubbles are either transported downstream with the water flow or ascent in opposite direction. With downward slopes from 0.4 to 1.7 %, up to a critical water velocity in the conduit, all air bubbles rise in opposite direction to the water flow. With increasing water velocities a portion of air is transported with the water flow. For each inclination angle and water velocity there exists a limit value for the volume flow rate of the transported air. Due to the research findings, the direction and the flow rate of the air can be evaluated.

The air-water flow pattern in the deaeration chamber was investigated and the percentage of the deaerated air was measured depending on its size and the air- and water flow rate. Based on the percentage of the deaerated air the dimensions of the deaeration chamber were found for witch the transported air in the conduit is completely evacuated.

Depending on the air flow rate, the pipe diameter and the way the air is entering the deaeration pipe the flow pattern in the deaeration pipe was observed and the average void fraction was measured. The observed flow pattern are in good agreement with those stated in the technical literature. The drift-flux model allows the calculation of the average and maximum two-phase mixture level swell. Because of the limited water column height in the experimental rig, the level swell for large initial water column heights had to be determined by simulation. The results of the measurements and simulation show that the two-phase mixture level swell is up to three times the initial water column height.

Based on the findings design guidelines for deaeration devices were developed and are illustrated with three examples.

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