PhD - Vortex induced air entrainment rate into pressure systems of HPP

Air in pressure systems of hydroelectric power plants (HPP) has in general negative consequences such as reductions in turbine efficiency and flow rate, pulsations and pressure surges. Vortices at intakes are a major source of air entrainment, requiring significant reserves during planning and operation of hydroelectric power plants to avoid intake vortices. Knowing the air entrainment rate and quantifying the resulting potential damages allow the design of counter-measures such as de-aeration systems, thereby improving the efficiency of a hydroelectric power plant, especially with regard to storage management.

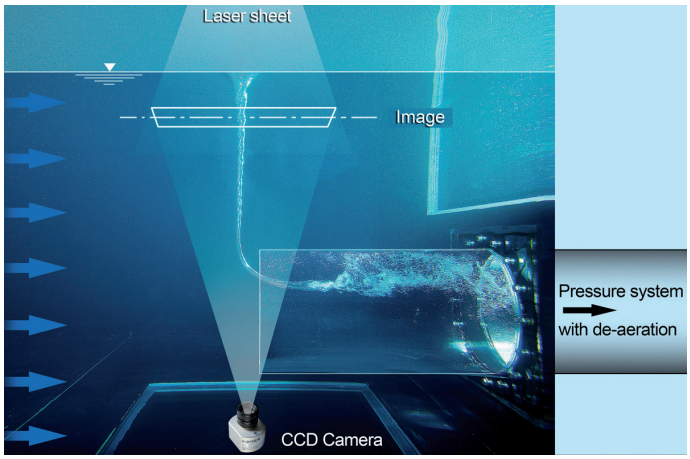

Fig.1: Experimental run in the physical model with air-entraining vortex. A deaeration device will allow to measure the vortex-entrained air.

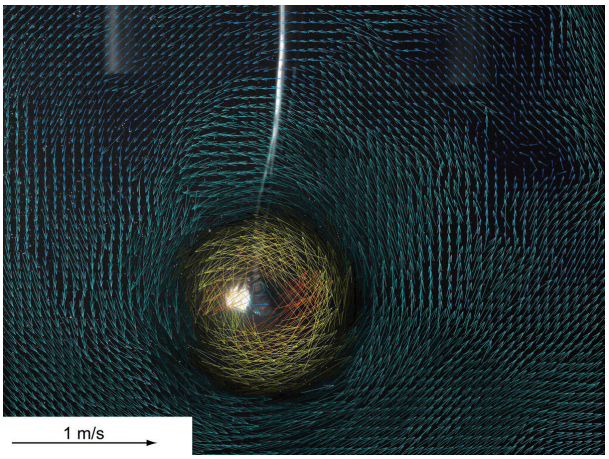

Fig.2: Detail of the horizontal velocity field with location of the full air core vortex in the background.

Large-scale physical model tests are conducted in a 50 m^3 laboratory tank at VAW to study air entraining vortices for discharges up to 500 l/s. The model allows to comply with the generally accepted limits regarding similitude criteria of intake vortex investigations.

Fig. 1 shows a typical experiment. The horizontal velocity field around the vortex is measured by means of 2D Particle Image Velocimetry (PIV) on a total area of up to 1 m^2. For this test run, the visually estimated air entrainment rate is significantly higher than expected. A de-aeration device to measure the vortex-entrained air is currently being adapted.

Fig. 2 illustrates a typical horizontal velocity field around the vortex. The essential parameters regarding vortex induced air entrainment are systematically varied and analyzed in the experiments. The aim of the project is to bridge the relevant gaps in knowledge and in practical design basis of intake structures and to improve the operation of hydroelectric power plants.

Keywords:	air ingestion/entrainment, hydropower intake, particle image velocimetry (PIV), critical submergence, turbine efficiency, pulsations, vortex, vortices
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