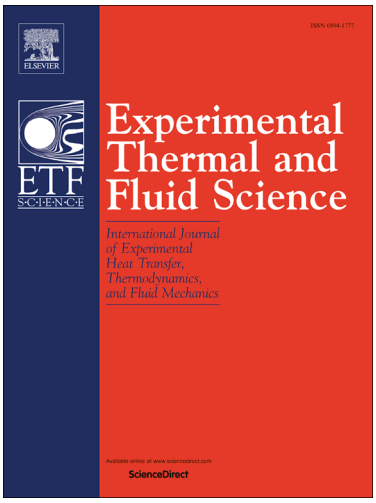

Unsteady regimes and pressure pulsations in draft tube of a model hydro turbine in a range of off-design conditions

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Unsteady regimes and pressure pulsations in draft tube of a model hydro turbine in a range of off-design conditions

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Abstract. We report on experimental study of flow and pressure pulsations in draft-tube of a laboratory air model of Francis-99 hydro-turbine operating over a broad range of regimes employing a rapid prototyping of the swirl generators and computerized measurements. In total, 867 operating regimes were examined corresponding to different combinations of the runner rotation speed and flowrates. The velocity measured by a computer-automated laser-Doppler anemometer and the pressure recording by wall-mounted acoustic sensors for a selection of operating conditions reveal a variety of patterns of the flow and vortex structures, with clearly identifiable regimes with the maximum coherent flow pulsations at non-optimal operating conditions. The regimes with distinct precessing vortex cores show notable rearrangement of the velocity and vorticity fields, accompanied by a sharp increase in the amplitude of the coherent pressure pulsations, as also confirmed by the peak cross-correlation of the spectra of pressures signals from two diametrally placed wall-mounted microphones. The paper closes with a scrutiny of the swirl number, its distribution and the relation of zero-swirl with the isogonal best-efficiency loci in a broad range of operating conditions. For the nominal best efficiency regime, the integral swirl number appears to have a small positive value of about S=0.15, but the tangential velocity distribution reveals two concentric counter-rotating cylindrical rod-like streams with a negative swirl (relative to the runner rotation direction) in the inner region and positive in the outer. In the regimes with the PVC formation, as illustrated for the maximum pressure pulsations regime at S>0.5, the axial velocity appears to be almost stagnant in the core (though positive apart from the cowl wake), the flow being pushed into the peripheral annular region.

Key Words: hydro turbine draft tubes, precessing vortex core, PVC, automated LDA, rapid prototyping.

1 Introduction

Large hydropower plants (HPP), together with fossil and nuclear plants are commonly entrusted with the base electricity production and operate usually at or close to the optimum design load conditions, when they perform with high efficiency and reliability. However, increasing world-wide