Interpolation of experimental data at hydro turbine draft tube inlets – a study of sensitivity to incomplete data

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Experimental data is frequently used for validation of CFD. Modern experimental techniques, such as LDV, PIV, and high-frequency piezo-electric pressure transducers, provide very accurate representations of the velocity and pressure distributions both in time and space. However, given that the experimentalist has taken all actions to provide the most accurate results, the techniques still suffer from limitations. A major limitation is that it is not possible to get complete information about the flow in the entire domain, or not even at a cross-section. It is thus often difficult to have full control under which conditions the experiments are conducted at.

When doing numerical investigations using CFD, only a small part of the flow is modeled, and cross-sections are chosen for inlets and outlets of the computational domain. In order to be able to use experimental investigations for validation of the numerical results, it is important that exactly the same case is studied both experimentally and numerically. Thus, the boundary conditions of the numerical simulation must be exactly the same as the flow at the same locations in the experimental investigation. Due to the limitations of the experimental techniques, sufficient boundary data is however not available. Therefore, it is still questionable if the differences seen in the validation is due to limitations in the numerical procedure, or due to the fact that it is not exactly the same flow conditions that are studied experimentally and numerically.

At the Turbine-99 workshops, detailed LDA measurements were provided of the flow at the inlet to a hydraulic draft tube [1, 2]. Further downstream in the draft tube, additional experimental data was provided for validation studies. The most detailed inlet data that was provided was based on phase-averaged LDA measurements along a single radial measurement line. I.e. the LDA probe was traversed in the radial direction only, but since the orientation of the preceding runner was monitored, a time-periodic picture of the runner wakes was captured. A two-component LDA probe was used, yielding only the axial and tangential velocity components and corresponding RMS values. It was not possible to measure the radial velocity component, and it was not possible to resolve the boundary layers.

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The present work describes an OpenFOAM inlet boundary condition that can apply phase-averaged experimental data such as that from the Turbine-99 workshops. In order to be able to test the effect of different lack of experimental data, the ’experimental’ data is extracted from fully resolved sliding grid simulations of the Timisoara Swirl Generator (TSG) [3, 4, 5], and the numerical results are compared with those of the fully resolved TSG case. With this approach it is possible to exclude chosen parts of the data and investigate how it influences the validation results.

References