Studies of the Timisoara swirling flow test rig.

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Abstract

This M.Sc project presents results from OpenFOAM simulations conducted on a swirl generator designed to give similar flow conditions to those of a Francis turbine operating at partial load. Francis turbines are today one of the most commonly used water turbines. In these turbines, there is however a frequent problem occuring at part load. The flow in the draft tube usually gets a swirling flow profile, this swirling flow causes transient helical vortex ropes to build up and create severe pressure fluctuations in the system that increases the risk for fatique. To predict and control such flow features is therefore critical. A test rig was thus developed at the ”Politehnica” University of Timisoara, Romania, to provide with a detailed database of such flow features.

The test rig in Timisoara has four parts: leaning strout vanes, stay vanes, a rotating runner which is designed to have zero torque, and a convergent divergent draft tube made of Plexiglass (to enable LDV). The computational domain is created with ICEM-Hexa mesh and the parts have been meshed separately and then merged together, using General Grid Interfaces (GGI) to couple them.

The numerical results are compared and validated against measurements realized on the swirling flow test rig at the Polytechnica University of Timisoara in Romania [1]. The finite volume method is used to solve both the unsteady- and steady- state Reynolds Average Navier Stokes equations and the standard k-ε model is used to close the turbulence equations. The steady state simulations is a preliminary method, but less time-consuming and it predicts the general behavior of the flow field. They also provides good initial conditions for the unsteady simulations.

The steady state solver uses a fixed rotor and simulates the rotation by using different reference frames for rotating and stationary parts, a similar solver to OpenFOAM:s MRFSimpleFoam. The only difference between them are new properties for handling effects of Coriolis forces in parts that rotates. For the unsteady simulations, the turbDyMFoam solver is used.

Finally the results are validated against experimental LDV measurements [2].

Previous studies have been made on the draft tube as well as the full test- rig [1] [3]. This case has a simple geometry and good quality measurements, which makes it very suitable for testing turbomachinery applications in OpenFOAM.

Key words: Francis turbines, GGI, OpenFOAM, rotor -stator interaction, vortex rope

References

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