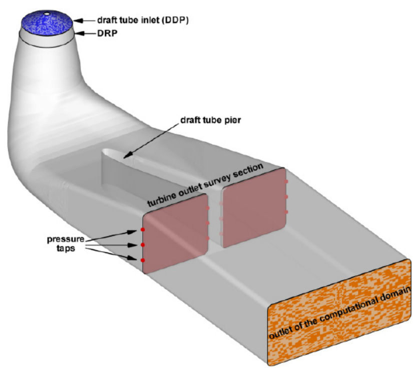
MODELLING THE TWO-DIMENSIONAL SWIRLING FLOW IN FRANCIS TURBINES FOR OPTIMIZATION OF DRAFT TUBE PERFORMANCES WITHIN AN OPERATING RANGE

Goal of the project

This first part of the project was aimed at the twodimensional, steady, axisymmetric swirling flow computation downstream the Francis runner. In addition, the kinematic constraint associated with the relative flow angle at runner outlet is to be considered as close as possible to the runner blades trailing edge, through the novel concept of swirl-free velocity profile from hub to shroud.

Short description of the project

When designing a new runner or refurbishing an existing one, the runner must be the best t for the draft tube, i.e. the head loss in the draft tube should be as small as possible over an operating range. We aim at optimizing the runner outlet geometry, such that the swirling flow ingested by the draft tube will provide minimum weighted averaged head losses over a given operating range.We substitute the runner blade outlet geometry by the swirlfree velocity concept, and use minimum information for geometrical data and operating point As a result, we define a small parameter space suitable for a-priori optimization of the turbine design.

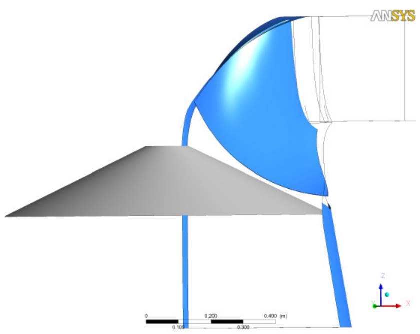


Project implemented by

The project was implemented by a team of both senior and junior researchers, within the Turbomachinery Hydrodynamics Division of the Research Centre for Complex Fluids Engineering, CFD Laboratory.

Implementation period

2012-2013



Main activities

There were two main activities during the project:
A1. Analysis of the 2D swirling flow downstream a Francis runner within the discharge cone:
A2. Development of a 2D swirling flow code and code validation within a large operating range.

Results

The main results can be summarized as follows:
1. Mathematical model for computing the swirling flow at the runner outlet (diagonal probing line in the neighborhood of runner blades trailing edge); it features the development of the stagnant region far from the best efficiency point through a novel variational formulation.
2. "TurboSwirlQ2D" computer code that solves the Bragg-Hawthorne equation taking into account the kinematic constraints at the blades trailing edge and integral constraints.

Applicability and transferability of the results

The computer code "TurboSwirlQ2D" has been installed at Alstom Hydro France, Grenoble, to be used for a-priori optimization of the runner outlet geometry. The main advantage of the methodology developed in the project is that one can compute the swirling flow ingested by the draft tube at arbitrary operating points without computing the runner flow (before designing the turbine's runner).

Financed through/by

ALST OM Hydro France, within the ALST OM-UPT Cooperation Agreement concerning the joint research and development projects related to assessing, developing and using mathematical and numerical modelling of the hydraulics of water turbines in a view to improve the performances of such turbines.

Fields of interest

Hydraulic turbines hydrodynamics, optimization of the runner outlet for best performance of the draft tube within a wide operating range. Variational methods and numerical algorithms for swirling flows with vortex breakdown.

Research Centre

Research Centre for Complex Fluid Systems Engineering

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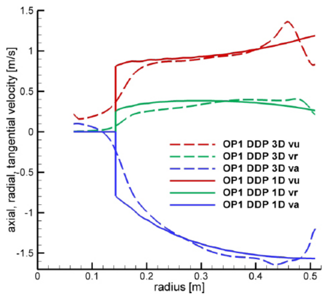

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