

CFD SIMULATIONS OF HYDRO TURBINES USING TCAE

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INTRODUCTION

This presentation introduces CFD SUPPORT, a company specializing in computational fluid dynamics (CFD) and turbomachinery simulations, which had the privilege of delivering a pre-conference workshop on hydro turbine simulations using its open-source-based software TCAE.

The presentation also includes a validated benchmark and tutorial of a Francis turbine, based on a real turbine installation.

CFD SUPPORT COMPANY

CFD SUPPORT is an engineering company providing a wide range of services related to engineering simulations, mainly computational fluid dynamics (CFD) and Optimization, and also finite element analysis (FEA) and fluid-structure interaction (FSI). The company also develops custom simulation software and automation tools, delivers consulting and training services, and participates in research and development projects in collaboration with both academia and industry.

PRE-CONFERENCE WORKSHOP

A hands-on pre-conference workshop was conducted, demonstrating the complete CFD workflow for hydro turbines. The session covered all major stages of the process, from geometry preparation and mesh generation to simulation setup, execution, and advanced post-processing, using the TCAE software suite.

TCAE SOFTWARE

TCAE is an integrated CAE simulation environment developed by CFD SUPPORT, designed for comprehensive analysis of turbomachinery and rotating machinery. It combines automated meshing, CFD, and FEA solvers, and advanced post-processing into a single, streamlined workflow.

TCAE is particularly well-suited for academic and research applications due to its transparency, flexibility, and open-source

foundation, enabling users to study, modify, and validate each step of the simulation process. Its low hardware requirements, automation capabilities, and ease of integration with optimization tools make it an ideal choice for education, research, and development of new turbomachinery designs.



Figure 1.- Francis hydro turbine - Assembly view.

FRANCIS TURBINE BENCHMARK

The Francis turbine benchmark represents a detailed CFD validation study performed by CFD SUPPORT in cooperation with Hidroenergia, a Brazilian hydro turbine manufacturer. The benchmark is based on the real HPP Fortuna II installation in Minas Gerais, Brazil, where experimental measurements of turbine performance were directly compared with TCFD simulation results.

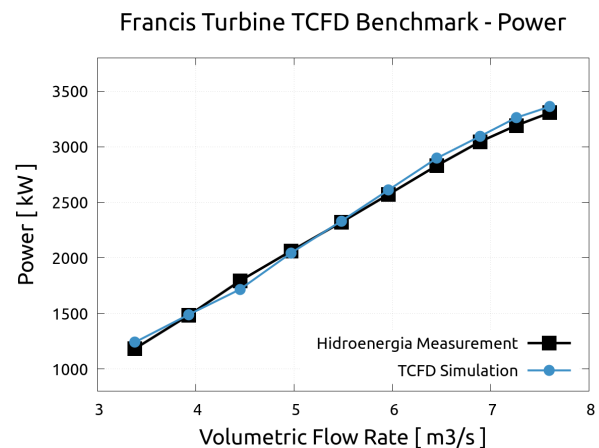


Figure 2.- Francis hydro turbine - Power.

The study covered the **entire CFD workflow**, from CAD preprocessing and meshing to steady-state simulations and post-processing, using **incompressible RANS modeling** with a realizable $k-\varepsilon$ turbulence model. The turbine model included four components (spiral casing, stay and guide vanes, impeller, and draft tube) and approximately **5 million cells**.

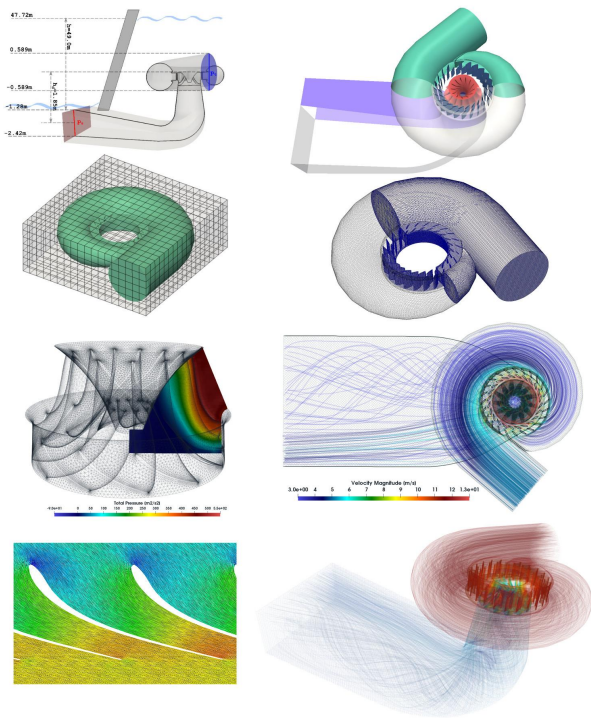


Figure 3.- Francis hydro turbine - CFD steps example.

The comparison of **turbine power and efficiency** between measurements and simulations showed **excellent agreement**, confirming the accuracy and reliability of TCFD for hydro turbine analysis. The benchmark demonstrates that TCFD provides an **efficient, transparent, and fully automated workflow** suitable for both **industrial validation** and **academic research** in turbomachinery

simulation.

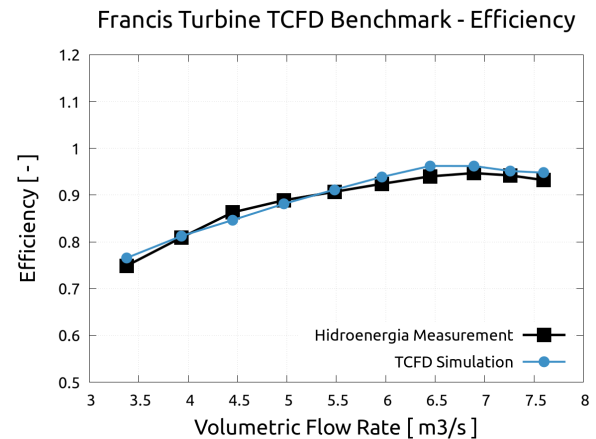


Figure 4.- Francis hydro turbine - Efficiency.

CONCLUSIONS

The presented work demonstrates the **capabilities of TCAE software** for accurate and efficient **hydro turbine simulations**. The Francis turbine benchmark confirmed a **high level of agreement** between simulation and experimental data, validating TCAE as a **reliable engineering tool** for both research and industrial applications. The integrated workflow, combining geometry preparation, meshing, simulation, and post-processing, enables **complete turbomachinery analysis** within a single environment. The results highlight TCAE's potential to **support education, research, and innovation** in the field of hydropower engineering.

REFERENCES

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