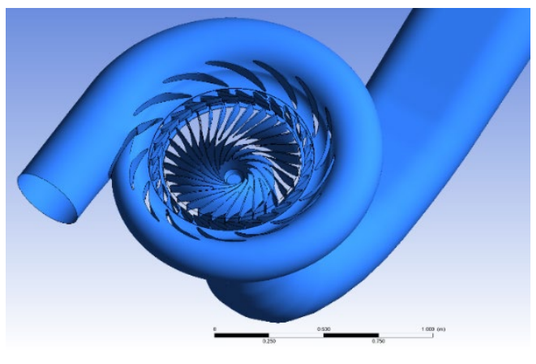
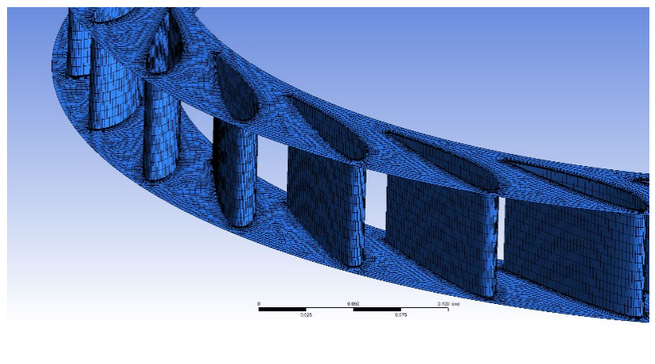
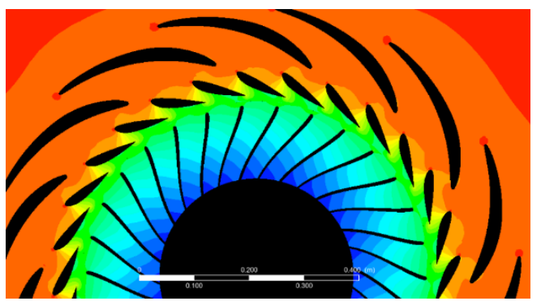
Mathematical and numerical modeling in order to optimize the hydrodynamic and geometrical parameters of the guide vanes in Francis turbines with variable speed

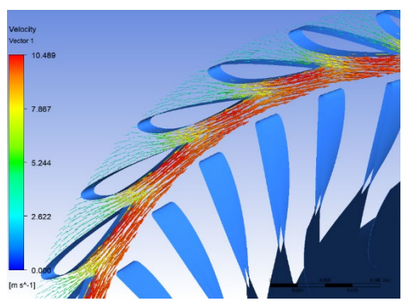
Introduction & Research Methodology

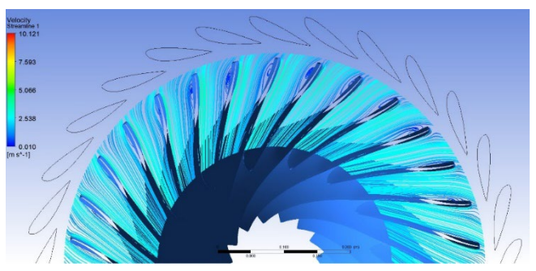
- Main Task: Development of several geometries for the guide vanes which can perform efficient flow "feeding" of the runner with variable speed
- Developing one dimensional mathematical models for calculating the flow parameters at the guide vanes
- Coding those models in MatLAB to obtain initial solution for the design points
- Defining 3D-CAD model from the calculated parameters
- Defining a Numerical CFD Model
- Analyzing CFD results in a way of performing corrections to the initial geometry
- Model Tests at NTNU Water Power Laboratory

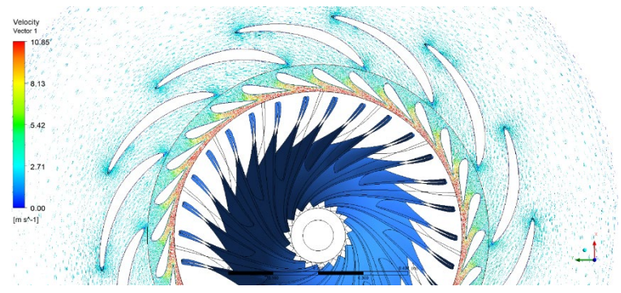


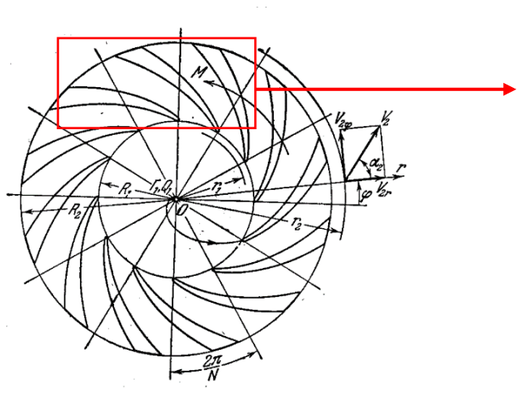


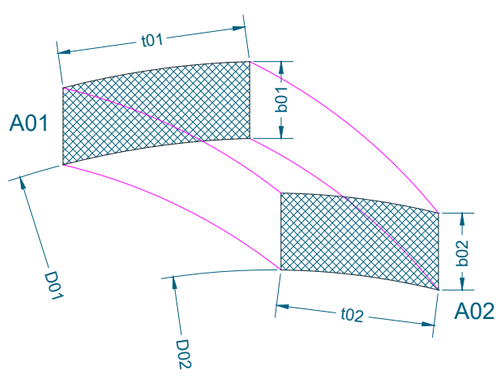


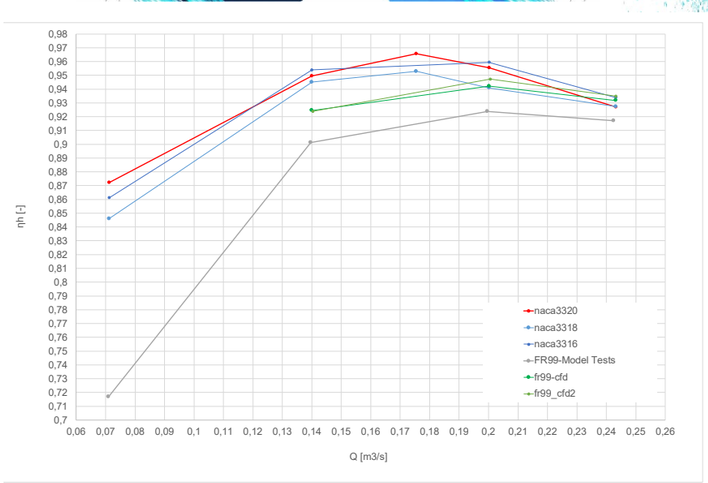


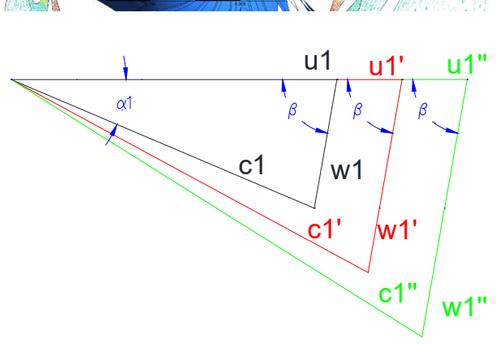


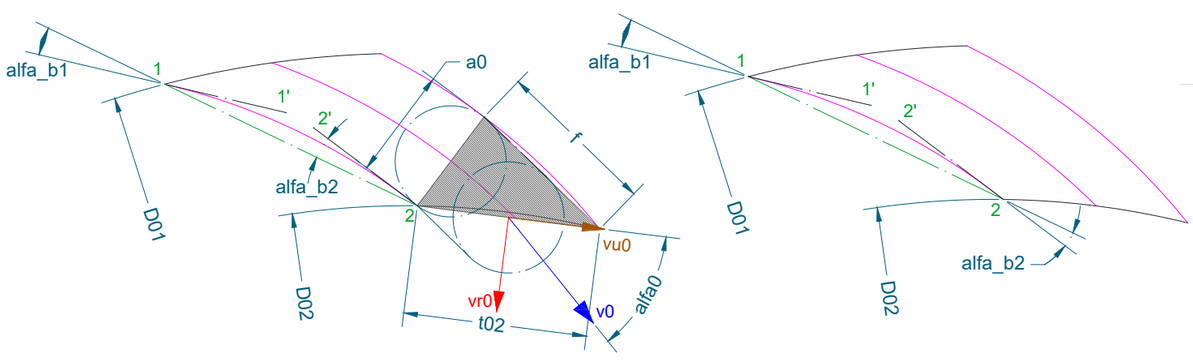


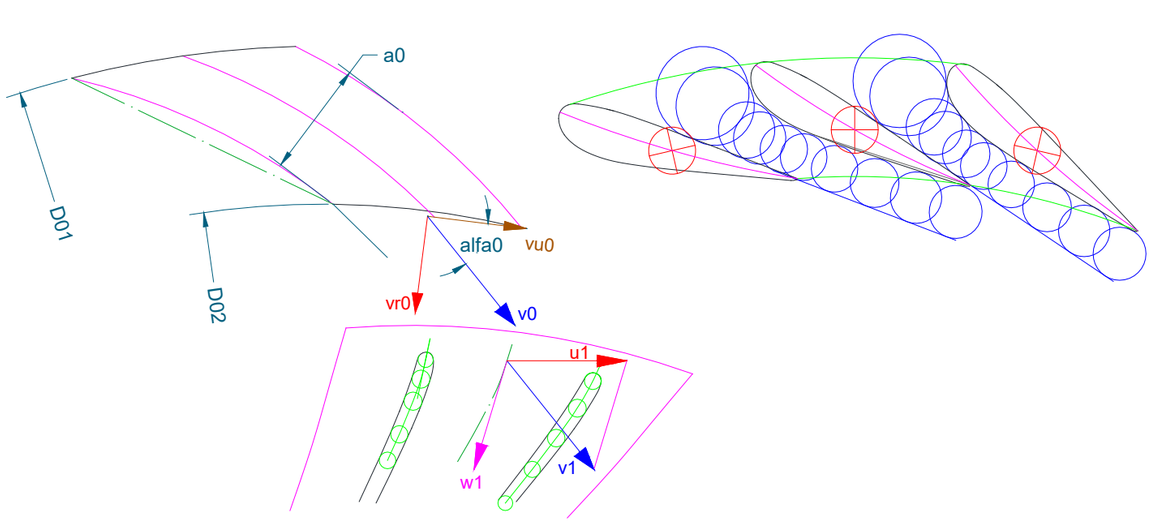


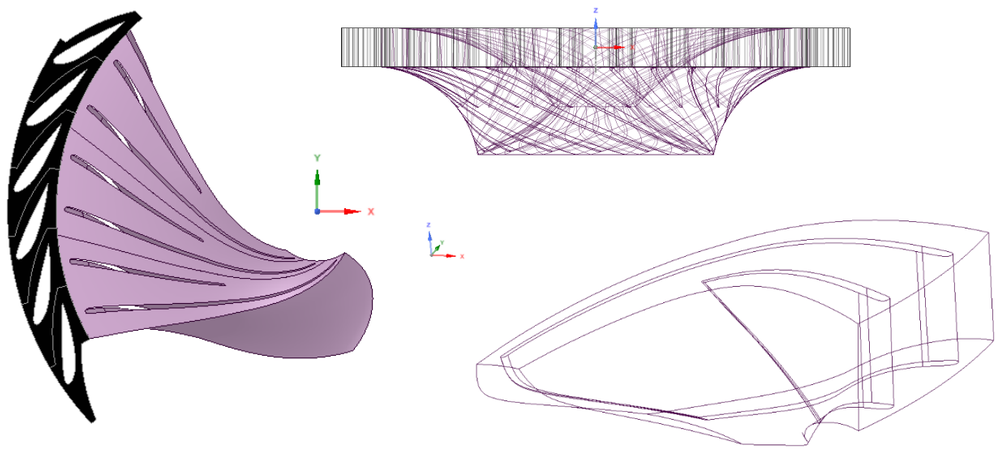












$$\frac{Q^2}{a_0 b_0} + Q^2 \cdot K_A + n^2 \cdot K_{D\pi} = 2gH_i$$

Derived Mathematical Relation (3 variables: Q, n and a0) for determining the Runner Inlet (Guide vane Outlet) Variable Conditions

Conclusions & Further Work

- Mathematical modeling: Gives fast and initial accurate solution needed for the guide vane system
- Numerical modeling: By solving the Navier-Stokes equations in 3D space, we obtain more realistic solution, including the flow space between the two blades (pressure and suction side) which are generating various hydrodynamic shapes (diffuser, jet etc.) and their influence on the runners inlet parameters and conditions.
- By deriving the mathematical relations for the guide vanes and their coding in MatLAB, the solving process is automated.
- Establishing quality numerical model for developing solutions for flow cases like this.

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