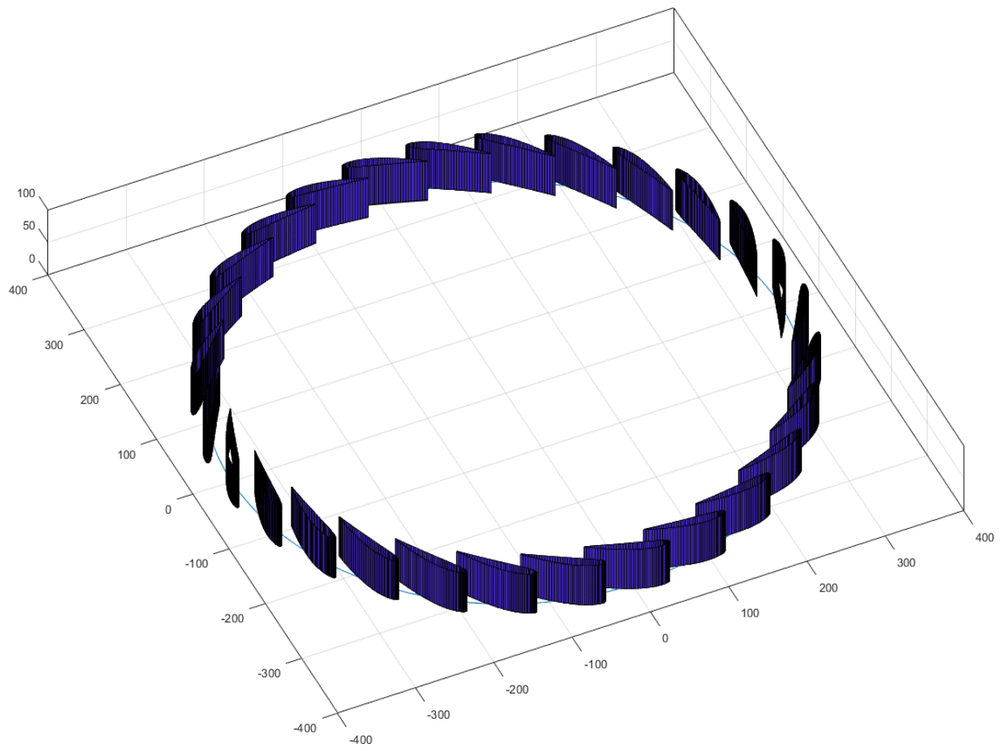
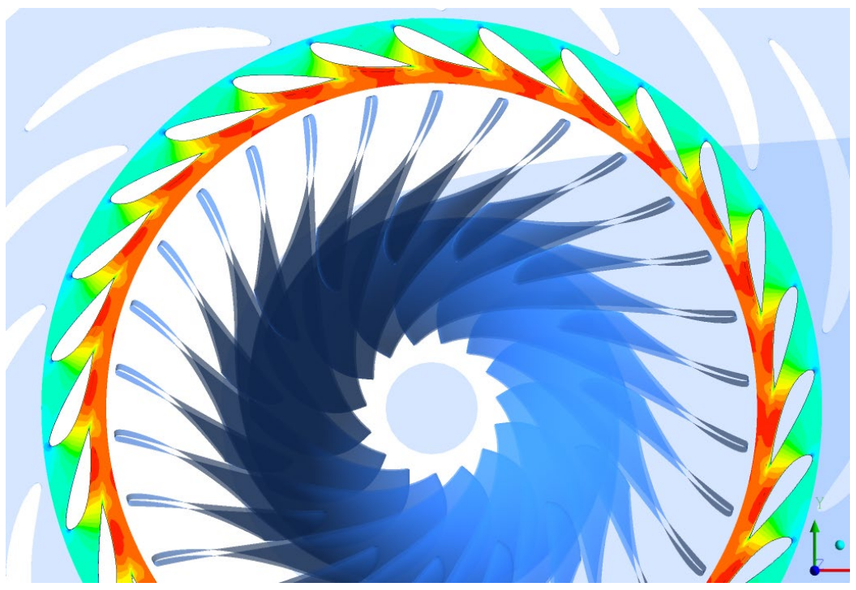
Influence of the guide vanes structural parameters on variable speed Francis turbine performance

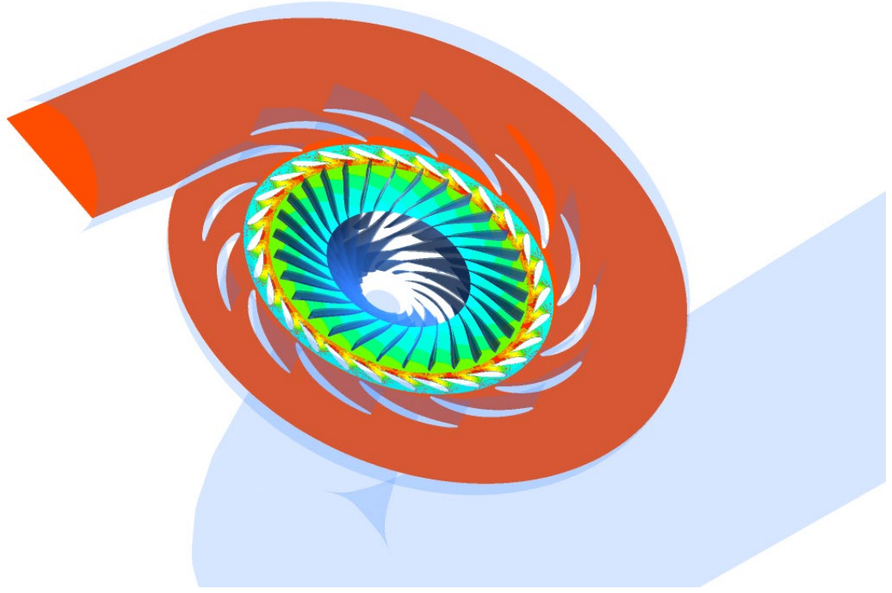
The need for rational and long-term harnessing energy from the water imposes finding new ways for obtaining higher efficiency and reliability of power generating equipment, such as operating at variable speed. The potential benefits of a variable speed Francis turbine are maximum efficiency tracking for given power demand and lower dynamic loads and stresses over turbine components when operating at off-design conditions.

Fatigue of materials occurs due to external fluctuating loads whose intensity affects the lifetime of turbine blades. By choosing an operating point where pressure oscillations are lowest, variable speed can contribute for extending turbine lifetime.

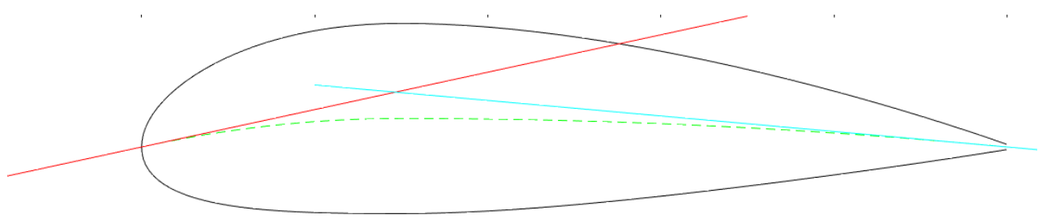


1. Methodology for calculating hydraulic and structural parameters of variable speed Francis turbine – analytical approach
2. Performing numerical simulations of fluid flow in Francis-99 turbine and one-way FSI analysis with different guide vanes in order to obtain optimal hydraulic and mechanical design
3. Experimental measurements on the Francis-99 turbine model in the Waterpower Laboratory at NTNU, needed for numerical model validation

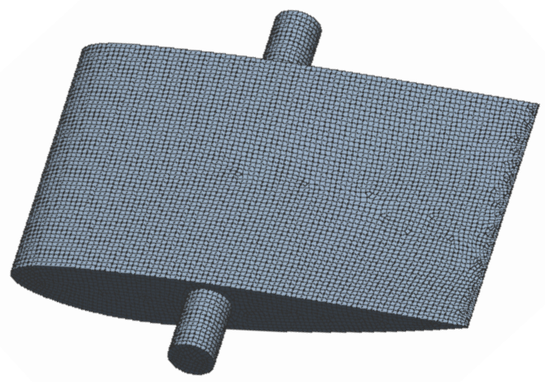


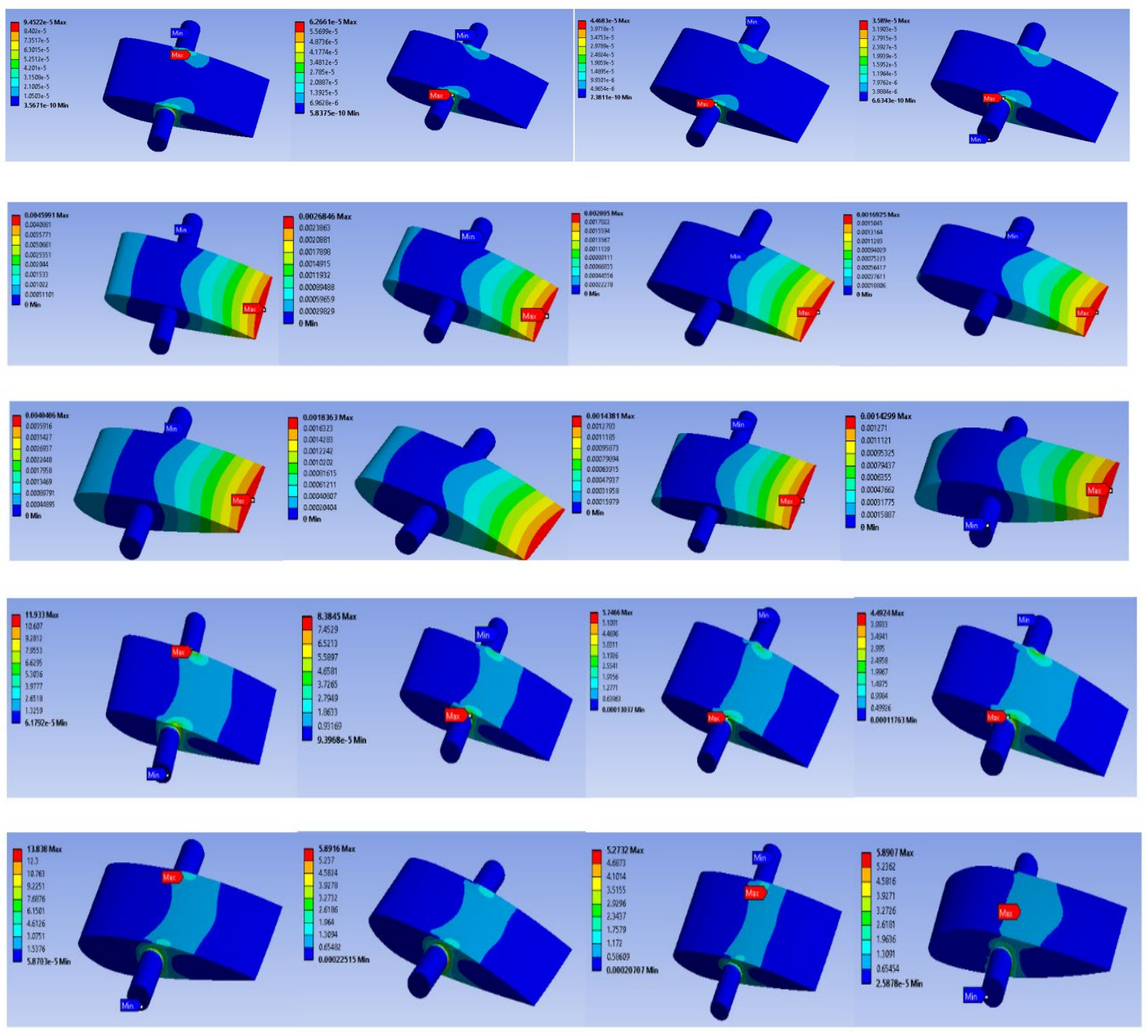


- Finite element method
- One-way FSI: Analysis of stress distribution over guide vanes and deformation of guide vanes
- Modal analysis: Determining natural frequencies of guide vanes and corresponding mode shapes
- Determining blade passing frequency and vortex shedding frequency
- Estimating the risk of resonance
- Estimating turbine lifetime and fatigue of material



- Developing design tool for generating stay vanes and guide vanes cascade of variable speed Francis turbine. Parameters which can be modified would be: three geometry parameters that define the blade shape, number of blades and angle of rotation.
- Defining optimization criteria
- Calculating constructive parameters
- Preparing 3D numerical model of Francis turbine to simulate fluid flow at different operating conditions
- Modeling and simulating interaction between water and turbine elements
- Automation of the optimization process





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