2-way FSI
Fluid damping coefficient of simplified hydrofoil

Context
Nowadays hydro power machine performances efficiency exceeding 93 %. To achieve these values, the turbine designs are highly optimized hydraulically, which provoked new dynamic phenomena due to Fluid Structure Interaction (FSI). In worst cases this leads to blade failure (Fig. 1)

The aim of this project was to simulate a fully coupled 2-way FSI to define the damping coefficient $\zeta$ in a flowing fluid field. The obtained results of the numerical model were compared with measurement of an experimental approach.

Experimental approach
After the failure of Unit 3 of St. Marguerite in 2003, Andritz Hydro identified the Rotor Stator Interaction (RSI) as the source of the blade cracking. The damping coefficient of the fluid flow field could be determined as the key value of this FSI.

4 piezoelectric patches glued on the simplified hydrofoil containing the same physical properties as a turbine blade, excited the first natural Eigenmode, which is the bending at 71 Hz. A laser at the center of the trailing edge measured the displacement of this forced harmonic vibration. Using a least square curve fit, the damping coefficient in fluid flow could be defined.

Numerical method
The 2-way FSI was performed using ANSYS Workbench V.14.0. The numerical model was deviated applying a force on the symmetry cut. After removing this force a free damped oscillation established. Approaching the peaks with an exponential function the damping coefficient could be defined

$$m \ddot{x} + c \dot{x} + kx = F(t)$$

$$x(t) = e^{-\zeta \omega_n t} \cdot x_0 \cdot \cos(\omega t + \varphi)$$

Results
Adjacent the mesh and time step sensitivity analysis, different fluid inlet velocities were simulated for the optimal numerical set up. The resulting damping coefficient was verified with the experimental data.

Conclusion
For inlet velocities higher than 9 m/s, the second mode was also excited, corrupting the extraction of the hydrodynamic damping coefficient. The results for lower fluid inlet velocities (3 m/s, 4 m/s and 6 m/s) showed an over-prediction of the damping coefficient $\zeta$ extracted from the numerical simulation. But the tendency of the damping coefficient is correct. The frequency of the numerics coincide well with the results of the experiment.

References

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