6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

Rotor Dynamic Analysis of a Tidal Turbine considering Fluid-Structure-Interaction and yawed Flow

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Key Words: *Rotor dynamics, Bond graphs, Fluid-Structure-Interaction, Vortex-Lattice-Method.*

To ensure the stability and reliability of submersed turbomachines in its design phase a rotor dynamic analysis is mandatory. In such analysis fluid flow and electric grid fluctuations as well as manufacturing related eccentricities and flexibilities of rotating components have to be considered as vibration sources. In liquid environments fluid-induced reaction forces, hydrodynamic forces, are related to damping and added mass of the surrounding fluid. Previous approaches in rotor dynamics focus on the estimation of hydrodynamic coefficients to account for the additional reaction forces. Usually, these coefficients are derived by experimental investigations, empirical formulas or computational fluid dynamic methods [1].

In this research work a time-resolved dynamic solution of the complete power train is conducted. The electro-magnetic and multibody dynamics of the power train are coupled with a computational fluid dynamics method. With the aim to overcome the need of hydrodynamic coefficients determination, a straightforward rotor dynamic analysis is achieved using a fluid-structure-interaction coupling (FSI).

A tidal turbine as a typical submersed turbomachine is used for the investigations in this work. The electromagnetic and structural dynamics are modelled using the bond graphs methodology. Within the fluid domain water is modelled as incompressible inviscid fluid. All fluid-induced forces are calculated using a potential theory based unsteady vortex-lattice method.

Two sets of simulation series are conducted considering bidirectional FSI for three sets of linear-elastic blade properties (nearly rigid to highly flexible) respectively. First, stationary, uniform inflow conditions are applied, to observe the startup behaviour of the system model and to derive performance curves. Second, a yaw flow angle is set to simulate fluid-induced thrust and torque fluctuations. The frequency spectra of shaft velocity and orbital displacement paths are compared in order to investigate the effects of flexible blades on the rotor dynamic behavior. Hereby, the applicability and effectiveness of the conducted Fluid-Structure-Interaction and multi-physic modelling approach is shown. For the further use this approach results in a parametric dynamic system model for a wide spread of applications like wind and water turbines, submersible mixers and ship propellers.

REFERENCES

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