Training Position

IFP Énergies Nouvelles

Rueil-Malmaison - 92500

Training position at IFP Energies nouvelles

Extreme mechanical response prediction of a floating wind turbine submitted to wind and wave time variant random processes.

Candidate profil

Grandes Écoles engineer and/or Master 2 in applied mathematics. Substantial knowledge in statistic and probability. Interest for computational mechanics and marine renewable energies. Required computing experience (or/and): R, Matlab, Scilab, C.

Context

The training position is proposed in the framework of the project MODNAT (Probabilistic Models for Natural Hazards), which aims at developing high fidelity stochastic models in order to simulate uncertain natural phenomena numerically and assess their effects on structures.
The efficient design of floating wind turbine to withstand the marine environment is of great importance to ensure the development of this technology. In particular, the extreme response prediction is a difficult task since it has to take into account the highly variable nature, at different timescales, of wind and wave actions, and the non linear nature of the floating wind turbine response. This non linear behaviour is related to both the mechanical system complexity, and to the control strategy implemented. The control scheme aims to maximize the generated power, ensure wind generator safety and survivability, and sometimes to decrease fatigue of strategic structural components or limit floating support displacements. Moreover, in specific cases, the interaction of the floating wind turbine with wind and wave loads may generate some instabilities, like negative damping of the rotor. Specifically, the determination of the most critical load combination is complicated and generally requires significant computation efforts.

Study description and aim

The modeling of loading acting on a floating wind turbine, is classically based on the distinction of short and long term conditions. The short term conditions relate to time dependant stationary random processes (wind velocity and wave elevation) whose spectra depend on some metocean parameters, for instance mean wind velocity, wave significant height and period, assumed to be constant during the short term calculation duration. The long term variations correspond to the evolution of these metocean parameters during the whole life cycle of the structure. These time-scales also apply to the structure mechanical response (for instance the moment at the wind turbine tower base or at blade root), which is, due to the system non linearities, a non gaussian but stationary random process. In particular, the extreme value statistics of this random process must be inferred to assess the system failure probability (the failure event corresponds to a threshold exceedance of the response process) and the floating wind turbine lifetime. The response time series is computed with DeepLines, a software dedicated to global dynamic analysis of floating support, moorings and wind turbine systems (including aeroelasticity and control) with a non linear finite element method.
The proposed study aims to develop a methodology to efficiently identify the critical wind and wave loads combinations to be considered in a floating wind turbine (FWT) design workflow. A first prototype was developed in 2011 and showed promising results on a FWT basic application. This method allows to determine, by numerical optimization, under the response process stationary assumption, a "critical" scenario (combination of wave and wind episodes) leading to the structure failure and an estimation of the associated probability of occurrence.
The key point of the procedure, derived from the outcrossing approach, consists in computing the mean of the outcrossing rate of the floating wind turbine response in the failure domain over both the short term variables and the variables defining long term parameters. However, the methodology implemented in the prototype suffers from several limitations and assumptions that will be identified and eventually revised in the study.

Responsable de stage

T. Perdrizet (Applied Mechanics Division) and M. Munoz Zuniga (Technology, Computer Science, and

Applied Mathematics Division)

Work expected from the candidate

The applicant will

- Analyze, implement and compare different approaches for the approximation of the failure probability (currently FORM/SORM approximation). Propose new numerical strategies and algorithms to validate and to improve the prototype. For instance, a prospective approach based on metamodeling and subset simulation could be considered.
- Achieve a reflection on the impact of approximations on the failure probability estimation (long term processes ergodicity, - response process stationarity and the choice of the time to compute the outcrossing rate - independence of the outcrossings of the response process including long term variables).
- Extend the prototype to deal with combiend wind gusts and wave elevation 1D gaussian processes with variable directions. The extension to more complex input process (3D gaussian or non Gaussian processes) will also be investigated.

Time: 12 month **Place:** IFP Énergies Nouvelles (Rueil/Solaize)

Please send your application (CV and cover letter) to :

Miguel Munoz Zuniga
IFP Énergies Nouvelles
Division Technologie, Informatique et Mathématiques Appliquées
1 et 4, avenue de Bois-Préau
92852 Rueil-Malmaison Cedex

01 47 52 50 03
miguel.munoz-zuniga@ifpen.fr