Reliability Analysis of an Innovative Root Assembly Design for Composite Ocean Current Turbines

Root assembly design is a most significant issue in composite Ocean Current Turbines structural design, as it is both the maximum bending moment location and multi-material junction with its geometrical and mechanical singularities. Local design of the root assembly can have a significant impact on the overall production costs. Peak exothermic temperature of thermoset resins is also a process constraint, limiting composite thickness.

The HOBIT project focuses on "Manufacturing of Composite Ocean Turbines Blades" and aims specifically at developing processes suited for increased production rates. In this context, a composite blade design suited to RTM light process has been developed. This design includes an innovative manufacturing principle for the blade root assembly, to transfer the loads from the composite blade to the metallic hub. While this new design is being set up on small scales and local scale prototypes, a structural assessment is also conducted by means of numerical computations.

The determination through advanced finite element analysis of the mechanical strength of such a composite/metal assembly is challenged by many an uncertainty on analysis assumptions. First, hydrodynamic loads are described in terms of statistical observations, individually (waves, current) and in combination (wave - current pairs). In order to reach this level of description in terms of effects of these loads on the structure (e.g. bending moment on blade root), one needs to take into accounts the hydrodynamic behavior of the blade and propagate the uncertainties. Second, the new manufacturing process is associated with specific tolerances, either measured or accepted. These parameters have to be included in the numerical model. Third, strength of the composite material is in itself a dispersed limit, with a statistical distribution dependent on the failure mechanism.

The study exposed is a practical – engineering – application of reliability analysis principles to this specific case, including:

- Incertitude propagation from environmental state (waves, current) to structural loading (bending moment)
- Model reduction from advanced composite finite element model to a parameter response function.
- Derivation of a target reliability criterion based on DNV-GL standard into effective design variables (thickness, manufacturing radius).

Prototype of composite tidal blade (Patent pending)

The prototype, at 1/7 scale, represents a composite tidal blade. It was developed in the HOBIT project. The aim of this project is to develop a new automated manufacturing process for a low cost and high volume production of tidal blade.

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