Enabling accurate modelling of the viscoelastic behaviour of HMPE ropes for more accurate mooring analysis of floating structures for offshore wind

MARINE 2023

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ABSTRACT

Advanced mooring analyses are performed to design robust solutions for floating offshore wind turbines. The mooring simulations often include features such as wave excitation and hydro- and aerodynamics to incorporate the operating wind turbine and its interaction with the floater in high detail. Next to requirements on overall design stability, floater offsets and dynamic motions, the eigenfrequencies of the design must be sufficiently robust to avoid excitation of resonance by rotor frequencies, first-order wave forces and vortex shedding [1]. Obviously, the eigenfrequencies of the system are directly related to the overall stiffness of the assembly, and the stiffness of the mooring lines plays a crucial role in this. This work aims at developing models that allow more accurate modelling of the response of synthetic ropes, in particular high-modulus polyethylene (HMPE) ropes.

Because where traditionally often steel mooring lines were considered, the number of designers exploring the potential of synthetic mooring lines is growing rapidly. However, the material behavior of synthetic ropes is much more complex than that of steel and a simple representation as a linear elastic solid is no longer sufficient. Instead, synthetic ropes are often characterized by one or two stiffnesses (quasi-static and dynamic stiffness) or sometimes the dynamic stiffness is considered a linear function of tension. However, it is known that the behavior is much more complex than this simplified approach since the behavior is (non-linear) viscoelastic, often even involving plasticity, affecting the elastic and damping response of the system.

Many studies focus on modelling the viscoelasticity, see for example [2], but unfortunately often involving a large amount of empirical model parameters that evolve with loading conditions. This is not only making it difficult to parameterize the model, but also making the parameters very case specific.

As manufacturer of the HMPE fiber Dyneema®, Avient Protective Materials aims at enabling the system designers that use our fiber to perform accurate modelling by providing them with the right material models. This paper will present our recent efforts to develop the Dyneema® 3T Rope Model ™, which accurately characterizes the viscoelastic behavior of ropes made out of Dyneema® in terms of stiffness and damping as functions of the three T's: Time (frequency), Tension, and Temperature. It will discuss the experimental program to characterize the fiber, establishing the constitutive material model and its link to physics, and the model will be compared with experiments. The model now interfaces with leading mooring analysis software programs, Orcina's OrcaFlex and Principia's Deeplines Wind. We believe that this model can eventually lead to the acceptance of reduced safety margins by certification bodies. Thereby reducing the costs of developing safe and reliable ropes for floating offshore wind.

REFERENCES

[1] A. Ojo, M. Collu, A. Coraddu, "Multidisciplinary design analysis and optimization of floating offshore wind turbine substructures: A review", *Ocean Engineering*, Vol. **266**, 112727, (2022).

[2] N. Nguyen, K. Thiagarajan, "Marine Structures 85", *Marine Structures*, Vol. **85**, 103257, (2022).