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Characterization and Modeling of an Innovative Textile Mooring Chain

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ABSTRACT

The mooring lines of future floating wind turbines, made of polymer fibre ropes (polyester, nylon, HMPE), are typically connected to the platform at their upper segment with a steel chain. Del Vecchio et al. (2024), aim to replace this steel chain with a polymer fibre rope, noting that chain failures account for approximately half of all permanent mooring failures. However, maintaining tension in polymer ropes using a winch system is challenging and can cause abrasion or damage to the rope. A solution proposed by BW Ideol and studied in the Velella project (a project funded by the French government as part of France 2030, operated by ADEME) involves the use of a textile chain made of HMPE fibres. This solution addresses challenges like steel's low oxidation resistance and high mass, while avoiding abrasion issues associated with winch systems for polymer ropes. The studied chain features an innovative Möbius strip-inspired design, constructed from woven HMPE fibres, as shown in figure below. Recent studies Y. CHEVILLOTTE (2020), L. CIVIER (2023), and C. BAIN (2023) have focused on proposing a visco-elasto-plastic (VEP) behaviour model for polymer fibre ropes in marine applications, as well as on measuring friction coefficients between their fibres, a key parameter for fatigue in such textile materials.

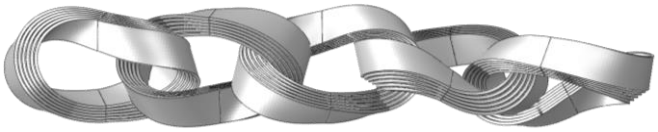

Figure 1: Geometric Model of a Textile Chain Composed of HMPE fibres

A finite element (FE) model of the chain under tension will be proposed, based on the behaviour of its main component, the strap, and a friction law governing interactions between the different strap layers. One of the objectives of the FE model is to better understand the contact phenomena between links. The FE model will also aim to optimize winding parameters to improve even more mechanical performance.

The presentation will highlight the mechanical characteristics of this textile chain, obtained through strap tests (negative Poisson's ratio, static and cyclic behaviour). We will then present a finite element method for determining the resting geometry of the link, with and without the Möbius twist, based on the known geometry of the strap, where the directions of anisotropy are simple and well-defined. A VEP behaviour law for the strap will be proposed in the next phase of this work to further enhance the FE model of the chain.

References

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