Composite materials for wind assisted ship propulsion systems

Moumita Sit[1], Ole T. Thomsen[1], Tobias Laux[1*]

[1]Bristol Composites Institute, School of Civil, Aerospace and Mechanical Engineering, University of Bristol, Bristol, UK.

[*] tobi.laux@bristol.ac.uk

ABSTRACT

The maritime industry is facing mounting pressure to decarbonise due to climate change and new environmental regulations; hence wind-assisted ship propulsion (WASP) technology is gaining attention to reduce emissions of cargo vessels (Wind ship association, 2022). The main load carrying structure of most WASP systems is currently metallic. Fibre reinforced polymer (FRP) composite materials have the potential to be used in WASP systems due to their high specific stiffness and strength, excellent corrosion resistance, fatigue performance, and scalable production, but are rarely used due to added complexity in design, fabrication, manufacturing, and health monitoring. The aim of this paper is to investigate the use of composite materials by holistically assessing the structural performance of a composite WASP system to unlock potential benefits of FRP materials. To this end, a parametric full-scale finite element (FE) model of the composite primary WASP structure was constructed in the commercial FE software Abaqus, as shown in Fig. 1 (a). The FE model was used to analyse the strength and failure modes of the WASP subjected to static and fatigue loading. Three static load cases were considered: maximum thrust operational, extreme at sea, and extreme in harbour, following BV NR206 (Bureau Veritas, 2024). The fatigue life was also predicted using Miner's linear damage accumulation model based on fluctuating stresses predicted by the FE model and SN curves for composite materials. Both static and fatigue load cases include aerodynamic wind loads and ship motion induced inertial loads computed according to (Bureau Veritas, 2024). The focus of the investigation is on the critical root connection between the composite primary spar and the metallic slew bearing connected to the deck of the ship, as shown in Fig. 1 (b). The connection is inspired by composite wind turbine blades (Peeters et al., 2017), where T-bolts are often used to connect the composite blades to the hub. To capture the complex stress distribution at the root section, the FE model includes the effect of bolt pre-tension and contact between barrel nuts and laminate and slew bearing and laminate. The numerical analysis, based on nonlinear, high-fidelity FE models subjected to realistic wind and ship motion induced loads, provides new insights into the critical load cases and failure mechanisms that can guide the development of future composite WASP systems.

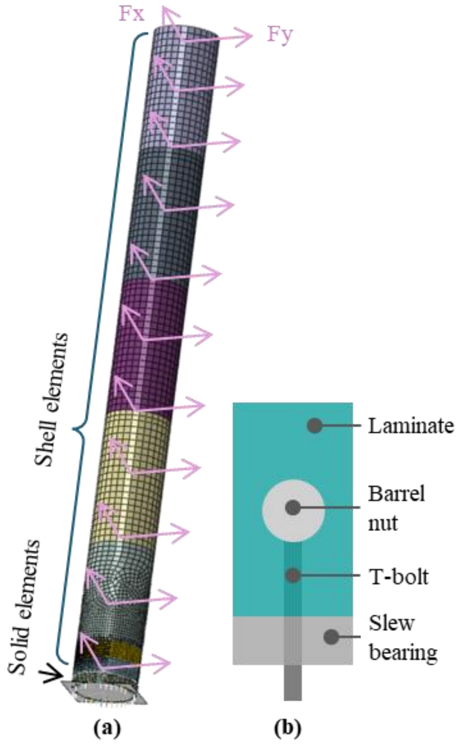

Figure 1, (a) FE model overview, (b) T-bolt connection.

References

Wind ship association, 2022. Wind propulsion for ships. URL https://doi.org/10.1016/b978-0-12-824471-5.00016-5

Bureau Veritas, Wind propulsion systems, Rule Note NR206, 2024.

Peeters, M., Santo, G., Degroote, J., Van Paepegem, W., 2017. The concept of segmented wind turbine blades: A review. Energies. https://doi.org/10.3390/en10081112