XI International Conference on Computational Methods in Marine Engineering

Thermomechanical Loading Induced Buckling and Failure Analysis of Thermoplastic Composite Pipes

Sunny O. Uguzo[1,*], Oleksandr Menshykov[1], Marina Menshykova[1] and Maria Kashtalyan[1]

[1] School of Engineering, University of Aberdeen, AB24 3UE Aberdeen, Scotland, UK

[*] s.uguzo.21@abdn.ac.uk

ABSTRACT

Global oil and gas industry is shifting from metallic to composite pipes due to the need for lightweight, corrosion resistant and cost-effective materials, especially for deep-water offshore exploration. Composite pipes, like thermoplastic composite pipes (TCPs), are preferred for their flexibility, lower installation costs and resistance to corrosion and fatigue, Pham et al. (2016). This transition is driven by increased industrial demands, limitations of ageing metallic pipes and reduced production cost of composite materials, Yu et al. (2017).

Despite their advantages, composite pipes face limitations such as low service temperature, sensitivity to radiation and moisture, reduced transverse elasticity, and complex design and analysis, Buragohain (2017). Their anisotropic nature and the interface between layers make their behaviour under load unpredictable. In oil and gas applications TCPs must endure various functional, environmental and accidental loads. For optimal performance, they must withstand combined mechanical (axial and pressure) and thermal loads, as well as significant bending moments during installation and operation, especially in sag bend and overbend regions, see, for example, Wang et al. (2024).

This study investigates the buckling and material failure behaviour of TCPs under combined mechanical and thermal loads typical of deepwater offshore operations. Numerical simulations using FE models with temperature-dependent material properties were conducted to assess how thermal gradients affect buckling, material failure resistance, and failure mode transitions. The study also includes a multi-parametric analysis of effects of design factors (e.g., reinforcement fibre orientation, stacking sequence, layer thickness, etc.) on failure behaviour.

References

M.K. Buragohain. Composite Structures Design, Mechanics, Analysis, Manufacturing, and Testing. CRC Press Taylor & Francis Group, 2017.

D.C. Pham, N. Sridhar, X. Qian, A.J. Sobey, M. Achintha, and A. Shenoi. A Review on Design, Manufacture and Mechanics of Composite Risers. Ocean Engineering, 112:82–96, 2016. ISSN 0029-8018. https://doi.org/10.1016/j.oceaneng.2015.12.004.

T. Wang, O. Menshykov, and M. Menshykova. Novel Computational Model for the Failure Analysis of Composite Pipes under Bending, Composites Science and Technology, 256:110757, 2024. ISSN 0266-3538. https://doi.org/10.1016/j.compscitech.2024.110757.

K. Yu, E.V. Morozov, M.A. Ashraf, and K. Shankar. A Review of the Design and Analysis of Reinforced Thermoplastic Pipes for Offshore Applications. Journal of Reinforced Plastics and Composites, 36(20):1514–1530, 2017. ISSN 0731-6844. https://doi.org/10.1177/0731684417713666.