Vortex-induced loads on subsea pipelines due to marine biofouling

Nikita Finogenov[*] and Victoria Kurushina[*,**]
[*]*Laboratory of Vibration and Hydrodynamics Modelling, Industrial University of Tyumen, Tyumen, Russia*
[**]*School of Engineering, Newcastle University, Newcastle upon Tyne, United Kingdom, ORCID 0000-0001-9294-5789*

Abstract. Marine biofouling is a major economic and technical concern worldwide for nearly all industries operating in water. The current work considers several geometrical configurations of the growing plants using the numerical computational fluid dynamics model to estimate the effect on the fluctuating fluid forces, pressure and vortex shedding patterns.

Introduction

The accumulation and growth of microorganisms, plants or small animals settling on subsea structures contributes to several aspects to be considered during the structural design of ship hulls, offshore platform supports, risers, jumpers, flowlines, subsea equipment, power cables, etc. Estimating the impact of marine biofouling represents a substantial modelling challenge for elements of both traditional oil and gas production systems and novel offshore energy harvesting systems. Biofouling expands the outer dimensions of subsea structures, increases its surface roughness, mass, changes the flow regime and resulting hydrodynamic loads from external currents and waves. Following the studies [1–3], the ongoing research attempts to identify the geometrical configurations leading to substantial alterations in the vortex shedding patterns and increase in the lift and drag forces using the computational fluid dynamics approach.

Results and discussion

The present work considers a circular cylinder in a fluid domain, where the structure with a partial coverage with fouling elements is subjected to a uniform flow, as shown in Fig. 1. The 2D numerical model is designed for the simplified cone-shaped fouling, equally-spaced over the downstream part of the structural circumference. The study considers several heights, widths and a different number of fouling elements and includes the mesh verification, simulations and analysis of hydrodynamic coefficients. The results obtained reveal maximum expected fluid forces, their dominant frequencies, vortex shedding patterns, changes to the velocity, pressure and vorticity fields.

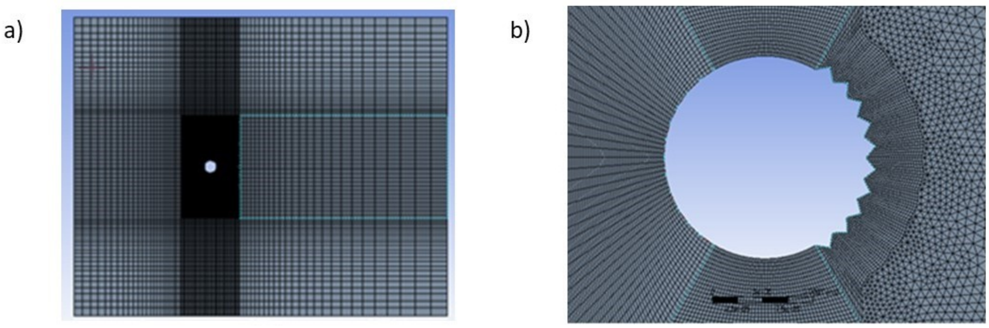

Figure 1: Numerical model for the flow over cylindrical structure with biofouling: a) general view on the mesh of the fluid domain; b) mesh around the structure with a simplified fouling model.

References

[1] Zeinoddini M., Bakhtiari A., Ehteshami M., Seif, M.S. (2016) Towards an understanding of the marine fouling effects on VIV of circular cylinders: Response of cylinders with regular pyramidal roughness. *Appl Ocean Res* **59**:378-394.

[2] Bakhtiari A., Zeinoddini M., Ashrafipour H., Tamimi V., Harandi M.M.A., Jadidi, P. (2020) The effects of marine fouling on the wake-induced vibration of tandem circular cylinders. *Ocean Eng* **216**:108093.

[3] Ashrafipour H., Zeinoddini M., Tamimi V., Rashki M.R., Jadidi P. (2022) Two-degrees-of-freedom vortex-induced vibration of cylinders covered with hard marine fouling. *Int J Mech Sci* **233**:107624.