Coupling of IGA-BEM and IGA-FEM for the Hydroelastic Analysis of Marine Flexible Propellers

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ABSTRACT

Marine propellers are traditionally made of metal alloys but there is an increasing interest in using composites. Reasons in support of composite materials are of diverse nature, ranging from lower production and life-cycle costs to improved hydrodynamic performance due to the hydroelastic tailoring of the blade. The anisotropic characteristics of fiber reinforced composites allow the self-adaptation of the blade geometry in terms of pitch, rake, and skew due to the bending-twisting coupling [1]. Assessing and optimizing the performance of a flexible propeller needs an integrated design-to-analysis tool capable of predicting the hydrodynamic loads, the elastic deformations and the interaction between them. To this aim, the concept of IsoGeometric Analysis (IGA) is adopted using NURBS as the basis functions for both the geometry and the analysis. The flow around the propeller is modeled with potential flow theory and the problem is reduced to solving a Fredholm Boundary Integral Equation of the second kind with respect to the unknown perturbation potential with the application of the Isogeometric version of the Boundary Element Method (IGA-BEM) [2]. In order to build the linear system of equations, both the collocation method using Greville's abscissa and the Galerkin method are compared. Furthermore, special attention is given to the treatment of the singular integrals. The structural analysis is performed with the Isogeometric version of the Finite Element Method (IGA-FEM) using either shell [3] or solid elements and a geometrically non-linear formulation. Several coupling strategies are evaluated for the fully isogeometric fluid-structure interaction (FSI) problem, extending the work done by one of the present authors with Stoke's flow [4] to potential flow. Preliminary results are presented for non-lifting deformable bodies.

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