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OPTIMIZATION OF 3D HYDROFOIL USING A CAVITATING LIFTING LINE METHOD

***Ing. Leonardo Dipilato[(a)], Ing. Michele Farnesi[(a)], Prof. Giovanni Lombardi[(a)]**

leonardo.dipilato@cubitlab.com, michele.farnesi@cubitlab.com, giovanni.lombardi@unipi.it

(a) Cubit Innovation Labs, Italy

PhD. Catherine Ramirez Villalba[(b)], PhD. Romain Lanos[(b)], Ing. Thomas Gaudiot[(b)]

catherine.ramirez@syro.co, romain.lanos@syro.co, thomas.gaudiot@syro.co

(b) Syroco, France

ABSTRACT

Cavitation is a complex phenomenon that inevitably takes place in high-speed foiling. As such, designing a hydrofoil specifically for supercavitation is mandatory when striving for high speeds, but doing so with common engineering tools is slow and inefficient. To achieve the World Sailing Speed Record, Syroco and Cubit had to research more advanced and faster tools to design the most efficient foil for the sailboat that will be used for the world record.

Said tools were developed over a long collaborative research, during which many different approaches to simulate supercavitating hydrofoils with Finite Volume Methods (FVM) have been tested, leading to an innovative optimization procedure to find the best 2D section with a compromise between hydrodynamic and structural properties.

Performing a 3D optimization using FVM was quickly found to be unfeasible due to large computational costs involved with accurately simulating a 3D domain, even with a very optimized setup. Therefore, a Cavitating Lifting Line (CLL) method that accounts for cavitation to bypass FVM during the optimization process was developed as a modification of [1]. The CLL is an implementation of traditional lifting line methods using more modern findings (e.g., [2]) to take into account the nonlinearities of cavitation, and is able to return results in computational time several orders of magnitude less than a common FVM setup.

This speedup, in turn, made an even more complex optimization possible, developing a multi-leveled loop that is able to converge to the most efficient design possible under hydrodynamic, structural and feasibility constraints.

References:

[1] G. Vernengo, L. Bonfiglio, S. Brizzolara, “Supercavitating Three-Dimensional Hydrofoil Analysis by Viscous Lifting-Line Approach” (2017)

[2] W. F. Phillips, D. O. Snyder, “Modern Adaptation of Prandtl’s Classic Lifting-Line Theory” (2000)