High-performance sailing aerodynamics: investigation of mast-sail interaction

Background:

With the advent of foiling in the America's Cup in 2013 and the subsequent interest in foiling, the future of high-performance sailing is pending toward a large portion of foiling boats being sailed and built. To reach a maximum level of performance, the whole foiling boat needs to be optimised and this means optimising both the hydrodynamic and the aerodynamic parts. The advance in sailing technology is brought forward not only by America's Cup design teams, but also by development classes such as the International Moth and the A-class catamaran, where sailors, designers and manufacturers work together with trial and error assessment of equipment to improve the performances. The International Moth class has been developing in recent years a "deck sweeper" sail. Being able to reduce the space between the "foot" (i.e. the bottom part) of a sail and the deck of the boat, will reduce the tip vortices under the sails, reducing therefore the overall induced drag. Furthermore, acting as an end plate, this physical barrier will prevent the air to pass from the high-pressure windward side to the low-pressure leeward side. Being a development class however, most of the advances are put forward without a strong scientific background and most of the discoveries are sailor specific. Another important issue to categorize is the mast-sail interaction and how the luff, leech and camber of sails are changed with softer-harder masts.

The project outcomes will be exploited for SSPA and Chalmers Formula sailing (CFS), which are dedicated to developing high-performance sailing technologies. SSPA is a well-known world-leading knowledge-based company based in Gothenburg. CFS has achieved a remarkable progress since it was founded in 2017.

Objective:

The objective of this project is to parametrically change the shape, size and angle of a deck-sweeper sail to increase the lift to drag ratio on the bottom part of an International Moth sail. Furthermore, how the mast-sail interaction affects the sail profile.

Methodology:

In this project you will study the effects of tip vortices and end-plate initially with simple aerodynamic vortex circulation methods. Furthermore, you will be developing your tools and flow-mechanics understanding to be able to create a parametric study of the aerodynamic performances of an International Moth sail in the Computational Fluid Dynamic (CFD) software Star-CCM+. The flexibility of the mast will be changed accordingly to bending theory to replicate the same simulations with different stiffnesses.

Prerequisites:

Knowledge in minimum one of the fields: mechanical engineering, structural mechanics, fluid dynamics.
Knowledge in computational fluid dynamics CFD is not necessary but an advantage.
Interest in sailing and the student project Formula Sailing is recommended.

Contact

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Figure 1: Triangular deck sweeper.

Figure 2: Rectangular deck sweeper panel.