Project Proposal: Low-Drag Hydrofoils for Non-Cavitating to Fully Cavitating Flow Featuring Precise Lift Control at all Speeds

Introduction

Today high-speed sailing boats reach speeds up to roughly 50 kt. When going faster massive cavitation on hydrodynamic active surfaces (i.e. ruder, keels and foils etc.) can no longer be prevented and the boats loose control. This became obvious with the spectacular crashes observed in 2008 (L'Hydroptère and SailRocket both in December 2008). A new high-speed sailing craft (**50**plus**X**) is currently under development, aiming to reach speeds well above 50 kt. Therefor suitable hydrofoils have to be developed.

Problem Statement

To tackle challenges the other boats met, new concepts for foil design have to be found. Since avoiding cavitation at this speed is no longer feasible the goal is to develop low-drag profiles, that maintain lift and its controllability from non-cavitating low speed conditions up to the fully cavitating high-speed regime.

Minimal drag is required since the drive force delivered from the sails is limited and all extra drag will reduce the boat speed. Controllability of the generated lift is essential, because the configuration of the boat under investigation is inherently instable (due to three fully submerged foils). This requires the foils to balance the ever changing aerodynamic forces dynamically with quick and precise changes in the lift generated by each foil. Besides this, the foils need to maintain good L/D while keeping the lift almost constant over a wide range of speed, i.e. from little above take-off up to maximum speed.

Purpose of project

The purpose of the proposed project is to design a hydrofoil meeting the above mentioned requirements. Finding concepts that allow generating almost constant lift for a speed range reaching from 30 m/s to as low speed as possible will be a key task. This will go closely along with the development of a fully cavitating hydrofoil at 25 to 30 m/s free stream velocity featuring mechanisms to precisely control lift, as well as finding methods to avoid the unsteady, non-controllable transitional regime between non-cavitating and fully cavitating flow.

Methods, procedures and timeframe

To reach the purpose, in a first step the behaviour of different foil geometries at different speeds will be analysed, intending to clearly understand the physics and mechanisms of the transition from non-cavitating to fully cavitating flow. Then several concepts that permit precise lift control will be derived and evaluated. This will include designs similar to Schertel (see US patent no. 3,896,752), similar to Pearce (Pearce, B. W.: Ventilated Supercavitating Hydrofoils for Ride Control of High-Speed Craft, AMC, *University of Tasmania,* 2011) as well as adaptive profile methods and other ideas. From the gathered pool of concepts the most suitable one has to be chosen and finalized. The results are then to be verified by experiments and employed on the high-speed sailing boat currently developed.
The total time frame for the project is three years.

Significance

For almost 40 years hydrofoil boats can go roughly 50 kt with medium power requirement. Yet, running faster than 50 kt is a barrier for marine vehicles that could only be overcome by the excessive use of power on planning boats, not, however, by low-power foiling systems. The reason therefore is, that the inception of massive cavitation, which can no longer be avoided at that speed, could not be handled. With this work, not only the scientific quest for pushing limits will be met. Moreover, concepts will be derived, that allow marine vehicles (for leisure as well as for security and transport issues) to reach speeds well above 50 kt with limited power demands.