Project SHRED

Surfing Hydrodynamic Research using Engineering Design

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Introduction

Project Surfing Hydrodynamic Research using Engineering Design (SHRED) focuses on the design and wind tunnel testing of several surfboard fins through the application of aerospace industry practices. The project recently succeeded in the design, production, and test of a winglet fin. Wind tunnel tests were then conducted in the Embry-Riddle Aeronautical University Low-Speed Wind Tunnel located at the John Mica Engineering and Aerospace Innovation Complex (MicaPlex).

Abstract

The primary objective aerodynamic efficiency must be maximized to obtain directional stability, maximize velocity, and avoid stalling. In Phase I, five fins were manufactured and tested in the Micaplex, in which the saltwater conditions wherein surfboard fins operate were mimicked using the principle of dynamic similarity. The Winglet Fin was selected for further analysis in Phase II, in which surface oil flow visualization (SOFV) was utilized to inspect the surface flow over a range of angles of attack (α) to understand how fin geometry affects hydrodynamic performance. Force measurements were collected to verify estimated forces and stall angle. Surface flow patterns were observed over the α range. Locations of open and closed separation points, three-dimensional flow effects, and pre- and post-stall vortex behavior were detected. By applying technology normally reserved for aerospace applications, this project hopes to bring a more innovative culture to the surfing industry.

Winglet Fin

The modern winglet is a common performance enhancing device developed to overcome aerodynamic losses due to wingtip vortices. This motivated winglet implementation on a surfboard fin, which possesses similar characteristics to an aircraft wing.

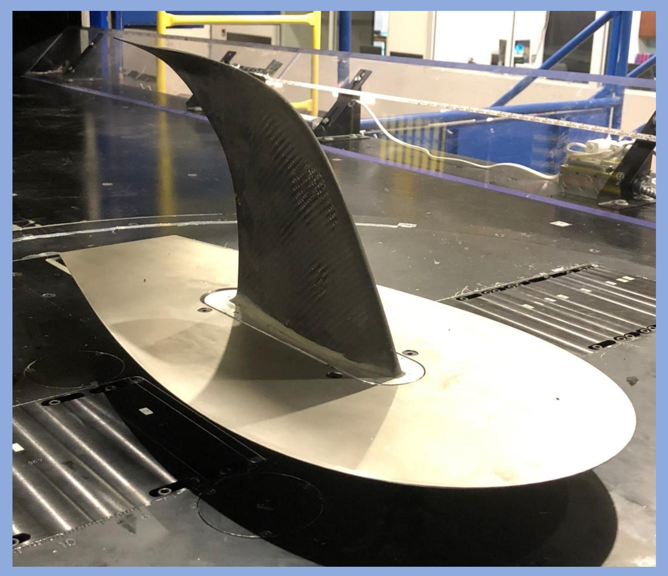

Figure 1: Completed 2:1 scale winglet fin model installed in the test section of the Micaplex Low-Speed Wind Tunnel.

Model Production

The fin was 3D-printed using Onyx™ filament (a nylon and chopped carbon fiber composite), and to increase the shear strength of and improve surface finish, a carbon fiber and epoxy resin wet layup was utilized. The model was sanded chordwise to a standard, 600-grit finish.

Figure 2: Applying the carbon fiber layup to the fin.

Figure 3: 20 lb. static load applied to the pressure surface of the WF while installed in mounting block.

Results

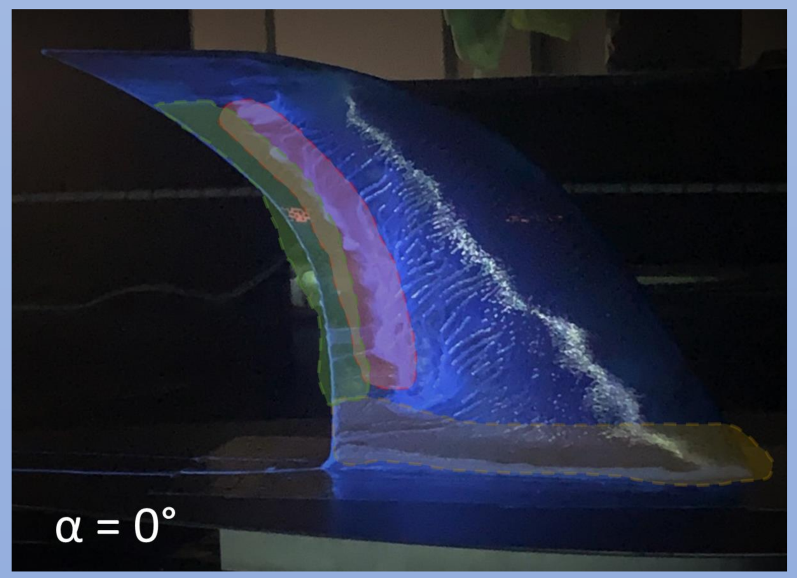

Figure 4: Regions of flow separation (green), splitter plate interference (orange), and a TESB (red) were observed..

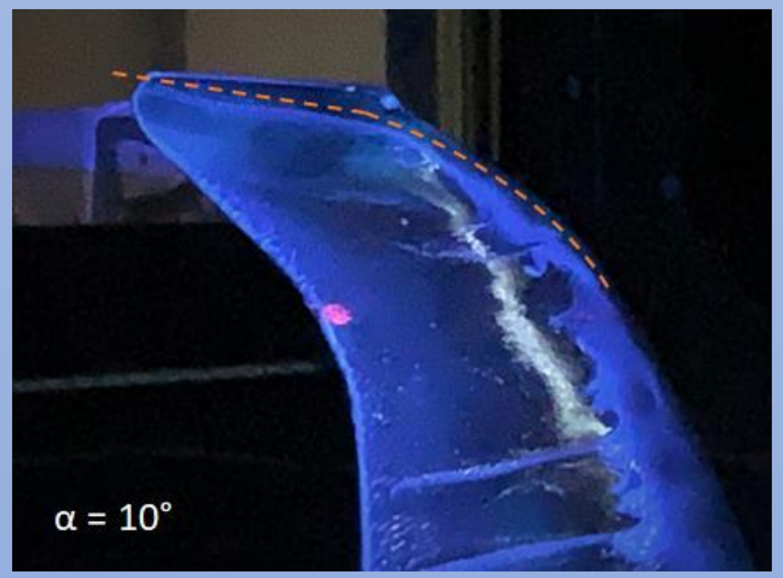

Figure 5: Oil is drawn from LESB into the turbulent regions towards the trailing edge due to increased shear stress in a turbulent boundary layer.

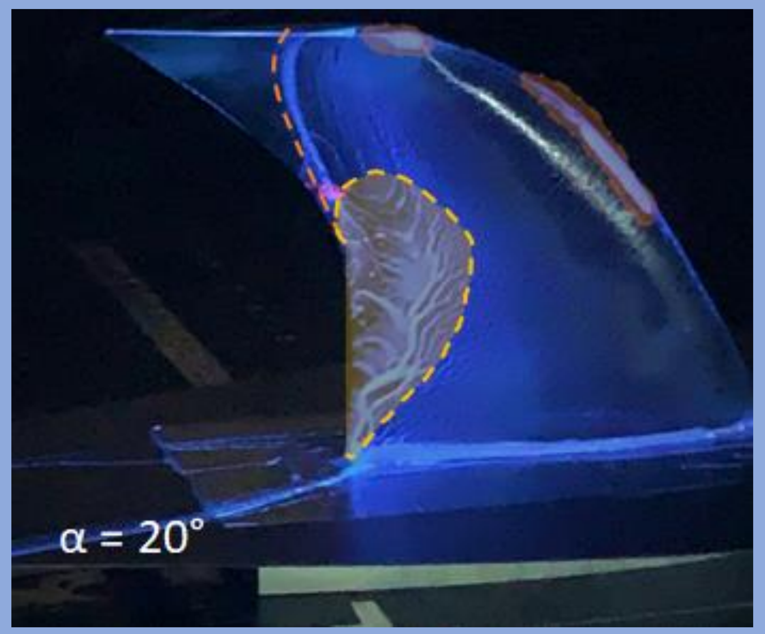

Figure 6: LESB (orange area), TESB (orange line), and area of strong gravity bias (yellow area) highlighted.

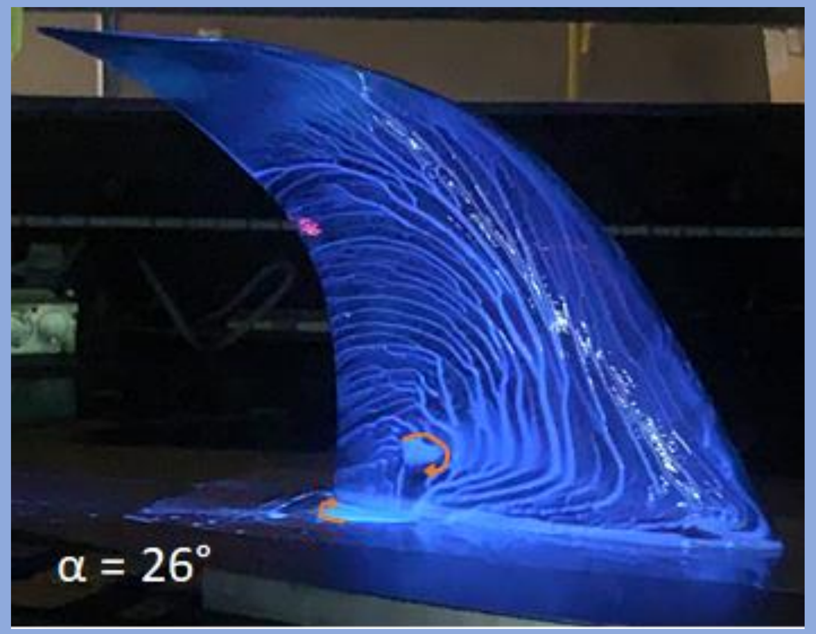

Figure 7: Post-stall flow showing recirculation over the surface of the fin and generated vortex direction.

Conclusions

Overall, several clear conclusions were able to be drawn from each yaw angle during the SOFV test through analyzing the qualitative data obtained during the tests. Closed and open separation regions were identified, surface flow patterns near the winglet and splitter plate were observed, leading edge separation was confirmed, and multiple vortices were documented. Regions of turbulence and high surface shear stress were also identified. Gravity bias was also observed and documented. These results will help further the designs of future surfboard fins in addition to serving as a proof of concept for this SOFV technique.

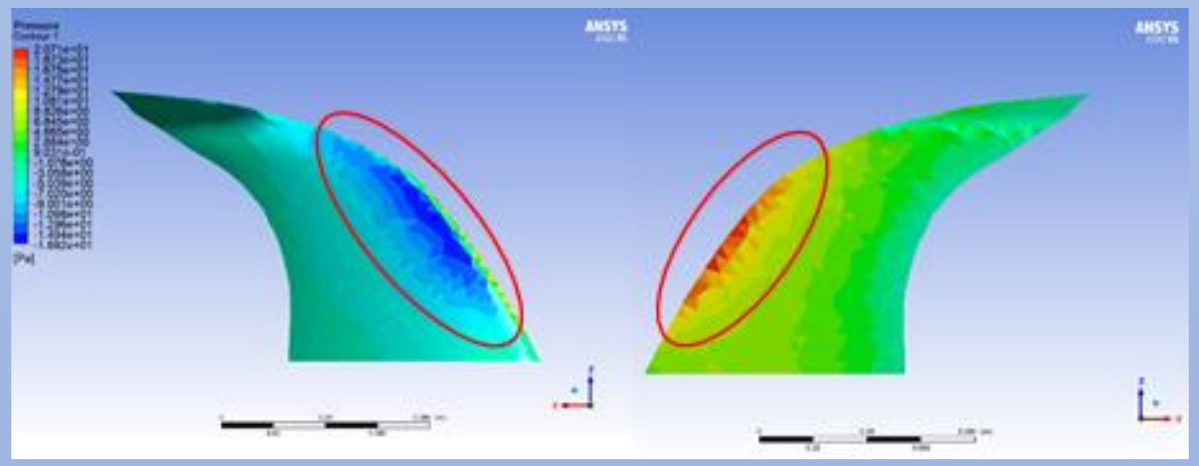

Figure 8. CFD Surface pressure visualization of the winglet fin

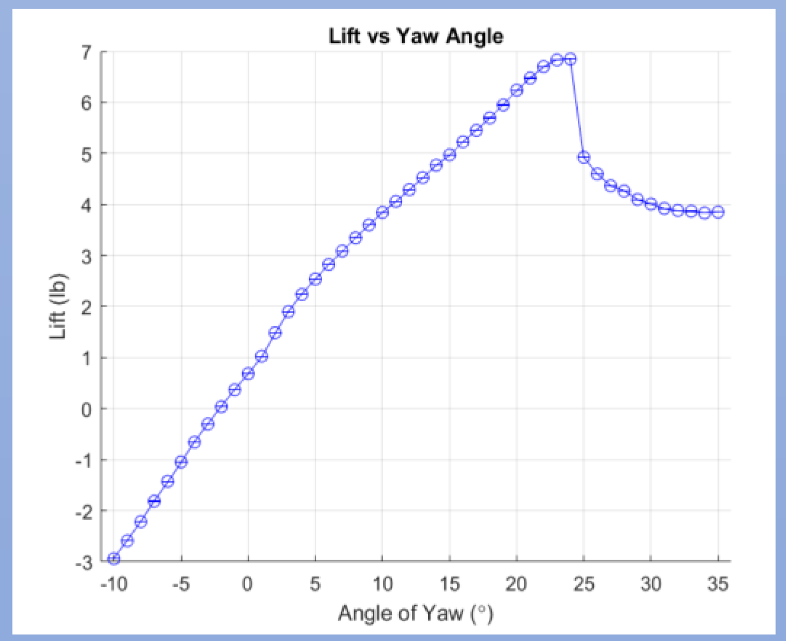

Figure 9: Lift curve developed from data obtained in static load testing of winglet fin.

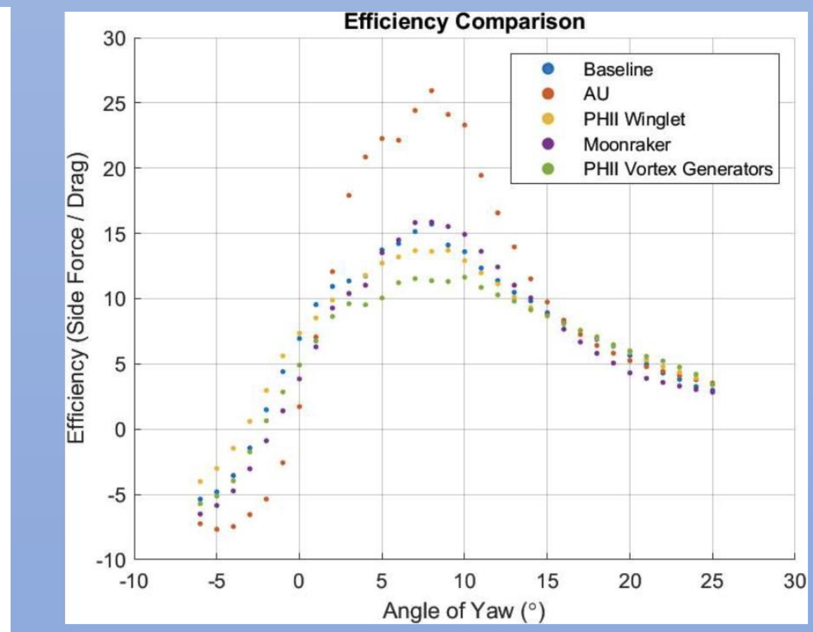

Figure 10: Average efficiency comparison of five fins tested in the low-speed wind tunnel.

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