Design of a High Speed Planing Hull with a Cambered Step and Surface Piercing Hydrofoils

LT Leon A. Faison, USN

Prof. Chryssostomos Chryssostomidis	Dr. Stefano Brizzolara
Thesis Supervisor	Thesis Advisor

Design of a high speed planing hull is analyzed by implementing a cambered step and stern, surface piercing hydrofoils, commonly known as a Dynaplane hull. This configuration combines the drag reduction benefits of a stepped hull with a fully ventilated afterbody by using a stern stabilizer. The largest obstacle with this design is maintaining trim control and stability at high speeds. There has been limited research on the Dynaplane design since Eugene Clement first conducted tow tank tests in the David Taylor Model Basin in the 1960s. Modern experimental methods such as computational fluid dynamics (CFD) allow the designer to run multiple simulations at once while testing a variety of parametric variables. The analysis in the design will combine theoretical, empirical, and computational methods to ultimately determine the hydrodynamic characteristics for such a design. The design approach begins with using a reference hull from a small systematic series of resistance tests at the DTMB, named Model 5631. This modeled hull is based on the U.S. Coast Guard 47' Motor Lifeboat which is a hard chine, deep V planing hull. Clement's Dynaplane design process was followed with exception of the stern stabilizer recommendation. Instead, a surface piercing, super cavitating hydrofoil designed by Dr. Stefano Brizzolara was used. Their designs further improve upon the powering requirements and effectively increasing the lift to drag ratio compared to a traditional transverse step. A commercially available CFD software package called Star-CCM+ is used for the computational portion. The test procedures require to first validate the computational model using results from the Model 5631 tow tank tests, then proceed with comparing empirical predictions with those results gathered from the computational model. Lastly, the computational results give hydrodynamic characteristics for the Dynaplane hull and provide predictions for dynamic instability. Three series of CFD tests were conducted; developing wake geometry predictions for a swept back, stepped hull, and then varying the trim angle and longitudinal center of gravity for the Dynaplane configuration. These tests were run at a volumetric Froude number of 5 in a calm sea state. Results from the analysis determine threshold values for trim angle and LCG location to avoid dynamic instabilities such as a bow drop occurrence or porpoising. Also, the results extend the range of application of Clement's Dynaplane design to hulls with 20 degree deadrise. This thesis gives naval architects design guidance for such a hullform and demonstrates the potential of CFD as a tool for analyzing these parametric variables.

Naval Engineer
Master of Science in Mechanical Engineering