Design of a Free-running, 1/30th Froude Scaled Model Destroyer for In-situ Hydrodynamic Flow Visualization

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ABSTRACT

Hydrodynamic flow visualization techniques of scaled hull forms and propellers are typically limited to isolating certain operating conditions in a tow tank, circulation tunnel, or large maneuvering basin. Although cost effective, these tests provide a limited perspective on the interactions of the entire system. Full-scale testing, other the other hand, provides real world data but is costly. In between, a Froude scaled, free-running model of an existing hull form controls costs but also provides superior hydrodynamic data that can be translated more accurately to full scale. This thesis details the design and construction of a 1/30th scale free-running model of the David Taylor Model Basin 5415 hull, the precursor to the ubiquitous Arleigh Burke Guided Missile Destroyer hull. The model serves as an experimental platform for advanced maneuvering and propeller crashback studies.

The propeller crashback (a core propulsion plant test for both the U.S. Navy and commercial vessels) imparts significant unsteady loads to the engineering plant and drive train. Each of these is respectively of interest to propeller designers and the Electric Ship Research and Development Consortium (ESRDC). The 1/30th scale model provides unsteady, time-resolved, accurate 3D flow visualization and propeller loading data as well as measurements of the effects on the electrical propulsion motors. Testing conducted with the model provides the real world effects of the propeller flow interaction with the hull and appendages.

The second area of research concerns the high inefficiencies of slender hull forms while maneuvering. During a turn, a significant amount of power is lost to the low pressure region developed on the inside of the turn from shedding vortices that originate along the keel. This increases the tactical diameter of the turn and reduces the turning efficiency of the vessel. Research is currently being conducted around controlling the shedding of vortices and keeping them attached to the hull thereby increasing the turning efficiency and decreasing the turning radius of the vessel. The final area of interest is in forward mounted podded propulsors for use on large vessels.

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