Parametric Optimization of Propeller Guards for Enhanced Hydrodynamic Performance and Acoustic Profile of Underwater Vehicles

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Increasing prevalence of remotely operated and autonomous underwater vehicles necessitates engineering propulsion systems that maximize thrust while aiming to limit anthropogenic-sourced noise pollution. While propeller guards alter hydrodynamics and can impact thrust and noise, research on underwater vehicle propeller guard optimization remains limited. Existing studies primarily focus on surface vehicles and open propeller designs, leaving a gap in understanding how guarded propellers influence underwater vehicle propulsion efficiency and an opportunity to make a positive environmental impact. This research employed parametric Computational Fluid Dynamics (CFD) to analyze 75 propeller guard configurations for optimal design identification. To validate these results, six guard configurations—selected from peaks and valleys in the parametric study across three guard lengths—were fabricated and tested in a custom-built apparatus to measure thrust generated and noise produced. Experimental results aligned with CFD predictions for thrust measurement. As thrust results were validated, all configurations from the parametric study that exceeded the open propeller's thrust level would yield higher thrust. Four of six experimental guards demonstrated noise reductions ranging from 0.01 dB to 10.29 dB less than the open propeller. The most efficient experimental propeller guard design increased thrust by 5.86% while reducing noise by 1.08 dB. This study demonstrates that propeller guards can be optimized to enhance underwater vehicle performance while simultaneously mitigating noise pollution. Future directions include exploring additional parameters to test, refinement of the testing apparatus, and evaluation of guarded propellers in real-world underwater vehicle applications.

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