Propeller Performance Analysis
Using Lifting Line Theory

LCDR Kevin M. Flood, USN

Richard W. Kimball	Prof. Mark S. Welsh
Thesis Supervisor	Thesis Supervisor

Propellers are typically optimized to provide the maximum thrust for the minimum torque at a specific number of revolutions per minute (RPM) at a particular ship speed. This process allows ships to efficiently travel at their design speed. However, it is useful to know how the propeller performs during off-design conditions. This is especially true for Naval warships whose missions require them to perform at a wide range of speeds. Currently the *Open-source Propeller Design and Analysis Program* can design and analyze a propeller only at a given operating condition (i.e. a given propeller RPM and thrust). If these values are varied, the program will design a new optimal propeller for the given inputs. The purpose of this thesis is to take a propeller that is designed for a given case and analyze how it will behave in off-design conditions.

Propeller performance is analyzed using non-dimensional curves that depict thrust, torque, and efficiency as functions of the propeller speed of advance. The first step in producing the open water diagram is to use lifting line theory to characterize the propeller blades. The bound circulation on the lifting line is a function of the blade geometry along with the blade velocity (both rotational and axial). Lerbs provided a method to evaluate the circulation for a given set of these conditions. This thesis implements Lerbs method using MATLAB® code to allow for fast and accurate modeling of circulation distributions and induced velocities for a wide range of operating conditions. These values are then used to calculate the forces and efficiency of the propeller. The program shows good agreement with experimental data.

Naval Engineer and Master of Science in Mechanical Engineering