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Computation Of Hydrodynamic Characteristics of A Marine Propeller Using Induction Factor Method Based on Normal Induced Velocity

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Abstract

In this study, induced velocity is determined with accuracy by overcoming the assumption of the vortex theory in calculating the induced velocity. The characteristics of a two bladed propeller are determined based on this velocity. The dominant parameters for the determination of the propeller characteristics are blade pitch angle, chord/diameter ratio, value of advance coefficient, position of blade sections and number of blades. The induction factor,the ratio of nomal induced velocities for helical and straight vortex respectively,is calculated to determin the normal induced velocity and then other characteristics.By keeping the values of propeller pitch and diameter constant with the filament of trailing vortices which produce helical surfaces extending infinitely backwards,the characteristics of propeller like lift coefficient, drag coefficient, thrust coefficient, torque coefficient and efficiency are derived for various blade sections and the values are compared with other experimental results.

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Keywords: Induction Factor Method; Normal Induced Velocity; Propeller Characteristics

1. Introduction

There have been many theories advanced to explain how a propeller produce thrust.Although the concept of most of the theories is quite simple, the mathematics can be quite complex and certain simplifying assumptions have to be made. Practical application of theories is possible using computers but one has to be careful in following theories and computer programs to avoid major mistakes. Therefore, the practical design of a propeller to suit a given set of conditions still often depends on the results of systemic experiments with model propellers. On the other hand, some theoretical knowledge of how a propeller works is essential to naval architects to guide them to the best propeller design.

If we look the historical development of the theories it must be mentioned that Rankine (1865) deduced the propeller forces from the motion of the fluid as it passes through the propeller and took into account blade friction. R.E. Froude (1889) extended the momentum theory[6] to take into account the reduction in the diameter of the slipstream. These theories give quite a bit of information about the propeller action and can be used to calculate the average velocity field around the propeller.

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The basis of modern propeller theories has been the treatise of Betz (1919) and Goldstein(1919) for the important case of optimum propellers[5]: Flow far behind the propeller can be regarded as that produced by rigid trailing vortex sheets receding with constant axial velocity. By Goldstein's solution it is possible to relate the circulation distribution of a propeller with a finite number of blades to one having an infinite number. The theory is called the lifting line theory and describes the relationship between the flow quantities at the lifting line and those for downstream.

The induced velocity field can then be derived by the laws of Biot-Savart. Many researchers have taken part in the development of these theories.

In this paper, based on Biot Savart Law, we calculated induction factor to calculate induced velocities and thus determined the characteristics of propeller [1]

Nomenclature

z	Number of propeller blades
D	Diameter of propeller
r	Radial distance of any blade element
n	Number of revolutions of the propeller per unit time
R	Radius of propeller
V_A	Speed of advance
Γ	Circulation around the blade
I	Induction factor
J	Advance coefficient
x	Non dimensional radius of any blade element
w_n	Normal induced velocity
V	Resultant velocity
C	Chord length

1.1. Propeller Forces and Moments

In the first phase of the design process no detailed data are needed for the flow around the propeller blades themselves but rather the disturbed flow field which interacts with the blade is needed.

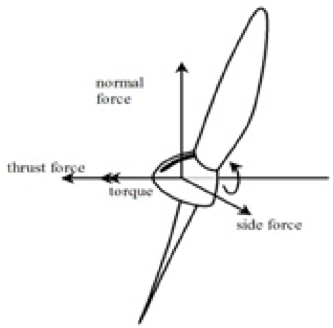

Fig. 1: The most important forces and moments acting on a propeller

In Fig. 1 the most important propeller forces and moments that act on the propeller are sketched. The main contributor to the ship performance is of course:

- the thrust force because of its important role in the thrust-resistance book keeping
- the propeller normal force for its direct contribution to the propeller lift coefficient and the considerable influence on the stability of the ship.