Numerical Analysis of Flow Around a Thruster

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Abstract

Recent developments in thruster design show an increasing interest in the application of thrusters at relatively high speeds and in higher required bollard pull. For free sailing condition this means a high free sailing open water efficiency of the unit. Performance of the bollard pull can be expressed in a so-called merit-coefficient (mc). This coefficient gives the non-dimensional ratio between thrust and torque of an installation. A high Merit coefficient represents a high bollard pull.

Steerable thrusters are available in a wide variety of configurations. The main components are in all configurations a fixed or controllable pitch propeller, a gearhouse and a strut or steering pipe. Many thrusters are equipped with a nozzle as well. The location of the propeller with respect to the strut results in a pushing or pulling type thruster.

The main differences with a single open or ducted propeller are the presence of the gearhouse and the strut. The effect of these two parts on the overall performance is twofold. Firstly, these parts can have a significant drag, which reduces the total unit thrust and secondly the inflow field to the propeller is affected by the strut especially in case of a pushing type unit. This can result in a change of the operating point of the propeller.

Research and development of propellers has been based on model scale measurements for decades. An interesting result of the experiments has been the development of a set of nozzles by MARIN, of which type 19A is the most commonly used (see for example Van Manen, 1957). Model scale experiments suffer from Reynolds scaling effects, which are compensated for by most model basins by means of empirical corrections in the extrapolation procedure. These scaling methods are based on normal ducted propellers in general. Scaling methods for thruster units are not straightforward. This can be attributed to the large variety of thruster configurations to a certain extent. Another aspect is the lack of understanding of the nature of the occurring flow phenomena and forces on the thruster unit. It is impossible to derive a good scaling method for a thruster unit without a good knowledge of the occurring flow phenomena.

The need for Reynolds scaling methods is eliminated, when the research is based on viscous numerical methods. These methods can be used to calculate the flow around a thruster unit both on model scale and at full scale. During the last decade the use of these methods, denoted as RANS methods, has increased enormously in industry. At Wärtsilä Propulsion Netherlands the numerical approach is used for many years to design the inlet geometry of waterjet propulsion systems (Verbeek&Bulten, 2001) and to determine open water performance characteristics of open and ducted propellers for example. One of the interesting conclusions of the calculations is the determination of the sensitivity of scaling on the bollard pull performance of the Lips-HR-nozzle. Calculations on both model scale and full scale have proven that there is a significant scaling effect on the bollard pull performance of the nozzle. This phenomenon will be discussed in more detail in this paper.

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The numerical method will be used to investigate the effect of the gearhouse and the strut on the open water performance of the thruster unit. Calculations are made on both model scale and full scale. The results of the model scale calculations are used for comparison with experimental data. In this way the accuracy of the numerical method is verified.

The results of the full scale thruster unit can be used to make a detailed investigation of the occurring flow phenomena. The forces, acting on the various parts of the thruster unit, like the propeller, nozzle and gearhouse, can be evaluated separately. This gives a clear picture of the thrust and drag forces acting on the separate parts. It will be shown that the actual drag of the thruster house can be divided in a component related to advance speed and a component related to propeller thrust. The latter is important at bollard pull conditions.

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