Development of Fishtail Rudder Sections with Higher Maximum Lift Coefficients

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ABSTRACT

This paper presents theoretical investigations on the performances of several kinds of fishtail rudder sections and hydrodynamic mechanism for generating higher lift forces due to the fish tails. The hydrodynamic forces acting on the sections and the flows passing them are calculated by using a CFD commercial code “Fluent”. At first, validation of the computed results is done by comparing the results with experimental results. Secondly, the effect of Reynolds number on the hydrodynamic forces are investigated. Thirdly, hydrodynamic characteristics of several kinds of rudder sections with different shape and fish tails are computed to find the effects of the cross section shapes and the size of fish tail on them.

KEY WORDS: Fishtail; rudder section; high lift, hydrodynamic forces.

INTRODUCTION

For better maneuverability or a smaller rudder of ships, rudders with higher lift and smaller drag have been sought. The ways to increase lift force of lift surfaces were comprehensively introduced in the text books written by Hoerner and Borst (1975) and by A.F. Molland and S.R. Turnock (2007). The books showed that a tail wedge foil, Fig.1a, increases its maximum lift by about 20-30% but is accompanied by higher drag.

Recently, fishtail rudders which have a similar tail shape to the tail-wedge foil are applied for many ships to get higher maneuvering performance due to their higher lift force. The rudders are called Schilling rudder. Maneuverability of pure car carriers (PCC) and VLCCs installed with the Schilling rudder was compared with the same ship installed with normal rudder (Hasegawa, 2004, 2006; Nagarajan, 2008). Their studies showed that Schilling rudder is superior to Mariner rudder not only from the aspect of maneuvering but also from the aspect of fuel efficiency under wind condition.

The hydrodynamic forces acting on the rudder of fish-shape section with end plates were studied by Yuda (2007, 2010a, 2010b) and Kimura (2008).

However, the mechanisms of high lift generation and smaller drag of fishtail rudders still have not been entirely clarified yet. In order to study the mechanisms and the effects of maximum thickness and trailing edge thickness on the lift and drag of fishtail rudders, twelve fishtail sections are designed and named as Fishtail 01~12, and the hydrodynamic forces and flows on/around them are computed in two dimensional flow by CFD in the present study.

RESEARCH BACKGROUND

The fishtail sections are defined as follows:

The maximum width is located at 20% of the chord length (c) from the head, taper to 80%, concave to 90% and flare to 100%.

The profiles of the developed fishtail-rudder sections and NACA0024 are shown in Fig.1b.

Fig.1a Wedge tail section.

Fig.1b Fishtail-rudder sections and streamlined foil NACA0024.

Twelve fishtail sections can be classified into three groups by maximum thickness (0.24c, 0.18c and 0.12c) and four groups by trailing edge thickness (0.026c, 0.052c, 0.07c and 0.09c) as can be seen in Table 1.

The purpose of these classifications is to reveal the effects of maximum thickness and trailing edge thickness on hydrodynamic forces of fishtail