International Journal of Offshore and Polar Engineering (ISSN 1053-5381)

Vol. 32, No. 3, September 2022, pp. 348–355; https://doi.org/10.17736/ijope.2022.ak47

http://www.isope.org/publications

Study of the Structural Effects on the Hydrodynamics of a Hollow Rectangular Cambered Otter Board Using the CFD Method

Yuyan Li*, Liuyi Huang† and Gang Wang
Fisheries College, Ocean University of China
Qingdao, Shandong, China

Qingchang Xu
Yellow Sea Fisheries Research Institute, China Academy of Fishery Science
Qingdao, Shandong, China

Mingxiu Jia
China National Fisheries Corp.
Beijing, China

In this study, hydrodynamic analyses were numerically performed for a hollow rectangular cambered otter board, which is adopted in Antarctic krill trawl fisheries. The Reynolds-averaged Navier–Stokes model was utilized in the CFD modeling. Its accuracy is validated by comparing its prediction with the experimental data. The results show that the lift coefficient and lift-to-drag ratio reach their maxima when the angles of attack are 25° and 10°, respectively. The lift coefficient increases with increasing aspect ratio and relative camber, whereas the lift-to-drag ratio increases with increasing aspect ratio. However, as the relative camber increases, the lift-to-drag ratio increases first and then decreases. Finally, minimizing the drag coefficient and maximizing the lift coefficient and lift-to-drag ratio are selected as the targets for the study, aiming to improve the hydrodynamic efficiency of the otter board during operations. The result indicates that the otter board has the best working efficiency when the aspect ratio is 2.06 and the relative camber is 0.10. Compared to the prototype otter board, the maximum lift coefficient and lift-to-drag ratio of the otter board with the best hydrodynamic properties in the investigated regions increase by 7% and 11%, respectively. This research has provided the scientific reference for the predesign and optimization of the hollow rectangular cambered otter board.

NOMENCLATURE

AOA	Angle of attack
AR	Aspect ratio
c	Chord
C_D	Drag coefficient
C_L	Lift coefficient
CFD	Computational fluid dynamics
ε	Turbulent eddy dissipation
f	Camber
F_D	Resistance
F_L	Lift forces
FFD	Full factorial design
Fr	Scale ratio in Froude criterion
k	Turbulent kinetic energy
l	Span
RC	Relative camber
Re	Reynolds number
S	Projected area
μ	Dynamic viscosity
V	Current velocity

*ISOPE Member; †Corresponding author.

Received February 28, 2022; updated and further revised manuscript received by the editors June 5, 2022. The original version (prior to the final updated and revised manuscript) was presented at the Thirtieth International Ocean and Polar Engineering Conference (ISOPE-2020), Shanghai, China (virtual), October 11–16, 2020.

KEY WORDS: Otter board, hydrodynamics, structural effects, CFD modeling.

INTRODUCTION

Otter board, known as the vital component for single-boat trawls, is used to keep the net mouth horizontally open during production states (Mukundan, 1970; Niedzwiedz and Hopp, 1998). Based on the previous research, the resistance of the otter board accounts for up to 30% of the total resistance of the trawl system (Sterling, 2000). The otter board adopted for use in Antarctic krill trawling has the unique feature of a high aspect ratio (AR), and its hollow structures result in low density, leading to different hydrodynamic performance than that of other kinds of otter boards. Hydrodynamic knowledge of the typical trawl door used in bottom trawls, which generally have ARs of approximately 1, cannot be directly referred to. Therefore, it is necessary to conduct a numerical study of this otter board, illustrating the unique dependencies of structural features on hydrodynamics.

In recent decades, the effects of structural factors on otter boards were investigated theoretically, experimentally, and numerically, presenting the improved properties of hydrodynamic efficiencies through optimizations. Kawakami (1953) proposed the theoretical formulae of the trawl system, including the relevance of the hydrodynamics of otter boards. Afterward, the hydrodynamics of varying types of otter boards were tested through flume tank experiments, such as simple camber and super V otter board (Lee et al., 1987), vertical V otter board (Matuda et al., 1990), cambered otter board (Park et al., 1996), biplane otter board (Fukuda et al., 1996), high lift V otter board (Yamasaki et al., 2007), and batwing otter board (Sterling, 2008). In recent years, the development of the computational fluid dynamics (CFD) method has contributed to the progress of hydrodynamic investi-