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PROCEEDINGS

Thrust Generation and Flow Structure of a Flapping Foil in a Stratified Flow

Jiadong Wang[1], Prabal Kandel[1] and Jian Deng[1,*]

[1] Department of Mechanics, Zhejiang University, Hangzhou, 310027, China

[*]Corresponding Author: Jian Deng. Email: zjudengjian@zju.edu.cn

ABSTRACT

The flapping foils with appropriate locomotion inspired by the high-aspect-ratio appendages from natural animals promise a new technical solution for the propulsion of both aircrafts and marine vehicles. The artificial devices using such a novel thrust system are possibly placed in a stratified flow due to the fact that the stratification is ubiquitous throughout real-world environment. Based on a series of two-dimensional numerical simulations, the propulsive performance and wake structure of a fully-activated flapping foil in a density stratified fluid are investigated in this work. It is found that the hydrodynamic characteristics of flapping foils in the stratified flow show an obvious difference with the homogeneous case. The current results indicate that the stratification effect can enhance the propulsion performance of flapping foils regarding both the thrust production and efficiency improvement. Especially, the high propulsive efficiency exceeding 70% is observed in the moderate-to-strong stratification level. The restoring effect of buoyancy in the stratified fluid is noted to inhibit the vertical development of flow structures but promote their horizontal growth, leading to the significantly different wake patterns in the stratified flow compared with the homogeneous counterpart. For a relatively strong stratification strength, the wake formation behind the flapping foil is identified to be a wavelike pattern dominated by the induced internal waves. By extending the flapping foil propulsors from homogeneous flow to stratified regime, the present study is expected to contribute to the propulsion community in facilitating the fundamental understanding of involved flow physics and accelerating the engineering application.

KEYWORDS

Biomimetic propulsion; flapping foil; stratified flow; internal waves

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