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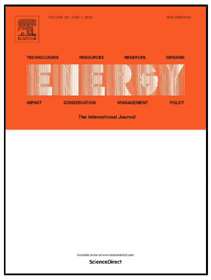

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Numerical analysis of a tidal current generator with dual flapping wings

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Abstract: Flapping wings, inspired by the mechanism of birds and fish, can act as generators to harvest energy from tidal currents. The hydraulic system is simplified as a spring-damper system to establish the coupling equations relating to the wing motion and the hydrodynamic forces. To provide guidance for design of a fully flow-induced flapping wings energy harvesting system, the behaviors of both system response and energy extraction performance are analyzed using two-dimensional numerical approach. Depending on the rotary actuator radius R, and the volume ratio β between the cylinder and rotary actuator, three distinguishable behaviors are observed in the system response and energy extraction performance. At larger R and smaller β, the dual wings tend to undergo a damped reduction flapping motion because the pitching motion consumes a significant amount of energy. Both decreasing R and increasing β can reduce the energy consumption of the pitching motion, and thus allow the dual wings to achieve a sustainable flapping motion. Although an irregular response can achieve a self-sustained flapping motion, it is unfavorable owing to its unstable power output. The regular response essential for stable energy harvesting is realized over a range of coupling parameters. The energy extraction performance of the system is closely associated with β but also slightly depends on R.

Keywords: tidal current generator; dual flapping wings; energy harvesting; hydraulic coupling system; system response; flow-induced;

1. Introduction

Tidal energy has been considered as an ideal alternative energy source to reduce dependence on fossil fuels. Conventionally, turbines with rotating blades are used for harnessing tidal energy. However, these devices are usually gigantic and have many negative effects on the environment and economy. Inspired by birds and fish, applying flapping wings to generators has gradually attracted increasing attention [1, 2].

In their early stages, studies on flapping wings mostly focused on the propulsion mechanism. If a wing is free to flap in both the pitching and heaving degrees of freedom, power can be transferred from the air or water to the wing. The application of flapping wings for extracting energy from a uniform flow was first proposed by Mackinney and Delaurier [3]. With the increasing importance of renewable energy, this concept has attracted more interest in recent years.

Following the study by Mackinney and Delaurier, Jones and Platzer studied the aerodynamics of a flapping wing using an unsteady panel code [4, 5]. Their results revealed that the wing could change from energy consumption to energy generation at a fixed flapping frequency and heaving amplitude