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Thrust Generation by Waves

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ABSTRACT

In this paper, from the viewpoint of thrust generation by waves, we discuss the fluid dynamics of two phenomena. One is a thrust generation by hydrofoil placed at the bow under water of a ship, and the other is a negative drift force acting on a floating oscillating water column (OWC) type wave energy converter "Backward Bent Duct Buoy (BBDB)" in particular wave frequency range.

A foil among waves can produce thrust. This may be utilized into ship propulsion in waves and reduction of mooring force of an ocean platform. We discuss the possibility of applying this phenomenon to ship propulsion and reduction of mooring forces.

In regard to BBDB, the mechanism of thrust generation and its characteristics are investigated by 2-D and 3-D tank tests and it is shown that this characteristic is very useful to reduce the wave drift force acting on BBDB in irregular waves.

KEY WORDS: Natural energy; wave energy conversion; ship; proplulsion; hydrofoil; thrust; OWC-type wave energy converter

INTRODUCTION

In this paper, from the viewpoint of thrust generation by waves, we discuss the fluid dynamics of two phenomena. One is a thrust generation by hydrofoil placed at the bow under water of a ship, and the other is a negative drift force acting on a floating oscillating water column (OWC) type wave energy converter "Backward Bent Duct Buoy (BBDB)" in particular wave frequency range.

Generally speaking, resistance of a ship becomes bigger in waves than in calm water. This phenomenon is well known to naval architects as the resistance increase of a ship in waves. It is, however, possible to convert wave energy into propulsive one by utilizing thrust generated by hydrofoil placed at the bow under water. Under a certain condition, a ship may advance at pretty high speed only by wave energy alone. Surprisingly enough, in 1895, Linden (The Naval Architect, 1973) filed a British patent on a ship which has a flexible hydrofoil at the bow and moves utilizing wave energy. According to the contemporary report, he really built two boats of 13 ft and 24 ft in length named Autonaut as shown in Fig. l, and the boat could move of their own motions due to waves against wind and wave at a speed of three to four knots. Some feasibility study is also conducted on the basis of the experimental results by Isshiki et al. (1986). In the feasibility study, a cargo ship of 80 m in length is assumed to navigate Japan-North America route in winter. According to the study, a very promising result is obtained. Namely, the ship speed of 7.10 knots in a wave most typical on the route is increased to 12.1 knots when a foil is attached to the ship. The speed in calm water is 11.4 knots.

Thrust generation by a hydrofoil in waves may also find an important application for easing mean and slowly varying force of an ocean platform in waves. In the present paper, some experimental results associated with the problem are reviewed, and the future research direction is discussed.

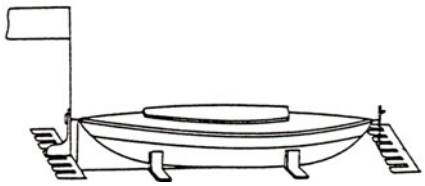

Fig. 1 Linden's Autonaut

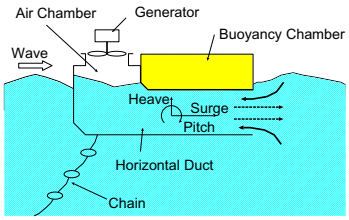

Fig.2 Principle of BBDB

"Backward Bent Duct Buoy (BBDB)" proposed by Masuda (1986) is an oscillating water column (OWC) type wave energy converter as shown in Fig. 2. It consists of an air chamber, an L-shaped duct, a buoyancy module, a turbine and a generator. The BBDB has some advantage. One of advantages is that BBDB advances slowly in a direction opposite to the wave propagation in some wave frequency