Proceedings of the Twenty-seventh (2017) International Ocean and Polar Engineering Conference **www.isope.org**
San Francisco, CA, USA, June 25-30, 2017

ISBN 978-1-880653-97-5; ISSN 1098-6189

Feasibility Study on Thrust Produced by Stabilizing Fins in Waves

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ABSTRACT

The topic of the paper is to answer the question whether wave energy can be utilized to propel a ship. In particular, whether a smart control of stabilizing fins may, in some conditions, produce a thrust easing the action of the propulsion system without losing its stabilizing function.

KEY WORDS: Stabilizing fins; wave energy utilization; propulsion.

INTRODUCTION

The idea behind the described research comes from full-scale observations made on-board a large passenger vessel, where a bow-wise oriented force acting on a stabilizing fin was detected.

Stabilizing fins are commonly used, in particular in passenger ships, as a mean to dampen an unwanted roll motion. In still water or in head seas they are retracted in order not to produce additional resistance to the ship. Although the control logic of stabilizing fins is not clear to the authors, it seems that normally they are controlled to maximize damping roll moment without much concern for the resistance.

The idea of using oscillating fins to propel a ship, as an alternative to the traditional marine propeller, has been studied for over a century. This research stems from biomimetics, that is from the imitation of the models, systems, and elements of nature, which in this case is fish propulsion. A comprehensive review of this research is given by Politis & Politis (2014). From a hydrodynamic standpoint, the concept has potential for increasing the propulsive efficiency if adequate mechanisms are used (Martio and Caja, 2016).

The current idea, discussed in the following, is to transfer ship movement caused by the waves to the forward oriented force acting on the stabilizer fins and thus save energy. The origin of this idea is not new. Fixed, controlled and flapping fins attached to a ship hull were investigated by many researchers. A particularly valuable and fresh contribution, in the form of experimental evidence and a successful simulation model, is given by Bøckman (2016). Bøckman (2016) gives also a good review of the research related to this topic. Politis & Politis (2014) present an interesting active pitch control method to produce thrust of a wing propulsor under random heaving conditions.

In this paper we concentrate on application of stabilizing fins to generate additional thrust to a ship. In particular, we focus on the feasibility of using stabilizing fins in a number of realistic operational conditions, including oblique waves and large ship motions, that result in a thrust generated similarly as by oscillating foils in still water.

A 6 degrees-of-freedom ship dynamics model, called LaiDyn (Matusiak, 2013), is used as the platform for studying the possibility of generating thrust by proper control of stabilizing fins. A quasi-steady potential flow assumption is made when evaluating fin forces with the lifting line model. The kinematics of flow at the fins is governed by ship motion, wave action and fin angles. The viscous effects are taken into account in an approximate semi-empirical manner. An algorithm for fin angle control is derived yielding maximum thrust.

Simulations are conducted for a passenger vessel considering three different configurations of stabilizing fins in two sea states represented by irregular long-crested waves and three ship headings. Moreover, the case of no fins, fixed fins and fins controlled to produce the maximum thrust are considered.

CASE STUDY

The investigated case is a passenger vessel of the main dimensions presented in the table below.