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Development of a Novel Device for Harnessing Wasted Energy Behind a Marine Propeller

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Abstract

The energy dissipated due to the movement of fluid for the rotation of a propeller is somewhat wasted. A novel device is developed to harness this energy installing aturbine with zero pitch behind the ship propeller. Experiments are conducted with turbine having various radii and numbers of blades. The distance of the turbine from the ship propeller is varied and its effect is observed. For different arrangements, the energy harnessed by the turbine and the reduction in ship speed due to the presence of the device were measured. Data found in the experiment was used to find out a regression relationship among the parameters and a C++ program was developed to find out the optimum radius and number of blades of turbine and its distance from the propeller. The rotary motion of turbine can be used for driving generator to produce electricity to be consumed by the ship itself.

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Keywords: Energy dissipation; marine propeller; turbine; rotary motion; generator; wasted energy

1. Introduction

Almost all of the ships run either on heavy fuel oil, low sulfur oil or diesel oil. It is estimated that world fleet oil consumption is about 289 million metric ton annually [1]. To reduce this consumption, various attempts are being made, one ofwhich is the addition of propeller/stator arrangement.It can be useful to recover energy lostin the wake-dueto the rotational motion of the fluid particles behind a propeller. The efficiency of this device depends on theradius shown byextensive research on the propeller/stator propulsor [2]. On the other hand, Lee, Bae, Kim and Hoshino[3] worked on contra rotating propeller. However, their work was based on Computational Fluid Dynamics (CFD). Our attempt focuses on finding an optimum number and radius of blades of the turbine and its distance from the propeller from the experimental data. Efficiency increases with the increase of blade number for propeller/stator propulsor. But for contra-rotating propeller/propeller stator arrangement, it is seen that there is a maximum number and radius of blades for which energy loss is minimum. The concept of zero pitch was first introduced by GrimseLeitrad[4]. For harnessing the rotary motion of fluid zero pitch and zero rake propellers were used during the experiments as turbines. The data were collected for a total of 16 turbines of various radius at various distances. These data are then analyzed to

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develop a relation for finding out the optimum number and radius of blades and the distance from the main propeller. The optimization was completed using a C++ program. Hence, the developed device may be able to lessen the load on ship's primary generator and reduce fuel consumption.

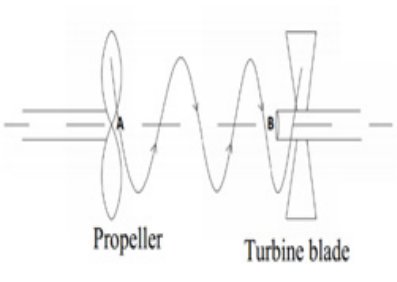
Nomenclature

P_{BE}	Power of the main engine of the ship
P_{DP}	Power developed by the propeller
P_{DT}	Power developed by the turbine
K_{QP}	Torque coefficient of propeller
K_{QT}	Torque coefficient of the turbine
P_{BG}	Power developed at the generator
Q_P	Torque created by the propeller
Q_T	Torque created by the turbine
ω_P	Angular velocity of the propeller
ω_T	Angular velocity of the turbine
n_p	Revolution per second of the propeller
n_T	Revolution per second of the turbine
η_E	Efficiency of the ship engine
η_H	Efficiency of the wake between propeller and turbine
η_T	Efficiency of the turbine
η_{final}	Final efficiency of the device

2. Theory

2.1. Basic Idea

a



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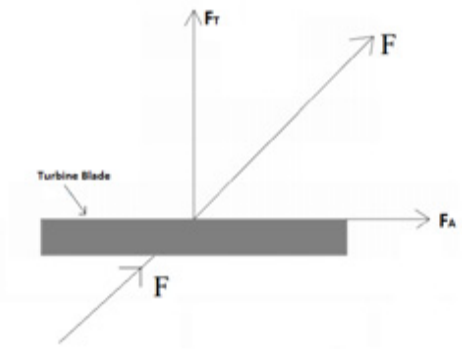

Fig. 1: (a) Side view of Propeller and turbine; (b) Top view of the turbine ;

A rotating propeller creates trailing vortex behind it and the slipstream has a swirling motion. The force created by this motion, **F**, has two components- $\mathbf{F_T}$ and **FA** as shown in Fig. 1. $\mathbf{F_A}$ creates the thrust which makes the advance velocity, $\mathbf{V_A}$. The other force, $\mathbf{F_T}$, is usually wasted. However, this force can be used to rotate a turbine to generate power. But there will be hydrodynamic loss in the wake AB as shown in the Fig.1 (a).