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Stern Flap Application on Planing Hulls to Improve Resistance

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Abstract
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Abstract

Drag is one of the main factors in improving fuel efficiency. Various study in regards to improve drag performance of a planing hull amongst them is a stern flap. The main parameters to design a stern flap are span length and angle of stern flap. The stern flap works by changing pressure distribution over the ship's bottom and creating a lift force on the stern transom part. This study aims to analyze the behavior of stern flap in variations of span length and angle of stern flap towards drag performance of Fridsma hull form. Finite Volume Method (FVM) and Reynolds-Averaged Navier-Stokes (RANS) are used to predict the hull resistance during simulations. Results show that shear drag is very sensitive towards the total drag value, proving that shear drag valued at least 60% of the total drag in each planing hull multi-phase characteristics phase. Stern flap with 58% of hull breadth span length installed at 0° is considered the most optimal, reducing 10.2% of total drag, followed by 18% displacement reduction. In conclusion, the stern flap effectively improves the Fridsma hull's total drag and its components on 0.89 < Fr < 1.89. © 2022, Materials and Energy Research Center. All rights reserved.

Author keywords

Drag; Finite volume; Lift force; Planing Hull; Shear force; Stern Flap

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Stern Flap Application on Planing Hulls to Improve Resistance

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ABSTRACT

Drag is one of the main factors in improving fuel efficiency. Various study in regards to improve drag performance of a planing hull amongst them is a stern flap. The main parameters to design a stern flap are span length and angle of stern flap. The stern flap works by changing pressure distribution over the ship's bottom and creating a lift force on the stern transom part. This study aims to analyze the behavior of stern flap in variations of span length and angle of stern flap towards drag performance of Fridsma hull form. Finite Volume Method (FVM) and Reynolds-Averaged Navier - Stokes (RANS) are used to predict the hull resistance during simulations. Results show that shear drag is very sensitive towards the total drag value, proving that shear drag valued at least 60% of the total drag in each planing hull multi-phase characteristics phase. Stern flap with 58% of hull breadth span length installed at 0° is considered the most optimal, reducing 10.2% of total drag, followed by 18% displacement reduction. In conclusion, the stern flap effectively improves the Fridsma hull's total drag and its components on $0.89 < Fr < 1.89$.

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NOMENCLATURE

y+	Boundary layer thickness	d_i	Vertex's displacement
L	Ship's length	n	Number of vertices
Re	Reynold's number	$subjc_j^2$	Basis constant
C_f	Friction coefficient	r_{ij}	Magnitude between two vertices
Δt	Time steps	λ_j	Expansion coefficient
U	Ship speed	α	Constant value
Fr	Froude number	Δ	Displacement
LCG	Longitudinal center of gravity	B	Breadth of the ship
VCG	Vertical center of gravity	T_{AP}	Draft of the ship
I_{yy}	Momen inertia at y axis	τ_o	Trim angle
I_{zz}	Momen inertia at z axis		

1. INTRODUCTION

Planing hull has very complex characteristics, especially during high-speed performance. Due to cost-related issues, the need to improve resistance performances of a planing hull emerges. Planing hulls have also been one of the most challenging problems for the naval architecture community as large hull motions complicate hydrodynamic calculations and hull optimization [1].

There has been a great deal of research towards saving devices to increase ship performance. Examples include microbubble injection method, stern wedges, tunnel stern, stern flap, and stepped hull. Yaakob [2] studied stern flap effect on a planing hull, resulting in 7.2% reductions in total drag.

Planing hulls are considered suitable to apply stern flap. That corresponds to the pressure drag value on the hull's bottom at a tangential angle between hulls and the water surface [3]. A boat or ship can be categorized as

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Design and Real Time Digital Simulator Implementation of a Takagi Sugeno Fuzzy Controller for Battery Management in Photovoltaic Energy System Application

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A B S T R A C T

This paper presents a acomprehensive design and control strategy for a photovoltaic (PV) energy storage system. The system consists of a 2kW photovoltaic system, two converter circuits, a resistive load of 6 Ohm and a lithium-ion battery storage integrated with DC Bus applying constant power to the resistive load. This scheme offered two converter topologies, one is a boost converter and another is a DC/DC bidirectional converter. The boost converter is directly connected in series to the PV array whereas the bidirectional DC/DC converter (BDC) is connected to the battery. The boost converter is used to regulate the maximum power point tracking (MPPT) of the PV array. Closed-loop control of the bidirectional controller is implemented with Takagi-Sugeno Fuzzy (TS-Fuzzy) controller to regulate the battery charging and discharging power flow. The proposed scheme provides a good stabilization in the DC bus volatge. Simulation results of the proposed control schema under MATLAB/Simulink are presented and compared with the Proportional Integral (PI) controller. The simulation results obtained from MATLAB are verified on Real Time Digital Simulator (RTDS).

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NOMENCLATURE

I_{pv}	Current from PV cell in amps	V_{oc}	Open-Circuit voltage of PV array in volts
I_O	Reverse saturation current of diode in amps	I_{sc}	Short circuit current of PV array in amps
η	Diode ideality factor	L	Inductor of boost converter in henry
V	Voltage across diode in volts	Io	Output current of boost converter in amps
V_T	Thermal voltage in volts	C_2	Output capacitor of boost converter in farads
V_{mp}	Voltage of PV array at MPP in volts	ΔI_L	Ripple current of bidirectional converter
I_{mp}	Current of PV at MPP in amps	V_O	Output voltage of boost converter in volts
Fsw	Switching frequency in kHz	$Vbat$	Battery voltage in volts
ΔV	Output voltage ripple of boost converter	ΔV_{dc}	Ripple voltage of bidirectional converter
Δi_l	Output current ripple of boost converter	V_{dc}	Voltage of DC bus in volts
D	Duty cycle	ΔI_L	Ripple current of bidirectional converter
Vin	Input voltage of boost converter in volts	I_{bat}	Battery current in amps

1. INTRODUCTION

Sustainable energy has played a vital role to control the global emission. Over the last few decades on average, 300GW renewable energy sources (RES) were grown in the year between 2018 and to reach the goal of the Paris agreement, according to the IEA'S Sustainable Development Scenario (SDC). A country like India has a significant advantages as there is a huge potential for sustainable energy resources. In 2023, the installed renewable energy capacity will be account for 35% [1]. The installed capacity of renewable energy in India is about 150GW in which wind power is 40.08GW, 49.34GW solar power, 10.61GW bio power, 4.83GW

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Installation Depth and Incident Wave Height Effect on Hydrodynamic Performance of a Flap Type Wave Energy Converter: Experimental Analysis

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ABSTRACT

The effect of installation depth and height of the incident wave on the hydrodynamic and economic performance of an oscillating wave surge converter (OWSC) wave energy converter is crucial. In this study, an OWSC by considering 1:8 scale has been studied under Caspian Sea wave conditions for 8 water depths from the semi-submerged to fully submerged. The study has been conducted to achieve the best draft ratio and evaluate the systems performance imposed to Caspian waves condition by experimantal method.The results are presented in three parts. The first part studied the converter's flow, power, and sensitivity to the installation depth on a laboratory scale. In the second part, the system results were converted to the main scale 1:8 by using Froude scaling method, and finally, the performance from an economic view evaluated. Results showed that the draft depth has a non-linear effect on the power. System's power in the dimensionless draft depth of 0.59 is better, and can produce 61 kW. Also, it can pump up to 50 l/s of water. Likewise, suppose the system is used for electricity generation, In that case, it sells $22500 of electricity to the grid annually, and if it is used as a pump, it can supply water to 4710 households on average.

***doi**: 10.5829/ije.2022.35.12c.02*

Symbols

d	Draft (meters)	*P*	Power (W)
H	Incident wave height (meters)	*Q*	Flow (cubic meters per second)
h	Water depth (meters)	*AEP*	Annual Energy Production (MWh)

1. INTRODUCTION

Today, fossil fuel resources have increased due to the high rate of population growth and industry development. Fossil fuels can cause many problems like rising atmospheric carbon dioxide, global warming, and climate change [1]. Therefore, the development of technologies that can produce economical and clean energy from renewable energy sources has become one of the main goals of modern industrial societies. Renewable energy sources include wave energy, solar energy, wind energy, and geothermal energy. Ocean wave energy has a higher energy density than other energy sources. Global wave energy sources are estimated to be more than 1 TW [2].

Wave energy converters come in various designs and sizes that use a wide range of energy conversion techniques. Oscillating Wave Surge Converters (OWSC) is a type of wave energy converters with a higher theoretical efficiency due to oscillations in surge direction [2]. OWSC is designed for areas near the coast, with water depths between 10 and 20 meters [3]. The energy conversion chain in these converters has three stages; In the first stage, the flap is affected by the force of the wave, due to the oscillating motion of the flap, the wave energy is converted into mechanical energy; In the second stage, mechanical energy is converted to potential energy stored in the fluid by the power transmission system, and in the third stage, to convert the energy of the

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