Energías Renovables Marinas

Las trasparencias son el material de apoyo del profesor para impartir la clase. No son apuntes de la asignatura. Al alumno le pueden servir como guía para recopilar información (libros, …) y elaborar sus propios apuntes

Departamento: **Ingeniería Eléctrica y Energética**
Area: **Máquinas y Motores Térmicos**

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Energías Renovables Marinas

- Introducción
- Panorama Energético Nacional
- Algunas "Curiosidades"
- Las EERR en la Unión Europea
- Visión de las Energías Renovables

Parte 1ª

- Búsqueda de Información Científica — Parte 2ª — Virtual
- Energías de las Olas, Mareas y Corrientes — Parte 3ª
- Tecnologías de Aprovechamiento — Parte 4ª — Virtual
- Energía Térmica Marina — Parte 5ª
- Turbinas Hidráulicas — Parte 6ª
- **Velas** — Parte 7ª
- Algas Marinas — Parte 8ª

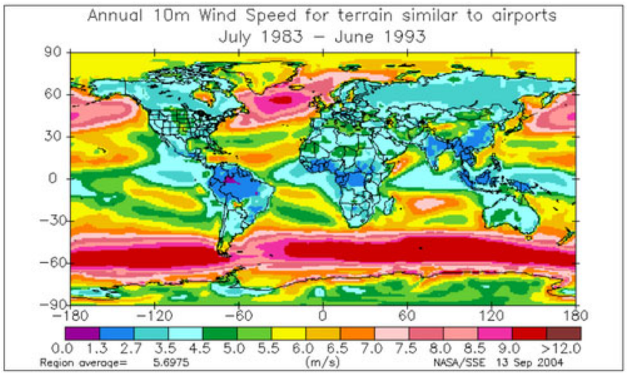
Velas

Viento

Movimiento en masa del aire de acuerdo con las diferencias de presión atmosférica

Son fruto de la diferencia de absorción de energía solar entre distintas zonas, y/o de la inercia y la fuerza centrífuga producidas por la rotación del planeta

Durante siglos ha sido la principal fuente de energía utilizada para la propulsión marítima

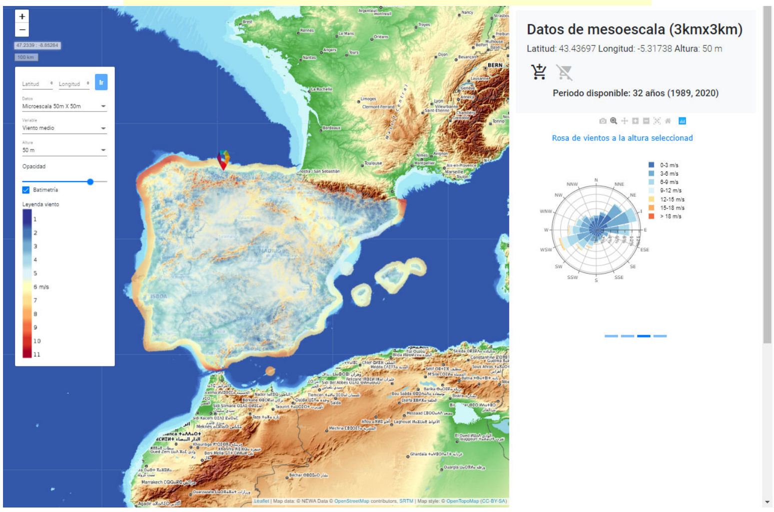


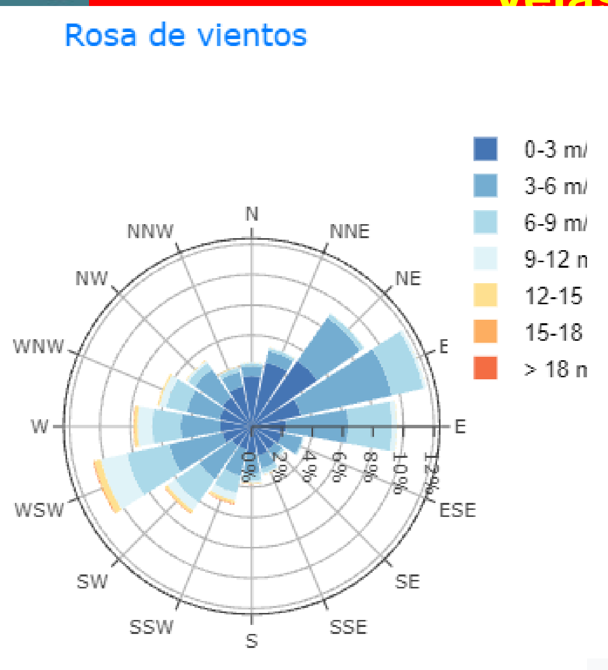
Velas

Rosa de los Vientos

Indica la dirección y velocidad predominante de los vientos en una determinada zona

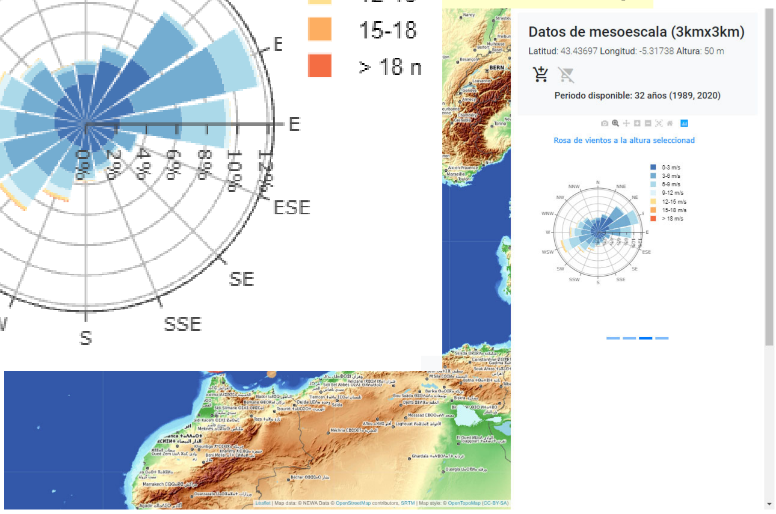
https://www.mapaeolicoiberico.com/map





…minante de los vientos en una

…berico.com/map



Velas Tradicionales

Velas

Velas Rígidas

Tienen un perfil similar al ala de un avión y se sitúan en vertical, por lo que convierten el efecto de sustentación en empuje

Se pueden girar 360º, por lo que permiten cambiar su orientación para aprovechar al máximo la dirección del viento

Se pueden plegar para evitar problemas con el mal tiempo o en las maniobras en puerto del buque

Puede ser una vela única, o tener un flap (alerón) final que permite modificar su geometría y orientación para optimizar su rendimiento en condiciones cambiantes de viento

Velas

Velas Rígidas

Tienen un perfil similar al ala de un avión y se sitúan en vertical, por lo que convierten el efecto de sustentación en empuje

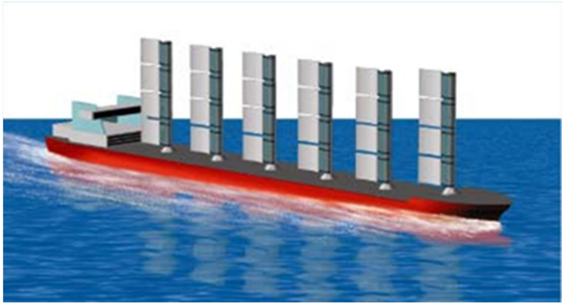
Se pueden girar 36... aprovechar al máxi...

Se pueden plegar ... maniobras en puert...

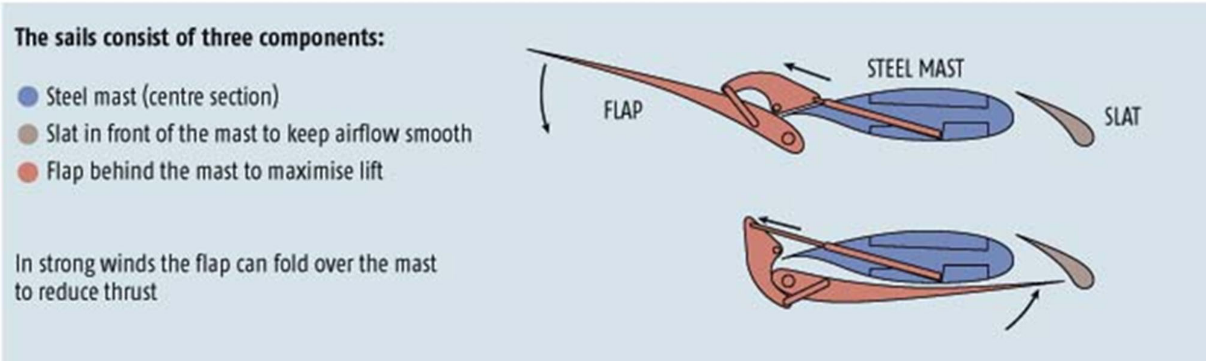
Puede ser una ve... modificar su geom... condiciones cambia...

Velas

Velas Rígidas



The sails on the Danish windship (right) are shaped like aerofoils to obtain the maximum amount of thrust from the wind



Velas

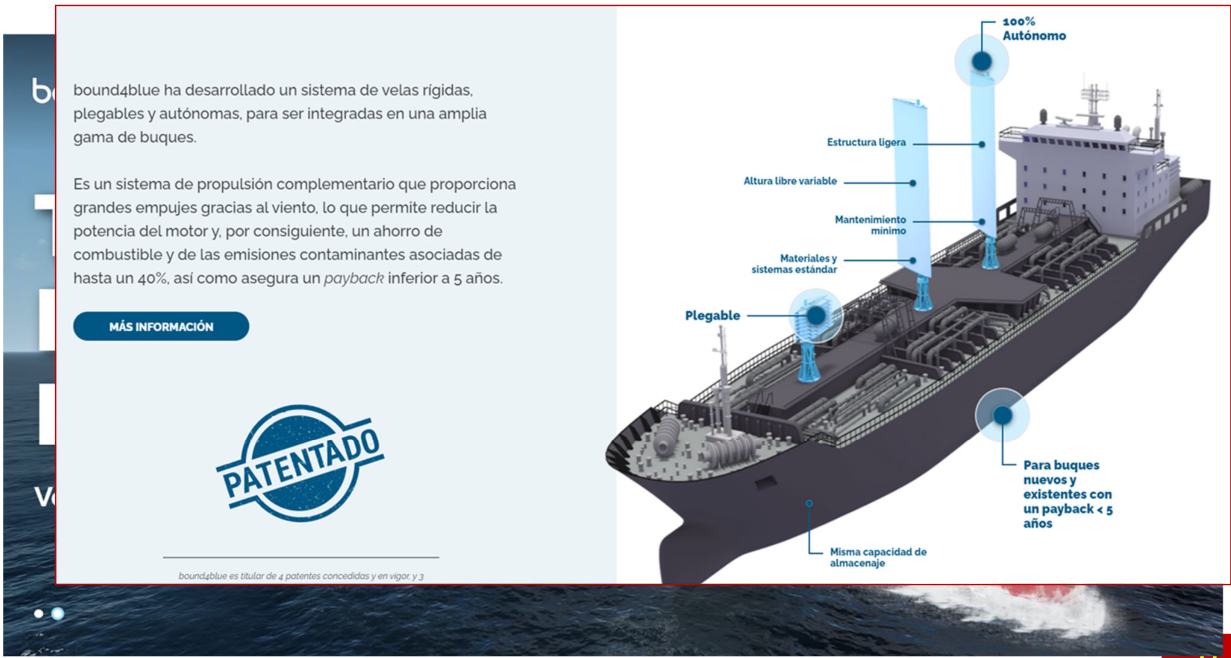
Velas Rígidas

https://bound4blue.com/es/

Velas

Velas Rígidas

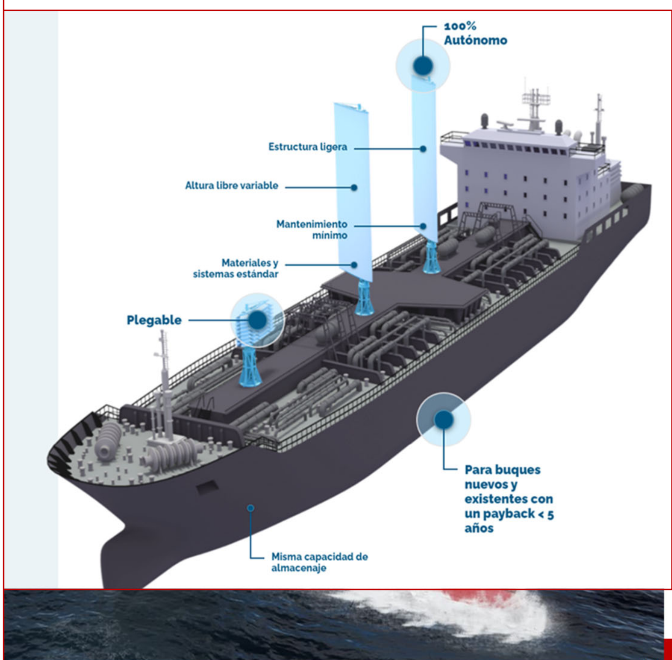
https://bound4blue.com/es/

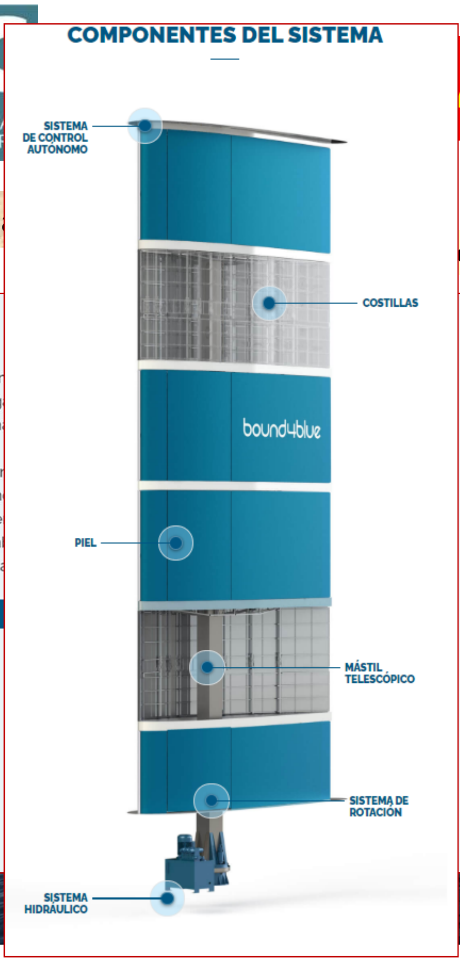


Velas

Vela

d4blue.com/es/





Velas

Velas Rígidas

Journal of Marine Engineering & Technology

Taylor & Francis

ISSN: 2046-4177 (Print) 2056-8487 (Online) Journal homepage: https://www.tandfonline.com/loi/tmar20

Analysis of drag, airflow and surface pressure characteristics of a segment rigid sail

Gregory Mark Atkinson & Jonathan Binns

To cite this article: Gregory Mark Atkinson & Jonathan Binns (2018) Analysis of drag, airflow and surface pressure characteristics of a segment rigid sail, Journal of Marine Engineering & Technology, 17:3, 143-152, DOI: 10.1080/20464177.2018.1492341

To link to this article: https://doi.org/10.1080/20464177.2018.1492341

Published online: 04 Jul 2018.

JOURNAL OF MARINE ENGINEERING & TECHNOLOGY 2018
VOL. 17, NO. 3, 143–152
https://doi.org/10.1080/20464177.2018.1492341

Velas

Velas Rígidas

Atkinson et al., *Cogent Engineering* (2018), 5: 1543564
https://doi.org/10.1080/23311916.2018.1543564

cogent engineering

MECHANICAL ENGINEERING | REVIEW ARTICLE

Considerations regarding the use of rigid sails on modern powered ships

Gregory Atkinson[1*], Hung Nguyen[2] and Jonathan Binns[2]

Received: 13 September 2018
Accepted: 30 October 2018
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Reviewing editor:
Duc Pham, School of Mechanical Engineering, University of Birmingham, UK

Additional information is available at the end of the article

Abstract: The global shipping fleet is vital to world trade with billions of tonnes of cargo being transported annually by merchant vessels. This activity however results in large volumes of carbon emissions and airborne particulate matter being released into the atmosphere due to the burning of fossil fuels for propulsion and on-board power. Recently, there has been an increasing focus on the need to reduce fossil fuel consumption and airborne emissions across the shipping sector. To facilitate this, a range of technologies have been developed or are currently in the development phase. Rigid sails are one of these technologies, yet despite these being installed on a number of ships in the 1980s they have to date been unable to gain widespread acceptance. This paper will briefly discuss the history of sails on ships and then review a broad range of issues regarding their use encompassing previous research studies, journal articles and operational experiences.

Subjects: Ship Operations; Ship Building Technology & Engineering; Sustainable Transport Engineering; Clean Technologies; Novel Technologies; Renewable Energy

ABOUT THE AUTHORS

Gregory Atkinson is the Chief Technology Officer at Eco Marine Power (EMP). He is a Fellow of the Institute of Marine Engineering, Science and Technology (FIMarEST), a Fellow of the Royal Institution of Naval Architects (FRINA) and currently a part-time student at the Australian Maritime College, University of Tasmania.

Jonathan Binns is an associate professor and is the Associate Dean Research, Australian

PUBLIC INTEREST STATEMENT

The use of rigid sails on powered ship potential to reduce fuel consumption NO_x SO_x emissions from a wide range going ships. Despite this they are curr widespread use even though trials du 1980s confirmed their effectiveness i fuel consumption. This study briefly r use of sails on powered ships and identifies a range of key areas related to the use of rigid

COGENT ENGINEERING 2018
Vol 5: 1543564
https://doi.org/10.1080/23311916.2018.1543564

Velas

Velas Rígidas

Journal of Sustainable Development of Energy, Water and Environment Systems
Year 2016
Volume 4, Issue 1, pp 1-13

Wing Sails for Hybrid Propulsion of a Ship

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e-mail: Branko.Klarin@fesb.hr

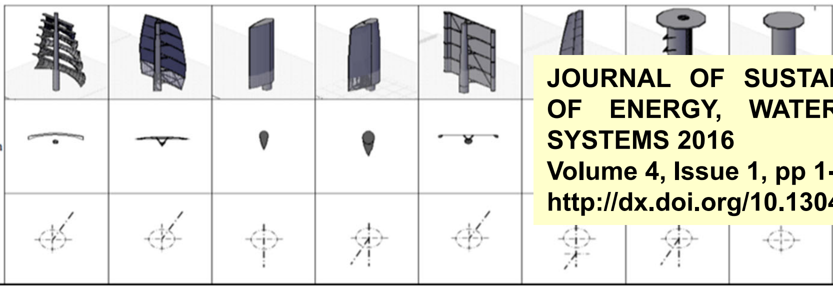
Cite as: Milić Kralj, D., Klarin, B., Wing Sails for Hybrid Propulsion of a Ship, J. sustain. dev. energy water environ. syst., 4(1), pp 1-13, 2016, DOI: http://dx.doi.org/10.13044/j.sdewes.2016.04.0001

ABSTRACT

e increasingly being applied in transportation. Wing sails
n to a motor-driven ship, thereby decreasing fossil fuel
utes to the selection and consideration of the influencing
ils for ship propulsion. Basic developmental factors and
escribed. In addition, influential parameters and their
arameters are connected to the physical and mechanical
eir impact on propulsion. It is important to recognize
fluential parameter in relation to the final achievement.
ibed for several common types of sails, to find the best
influencing parameters on wing sails can significantly
. The aim of this study was to note the parameters that
ships more efficiently. Their importance is explained in
ost important sail types. This article evaluates the main
i-rigid wing with additional circulation for hybrid
should be focused on this wing. Finally, guidelines for
es in future wing sails are provided, which may assist
rts to discover a better solution for ship propulsion.

Table 1. Drag and lift coefficients for different types of sails and their cross sections, axis of rotation, chord direction and auxiliary chord direction [13-17]

	Classic sail	Indo-sail	Rigid sail, i.e. wingsail	Rigid sail, i.e. wing sail with flap	Japanese sail	Two-component semi-rigid wing sail	Cousteau-Pechiney turbo-sail	Flettner rotor
Drag coefficient	0.65	0.46	0.27 - 0.17	0.65 - 0.45	0.58	*** 0.20 - 0.25	** 1.2 - 1.8	* 0.5 - 4 - 5.6
Maximum lift coefficient	0.9 - 1	1.5	1.1 - 2	1.8 - 3.5	1.5 - 2	4 - 5	5 - 6.5	0 - 7 - 13
Sail or wingappearance								
Typicalcross-section								
Axisofrotation, chord direction and auxiliary chord direction								



JOURNAL OF SUSTAINABLE DEVELOPMENT OF ENERGY, WATER AND ENVIRONMENT SYSTEMS 2016
Volume 4, Issue 1, pp 1-13
http://dx.doi.org/10.13044/j.sdewes.2016.04.0001

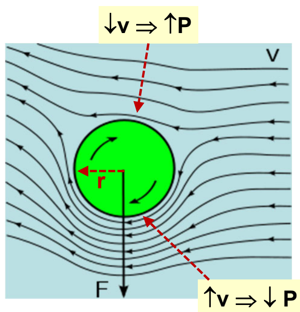
Velas

Rotor Flettner

https://es.wikipedia.org/wiki/Efecto_Magnus

Es un sistema de impulsión eólica para naves, inventado a inicios del siglo XX por Anton Flettner haciendo uso del efecto Magnus

Un objeto en rotación crea un flujo rotacional a su alrededor. Sobre un lado del objeto, el movimiento de rotación tendrá el mismo sentido que la corriente de aire a la que el objeto está expuesto, y la velocidad se incrementará. En el otro lado, el movimiento de rotación se produce en el sentido opuesto a la de la corriente de aire y la velocidad se verá disminuida.



La presión en el aire se ve modificada desde p_{atm} en una cantidad proporcional a v^2, con lo que la presión será menor en un lado que en otro, causando una fuerza perpendicular a la dirección de la corriente de aire

$$\frac{F}{L} = \rho \cdot V \cdot (2 \cdot \pi \cdot \omega \cdot r^2)$$

Velas

Rotor Flettner

El control de revoluciones incrementa su rendimiento en condiciones menos favorables de viento

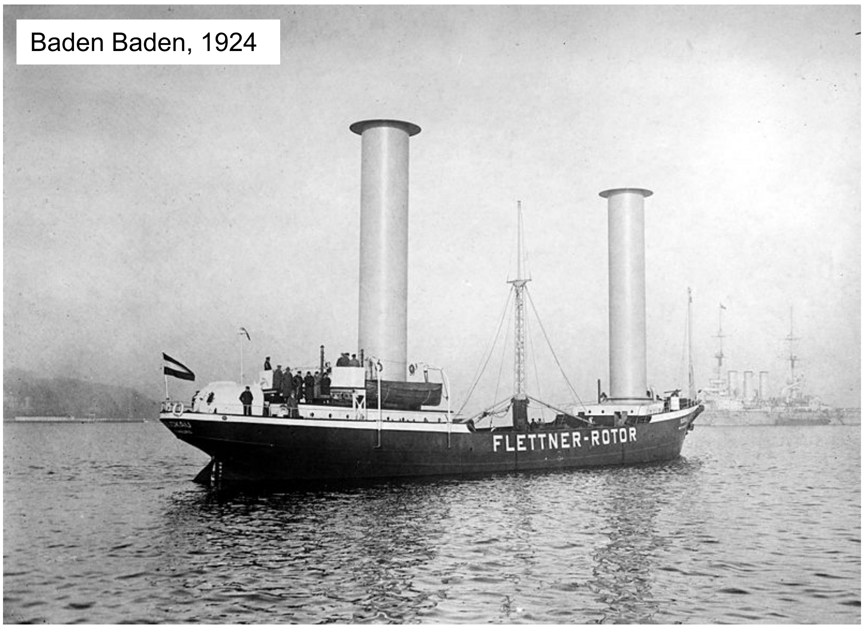
Permiten plegarse para no dificultar las maniobras en puerto

Velas

Rotor Flettner

https://vadebarcos.net/2014/04/28/buques-rotores-flettner-e-ship-1/

Baden Baden, 1924



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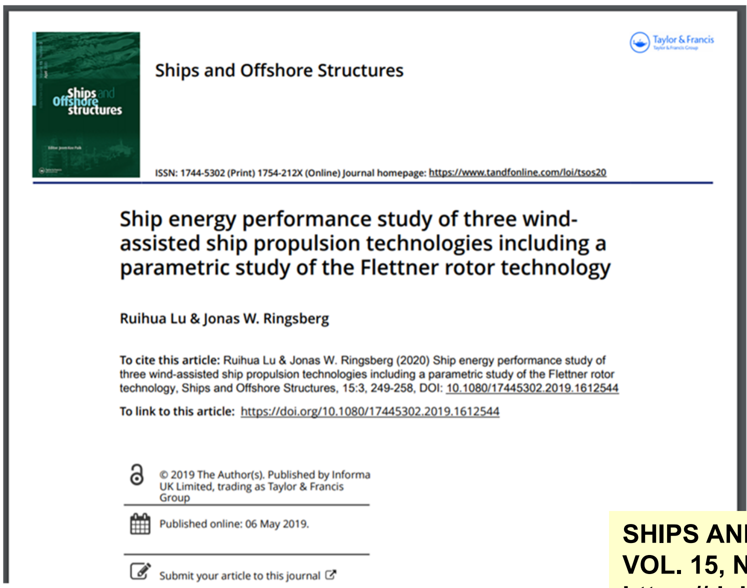
Rotor Flettner

https://vadebarcos.net/2014/04/28/buques-rotores-flettner-e-ship-1/

Velas

Rotor Flettner



Ships and Offshore Structures

Taylor & Francis

ISSN: 1744-5302 (Print) 1754-212X (Online) Journal homepage: https://www.tandfonline.com/loi/tsos20

Ship energy performance study of three wind-assisted ship propulsion technologies including a parametric study of the Flettner rotor technology

Ruihua Lu & Jonas W. Ringsberg

To cite this article: Ruihua Lu & Jonas W. Ringsberg (2020) Ship energy performance study of three wind-assisted ship propulsion technologies including a parametric study of the Flettner rotor technology, Ships and Offshore Structures, 15:3, 249-258, DOI: 10.1080/17445302.2019.1612544

To link to this article: https://doi.org/10.1080/17445302.2019.1612544

Published online: 06 May 2019.

SHIPS AND OFFSHORE STRUCTURES 2020
VOL. 15, NO. 3, 249–258
https://doi.org/10.1080/17445302.2019.1612544

Velas

Rotor Flettner

Journal of Wind Engineering & Industrial Aerodynamics 196 (2020) 104024

Contents lists available at ScienceDirect

Journal of Wind Engineering & Industrial Aerodynamics

journal homepage: www.elsevier.com/locate/jweia

The effects of the aerodynamic interaction on the performance of two Flettner rotors

G. Bordogna [a,*], S. Muggiasca [b], S. Giappino [b], M. Belloli [b], J.A. Keuning [a], R.H.M. Huijsmans [a]

[a] Section of Ship Hydromechanics, Delft University of Technology, Mekelweg 2, 2628 CD, Delft, the Netherlands

[b] Department of Mechanical Engineering, Politecnico di Milano, Via La Masa 1, 20156, Milan, Italy

ARTICLE INFO

Keywords:
Flettner rotor
Rotating cylinder
Aerodynamic interaction
Rotor sail
Magnus effect
Wind assisted ship propulsion

ABSTRACT

Flettner rotors are nowadays becoming a widespread solution for wind-assisted propulsion. To increase the fuel savings of the ship on which they are installed, multiple devices are typically used. However, in the performance estimate of these hybrid ships, it is currently assumed that Flettner rotors operate independently, regardless of the number of devices employed and their relative position on the ship's deck. The present investigation deals with a wind-tunnel experimental campaign aimed at understanding the aerodynamic interaction effects on the performance of two similar Flettner rotors. The study indicates that the aerodynamic performance of the two Flettner rotors is affected by their interaction, and, generally, this is most noticeable when the devices are set closer to each other and when they are aligned with the wind direction. It is demonstrated that, depending on the apparent wind direction, the layout of the Flettner rotors on the ship's deck has a remarked influence on the driving and heeling force coefficients of the entire rig. Lastly, the velocity ratio is found to ... of how the interaction affects the Flettner rotor aerodynamic performance.

1. Introduction

In the context of wind-assisted propulsion, Flettner rotors are currently attracting increasing interest as a viable technology to reduce the fuel consumption of commercial ships. The Flettner rotor is a rotating ...

by each of the installed devices, i.e. the ... are fully disregarded (Li et al., 2012; T... 2014; De Marco et al., 2016). On the ot... the interaction effects are taken into a... aerodynamic force is assumed. Eggers... reduction in lift force to the leeward ...

JOURNAL OF WIND ENGINEERING AND INDUSTRIAL AERODYNAMICS 2020
Vol 196,104024
https://doi.org/10.1016/j.jweia.2019.104024

Velas

Rotor Flettner

Environmental Science and Pollution Research (2021) 28:32695–32707
https://doi.org/10.1007/s11356-021-12791-3

RESEARCH ARTICLE

Harnessing wind energy on merchant ships: case study Flettner rotors onboard bulk carriers

Ibrahim S. Seddiek [1] · Nader R. Ammar [2,3]

Received: 3 June 2020 / Accepted: 31 January 2021 / Published online: 25 February 2021

Abstract

Shipping faces challenges of reducing the dependence on fossil fuels to align with the international regulations of ship emissions reduction. The maritime industry is in urgent need of searching about alternative energy sources for ships. This paper highlights the applicability of harnessing wind power for ships. Flettner rotors as a clean propulsion technology for commercial ships are introduced. As a case study, one of the bulk carrier ships operating between Damietta port in Egypt and Dunkirk port in France has been investigated. The results showed the high influence of the interaction between ship course and wind speed and direction on the net output power of Flettner rotors. The average net output power for each rotor will be 384 kW/h. Economically, the results reveal that the use of Flettner rotors will contribute to considerable savings, up to 22.28% of the annual ship's fuel consumption. The pay-back period of the proposed concept will be 6 years with a considerable value of levelized cost of energy. Environmentally, NO_x and CO_2 emissions will be reduced by 270.4 and 9272 ton/year with cost-effectiveness of $1912 and $55.8/ton, respectively, at annual interest rate of 10%.

Keywords Wind energy · Flettner rotor · IMO · Ship emission reduction · Cost-effectiveness

Introduction

More than 90% of the international trade is transported by ships (Jiang et al. 2018; Pasha et al. 2020). In year 2019, about 92,295 ships of 1.98 million deadweight shared in the maritime field activities, and more than 60,000 ships transported billions of tons of cargo worldwide (UNCTAD 2019). On the other hand, this growth contributed significantly to increasing the amount of emissions from ships. Annually, vessels emit large quantities of pollutants into the air, principally in the form of nitrogen oxide (NO_x), particulate matter (PM), and sulfur oxide (SO_x), which have been steadily expanding and affect human health (Ammar and Seddiek 2018, 2020; Seddiek 2016). Latest statistics revealed that maritime transport is responsible for producing 3% of the world's total greenhouse gas emissions, contributing to global warming and extreme weather effects (Abdelkhalek et al. 2014; Bouman et al. 2017; Sadek and Elgohary 2020; Seddiek 2017; UNCTAD 2019).

In continuous steps, the International Maritime Organization (IMO) seeks to reduce the adverse effect of ship

Responsible editor: Philippe Garrigues

ENVIRONMENTAL SCIENCE POLLUTION RESEARCH (2021)
Vol 28 pp
https://doi.org/10.1007/s11356-021-12791-3

Velas

Cometas

Consisten en un cometa de forma similar a un parapente, sujeto por un cable que tracciona el buque desde la proa

Se pueden replegar en temporales o entradas a puertos, por lo que no dificultan las maniobras

Operan a alturas entre 100 y 300 metros, donde los vientos son más fuertes y constantes, por lo que aprovechan más energía que las velas tradicionales

Proporcionan empuje ascensional en proa (la levanta), lo que aumenta el asiento de la popa favoreciendo el funcionamiento y rendimiento de la hélice

Velas

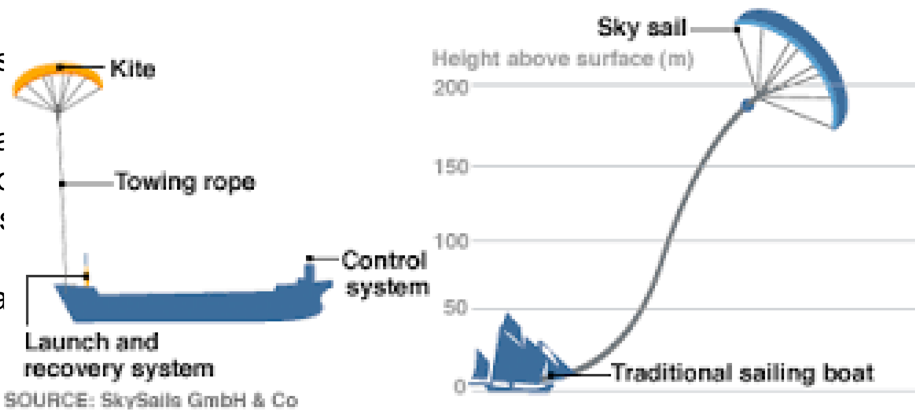
Cometas

Consisten en un cometa de forma similar a un parapente, sujeto por un cable que tracciona el buque desde la proa

Se pueden ... no
dificultan las

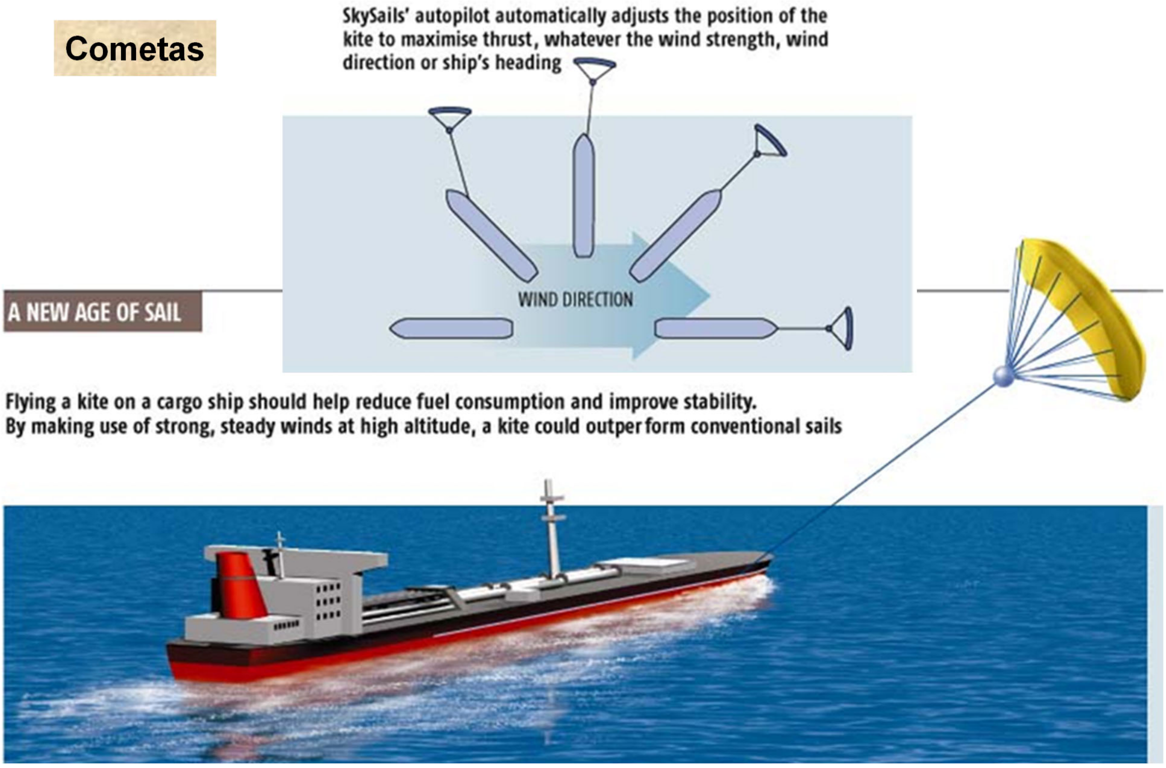
Operan a ... ás
fuertes y c ... as
tradicionales

Proporciona ... el
asiento de ... la
hélice



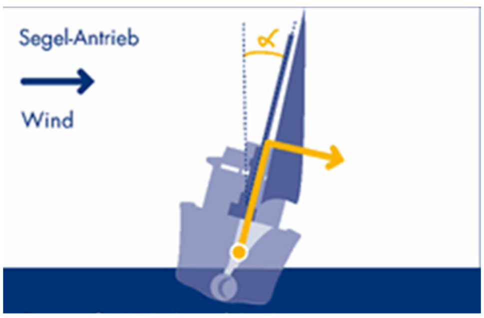
Velas

Cometas



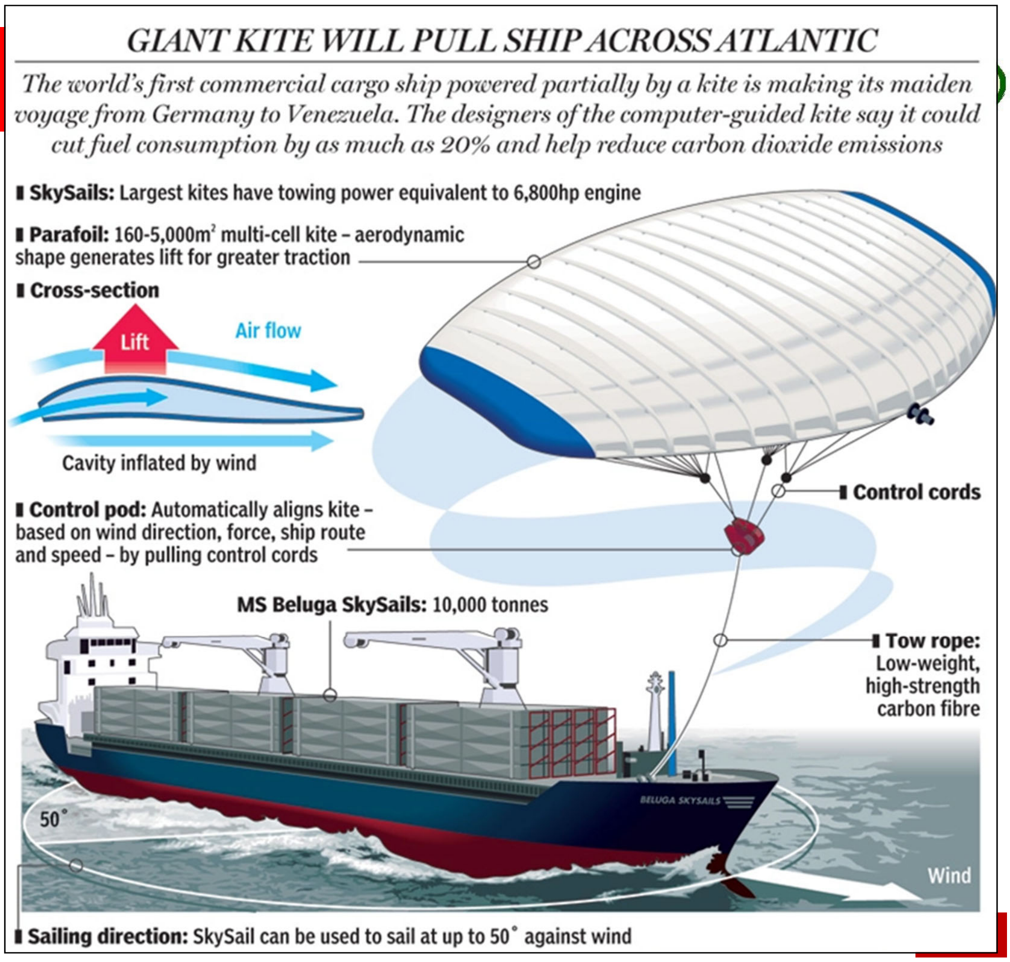
Velas

Cometas

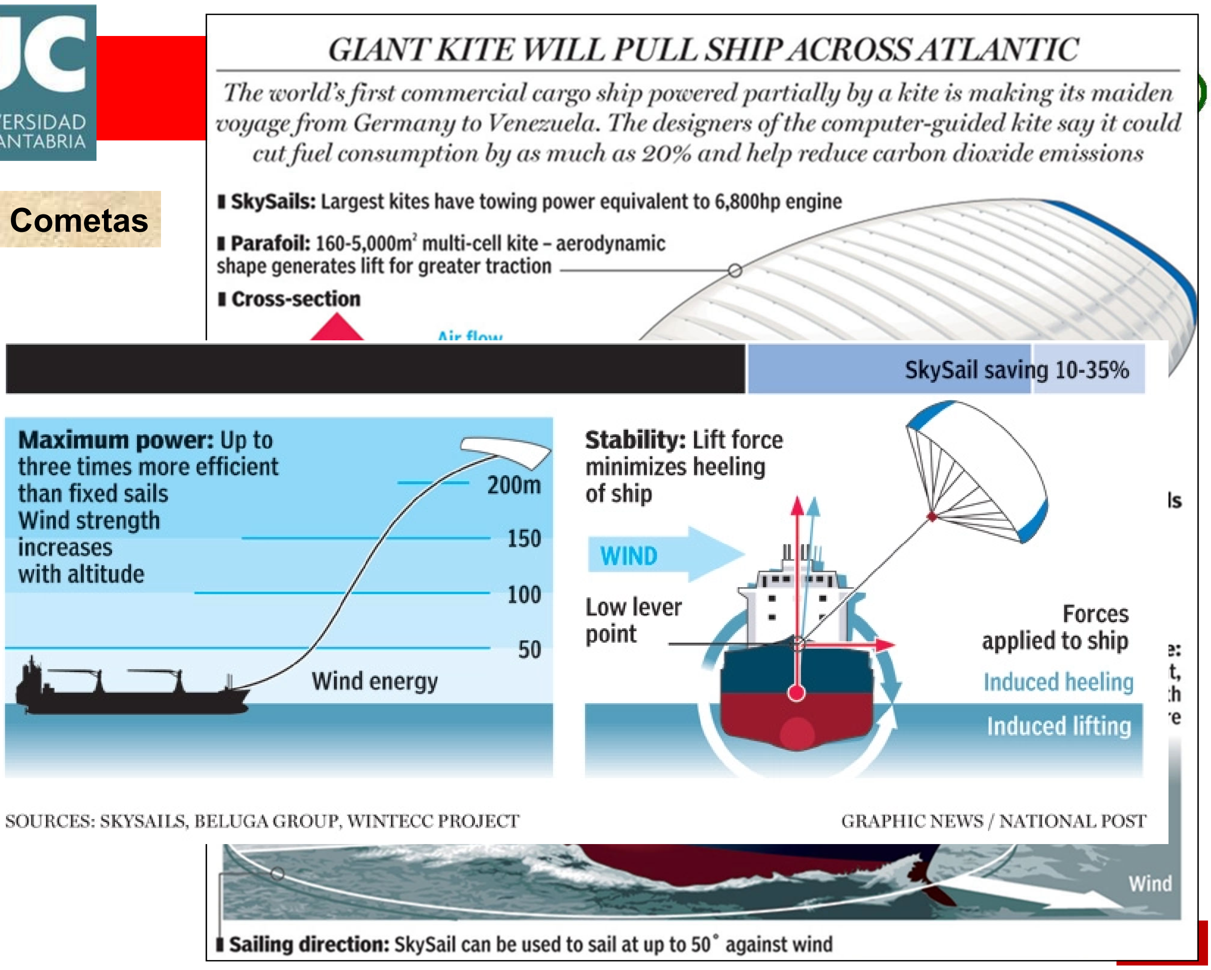


Produce una escora menor que una vela tradicional

Cometas

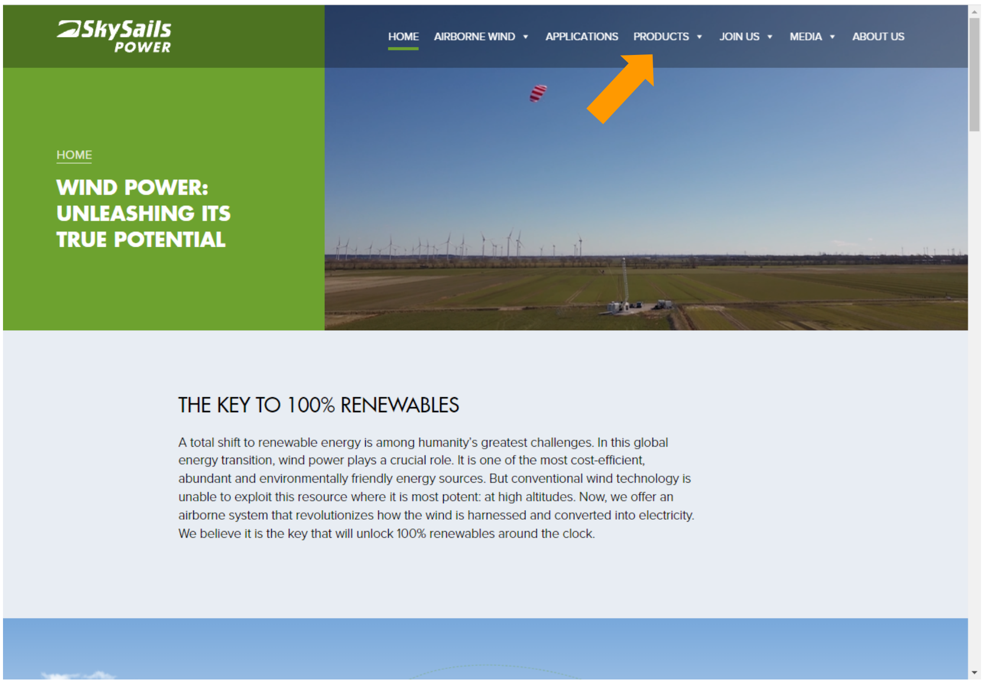


Cometas

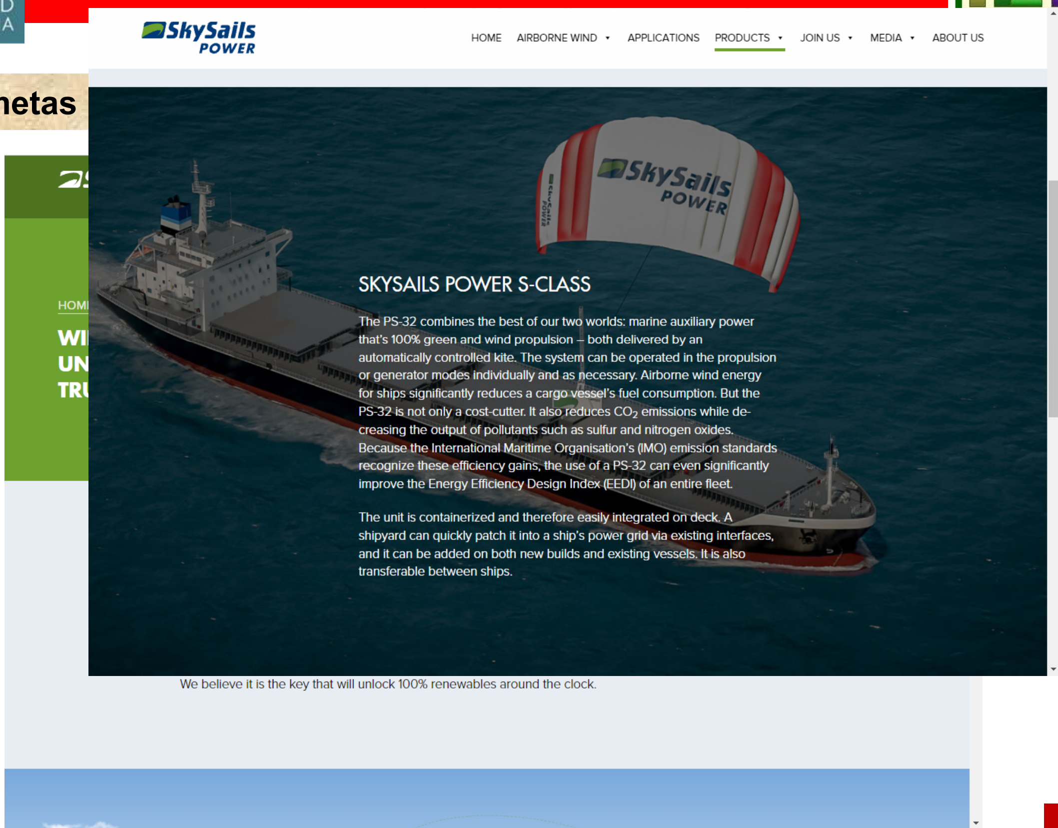


Cometas

https://skysails-power.com/



Cometas



Velas

Cometas

https://skysails-marine.com/

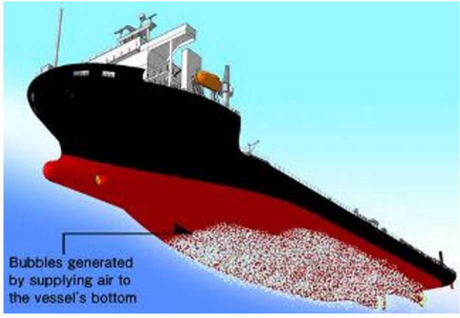
Velas

Cometas

Otros

Air Lubrication

El Air Lubrication System de Mitsubishi fue el primer método propuesto para reducir la resistencia entre el casco del buque y el agua que utiliza burbujas de aire desprendidas en la superficie plana sumergida



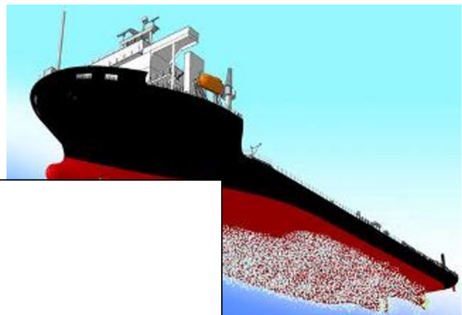
Se basa en crear una capa continuada de burbujas de aire comprimido de entre 1 y 3 mm de diámetro en toda la superficie plana inferior del casco del buque; esto reduce la fricción de avance con el agua mejorando la eficiencia del motor

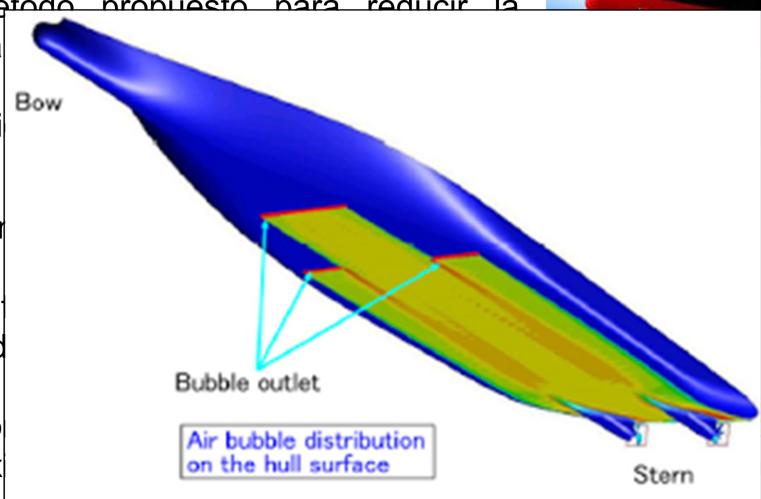
Puede economizar combustible en el rango del 6 al 9% cuando se aplica a buques existentes, números que mejoran hasta alcanzar del 10 al 15% cuando se diseña el casco específicamente para ello

Otros

Air Lubrication

El Air Lubrication System de Mitsubishi fue el
primer método propuesto para reducir la
resistencia
que utiliza
la superfici





Se basa en ... omprimido de
entre 1 y 3 ... del casco del
buque; es ... mejorando la
eficiencia d

Puede eco ... do se aplica a
buques ex ... el 10 al 15%
cuando se diseña el casco específicamente para ello.

Otros

Air Lubrication

Mitsubishi Heavy Industries Technical Review Vol. 47 No. 3 (September 2010)

41

Experimental Study of Air Lubrication Method and Verification of Effects on Actual Hull by Means of Sea Trial

SHUJI MIZOKAMI[*1] CHIHARU KAWAKITA[*2]
YOUICHIRO KODAN[*3] SHINICHI TAKANO[*3]
SEIJIRO HIGASA[*1] RYOSUKE SHIGENAGA[*3]

This paper relates to the verification of the effects of an air lubrication method that is intended to reduce skin friction resistance working on a hull through the use of air bubbles. This experiment is the world's first trial carried out on a newly-built carrier. Prior to the experiment in an actual hull trial, in order to confirm the performance of the air delivery system, a full-size mock-up unit was fabricated and the air delivery conditions were observed in a water tank. In addition, using a ship moored on a wharf wall, an air blow-off test was carried out and the air blow-off conditions were examined, the results of which were as expected. In an actual hull trial, a real energy-saving effect was confirmed as estimated and the effectiveness of this method was validated. Mitsubishi Heavy Industries, Ltd. (MHI) hereafter will develop this technology toward general carriers such as VLCCs and bulk carriers.

Otros

Air Lubrication

Mitsubishi Heavy Industries Technical Review Vol. 52 No. 1 (March 2015)

50

Application of Simulation Technology to Mitsubishi Air Lubrication System

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TAKAHIRO OKIMOTO[*2]

For the development and design of the Mitsubishi Air Lubrication System (hereafter MALS), which targets energy saving in ships, the utilization of simulation technology is essential. This paper describes the key technology for the development of MALS, which is CFD-based prediction technology for air bubble distribution around a hull, and also presents the frictional drag reduction effect. It also presents a prediction technology for the pressure fluctuation of a propeller that rotates in the bubbly flow, as well as a related technology for the prediction of gas-liquid separation in a sea chest that is an engine cooling water suction port. The prediction accuracy of these technologies has been verified and enhanced through verification in actual ship tests and model tests, and therefore they are used as effective development and design tools. Also in the future, MHI will continuously obtain data from the measurement results of actual ships and utilize it for the performance enhancement of MALS.

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...r lubrication method that is ... the use of air bubbles. This ...er. Prior to the experiment in ...r delivery system, a full-size ...observed in a water tank. In ... was carried out and the air ...cted. In an actual hull trial, a ...tiveness of this method was ...velop this technology toward

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Computational Analysis of Air Lubrication System for Commercial Shipping and Impacts on Fuel Consumption

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Abstract: Our study presents the computational implementation of an air lubrication system on a commercial ship with 154,800 m^3 Liquified Natural Gas capacity. The air lubrication reduces the skin friction between the ship's wetted area and sea water. We analyze the real operating conditions as well as the assumptions, that will approach the problem as accurately as possible. The computational analysis is performed with the ANSYS FLUENT software. Two separate geometries (two different models) are drawn for a ship's hull: with and without an air lubrication system. Our aim is to extract two different skin friction coefficients, which affect the fuel consumption and the CO_2 emissions of the ship. A ship's hull has never been designed before in real scale with air lubrication injectors adjusted in a computational environment, in order to simulate the function of air lubrication system. The system's impact on the minimization of LNG transfer cost and on the reduction in fuel consumption and CO_2 emissions is also examined. The study demonstrates the way to install the entire system in a new building. Fuel consumption can be reduced by up to 8%, and daily savings could reach up to EUR 8000 per travelling day.

Keywords: air lubrication system; ANSYS FLUENT CFD analysis; skin friction coefficient; decrease of fuel consumption and emissions

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