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RESEARCH ARTICLE

A STUDY ON GREEN SHIP CONCEPT USING RENEWABLE ENERGY ONBOARD SHIPS WITH KITES AND TUNNEL PIPES / TURBINES

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ABSTRACT

This paper gives an idea about introducing renewable energy for ship propulsion. The present scenario is that fuel prices are increasing day by day and IMO tier-II regulations should be met for all new ships. As per tier II regulations, 20 % of reduction in NOX in the ECA areas should be met. Regulations on energy efficiency for ships is to be made mandatory and all new ships are to satisfy the Energy Efficiency Design Index (EEDI). The Ship Energy Efficiency Management Plan (SEEMP) should be followed for all existing ships. The aim of this paper is to use natural energy / Renewable energy resources like wind and movement of water to get the desired power to propel the ship. Tunnel pipes with turbines installed at the bottom of the ship produce power for domestic use onboard and by using Parafoil Kites, thrust is produced to pull the vessel in the forward direction without running the main engine in ballast condition. Usage of Kites onboard ships are soon going to be proven technology which can be installed in any existing ships as well as new ships. A technical analysis is carried out to meet the installed power.

Nomenclatures:

C= chord length of kite (meter)
X= horizontal distance along which thickness of sections are taken (meter)
Y= thickness at particular X value (meter).
V_h =wind speed at required height (meter/sec)
V_O = wind speed at 10m height (meter/sec)
L = lift force (Newtons)
T_{af} = total aerodynamic force (Newtons)
C_t = towing cable tension (the value is Equal to value of T_{af}) (Newtons)
ɵ= incidence angle of wind/Angle of attack (degree)
w = wind velocity (meter/sec)
K_c = application of center of forces
C_l – lift coefficient
C_d – drag coefficient
ρ=Density of air (tones/m3)
T=Thrust force (Newtons)
P=power (Watts)
Ɵ=Angle of attack (45 degree)

INTRODUCTION

Most of the large ocean going ships can be fitted with kites and sails. Use of kites / Sails to propel a vessel is a proven technology and it is being used since many years in small vessels.

INTRODUCTION TO KITE

By using kites, the delivered traction force of a kite can be calculated depending on the apparent wind direction and wind speed. Parafoil kite is used onboard ships and it is important that the design suits the ships. At a distance above the main deck level, kites are used and therefore there is no obstruction between the kite and other equipment. The wind is an important factor and it would be a greatest advantage to be able to measure wind velocities at and upto several hundred meters. A kite is a tethered aircraft. The necessary lift that makes the kite Wing fly is generated when air flows over and under the kite's wing, producing low pressure above the wing and high pressure below it. This deflection also generates horizontal drag along the direction of the Wind. The resultant force vector from the lift and drag force Components is opposed by the tension of the one or more lines or tethers.

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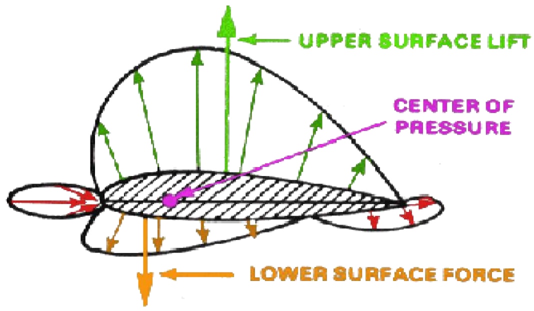
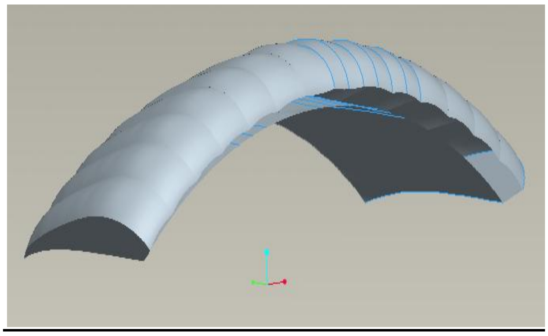


CAMBERED AIRFOIL AT POSITIVE LIFT

Para foil kite:

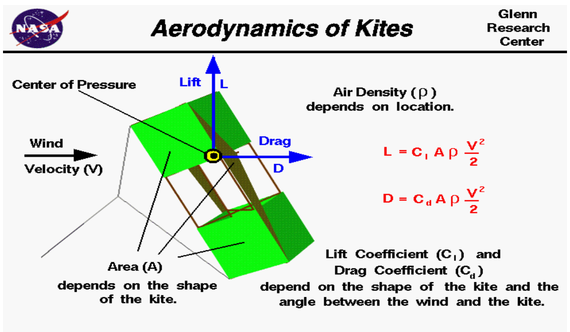
The main characteristics of the Para foil kite is strength and steadiness in relatively high wind speed. This kite is a high performance kite for developing relatively high lift. The unevenness of the ground slows down the flow of wind at low altitudes and at high altitude wind blows stronger, and it is almost constant. Its energy increases with cube root of the increase of speed and for this reason the Para foil kite has been chosen.



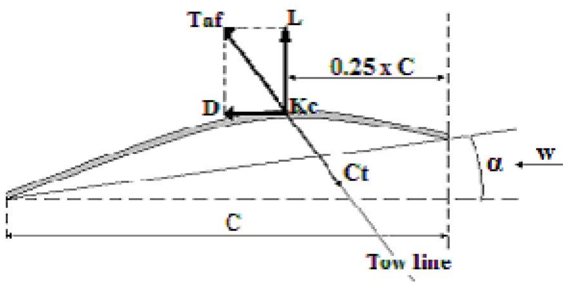
Working principle of kite

Aerofoil section:

Aerofoil section **NACA 0012** has been chosen because this section will have more lift coefficient (C_L) and less drag coefficient (C_D)



At different wind speeds, the power is calculated using the power law as follows:
Power law, $V_h = V_0\ (h/10)\ \hat{}0.27$



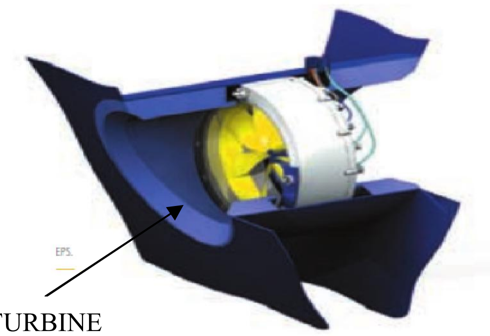
With kite area of 500 m^2 and angle of incidence ranging from 0 to 50 degrees in steps of 5 deg, the lift, drag and total aerodynamic forces are calculated using the following formulas:

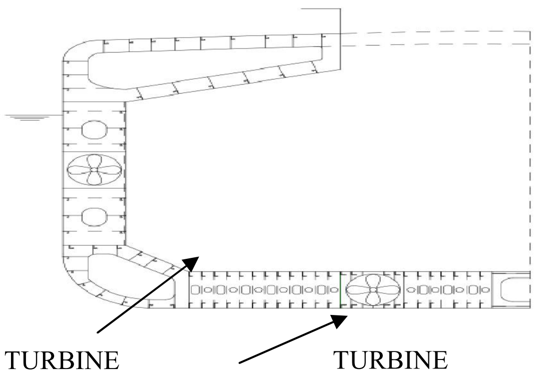
$$L = \tfrac{1}{2}\,\rho C_L w^2 A_K$$
$$D = \tfrac{1}{2}\,\rho\, C_D w^2 A_K$$
$$T_{af} = \sqrt{L^2+D^2}$$

The lift, drag and total aerodynamic forces are calculated by assuming the kite to be at fore and half centerline and angle between the rope and deck to be45 deg. The total aerodynamic forces are resolved in the fairlead point as thrust force from kites.

TUNNEL TURBINES

Tunnel pipes (4 no's) fitted inside the ship, two at the double bottom tanks on both sides of centre girder, two at the side double hull i.e port and starboard, below the draft line along the ship length in that three number of turbines are fitted inside the tunnel, one near the aft, one at centre of pipe and one near the forward. To avoid the marine growth and sea wastage, grating doors are fitted at the end of the tunnel pipes. End of tunnel pipes are with certain angle to regulate the water flow easily. The aft end of the pipes are narrowed and reduced in diameter like a jet so that when water is let out, due to jet action, certain amount of thrust is produced in the forward direction. Three numbers manholes are fitted for maintenance and inspection.





MIDSHIP SECTION OF SHIP WITH TURBINES (12 Nos.)

WORKING PRINCIPLES OF TUNNEL TURBINES

Tunnel turbines are like an underwater windmill where the blades are driven by consistant, fast-moving water. The submerged rotors harness the power of the flowing water to drive generators, which in turn produce electricity. Water is 832 times denser than air so consequently tunnel turbine rotors can be much smaller than wind turbine rotors and capable of generating equivalent amounts of electricity. The turbine resembles a water turbine, but with the rotor totally submerged in seawater inside the tunnel. It has four bladed, horizontal-axis rotors, 1.4m in diameter mounted on the end of a cross beam. The rotors are directly mounted on to shafts of speed increasing gearboxes, which in turn drive the generators. The rotors are turned by the flow of water when the ship is sailing and the generators produce electric power. The orientations of the rotors are fixed. The main component of power train consists of rotor, gearbox and generator. The rotors (3 nos.) are located inside the Tunnel and are connected to generator through the gearbox. The gearbox and generator are mounted inside the generator compartment. The controls for the system are located in ECR /MCR and Bridge.

TECHNICAL ANALYSIS:

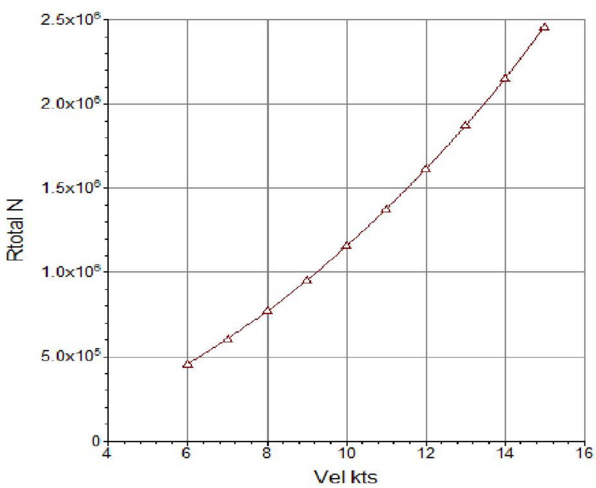
Principal Particulars of the ship:

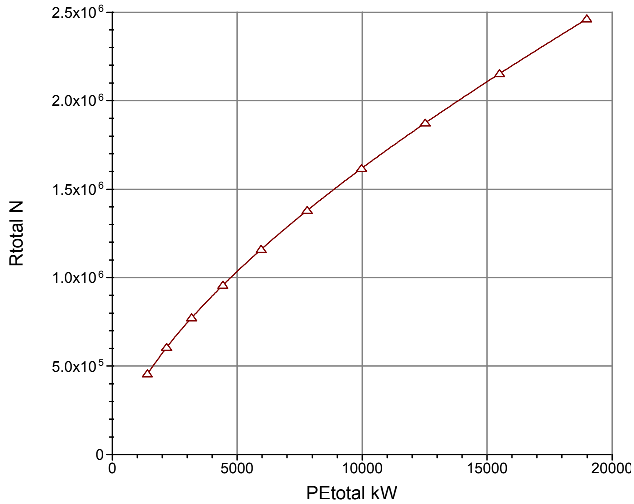
Type of ship: Bulk carrier
LBP = 295m
B = 51.75m
D = 25.65m
Design Draft = 18.58m
Speed = 15 knots
C_b = 0.85
Volume of Displacement = 241157.3m^3
Displacement (Δ) = 247186.23 Tonnes

Power Requirement of ship without kites and turbines

v_s(knots)	C_F	C_R	R_T(N)	P_E(KW)
6	0.0016	0.0026	456117	1408
7	0.0002	0.0025	604860	2178
8	0.0015	0.0025	772019	3177
9	0.0015	0.0024	956986	4431
10	0.0015	0.0023	1159299	5964
11	0.0015	0.0023	1378832	7803
12	0.0015	0.0023	1616131	9977
13	0.0014	0.0022	1872907	12526
14	0.0014	0.0022	2152614	15504
15	0.0014	0.0022	2461021	18991

The above calculations are carried out using Holldrop Mennen Method.



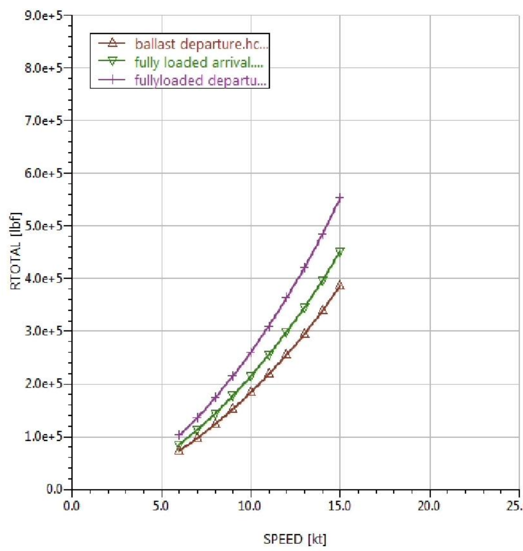


RESISTANCE AND POWER CURVES BALLAST DEPARTURE

Vs(knts)	C_F	C_R	R_T(N)	P_E(KW)
6	0.00158	0.00208	325932	1006
7	0.00155	0.00201	431189	1553
8	0.00153	0.00196	548893	2259
9	0.0015	0.0019	678491	3141
10	0.00148	0.00186	819568	4216
11	0.00147	0.00181	972002	5500
12	0.00145	0.00178	1136230	7014
13	0.00144	0.00175	1313600	8785
14	0.00142	0.00174	1506710	10852
15	0.00141	0.00174	1719810	13271

FULLY LOADED ARRIVAL

Vs (knts)	C_F	C_R	R_T(N)	P_E(KW)
6	0.00158	0.00242	380030	1173
7	0.00155	0.00235	503178	1812
8	0.00153	0.00228	641011	2638
9	0.0015	0.00223	792881	3671
10	0.00148	0.00217	958276	4930
11	0.00147	0.00213	1136980	6434
12	0.00145	0.00209	1329370	8207
13	0.00144	0.00205	1536840	10278
14	0.00142	0.00204	1762320	12693
15	0.00141	0.00203	2010730	15516



WIND SPEED AT DIFFERENT HEIGHTS AND DIFFERENT SEA STATES

Beaufort: 3

$V_{0\ (m/s)}$	Ht(m)	$V_{h\ (m/s)}$
4	100	7.448
4	150	8.310
4	200	8.981
4	250	9.539
4	300	10.020

Beaufort: 5

V_0 (m/s)	ht (m)	V_h (m/s)
9	100	16.7588
9	150	18.6977
9	200	20.2079
9	250	21.4628
9	300	22.5458

Beaufort: 8

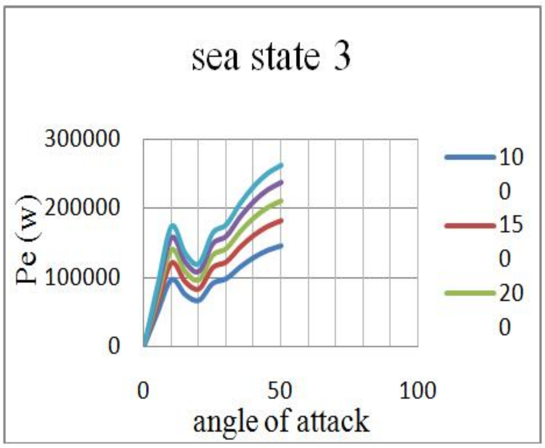
V_0(m/s)	Ht(m)	V(m/s)
19.5	100	36.311
19.5	150	40.512
19.5	200	43.784
19.5	250	46.503
19.5	300	48.849

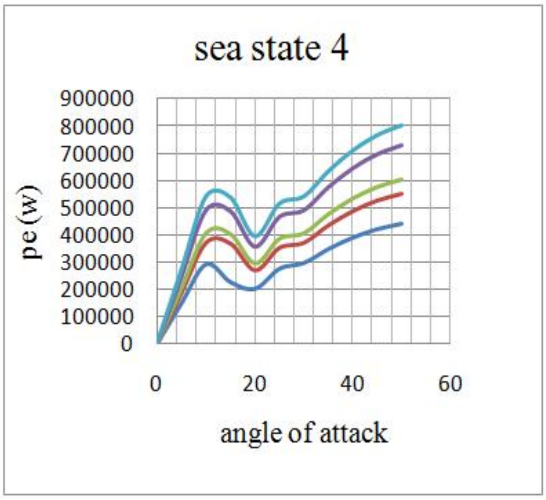
For Angle of Attack 5 degree ,

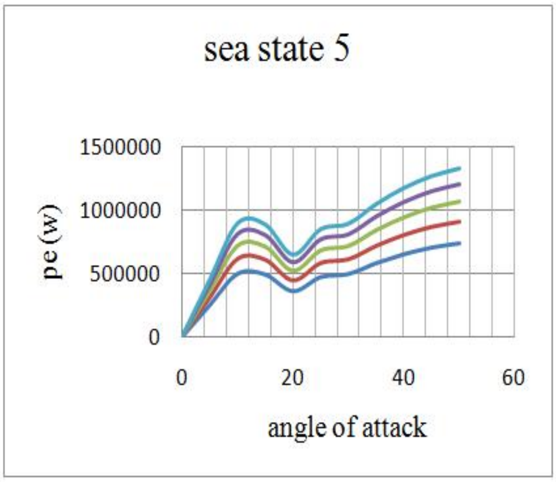
$$\text{Lift} = 0.5 * \rho * \text{Area of kite} * V^2 * C_L$$
$$= 0.5 * 1.2047 * 500 * 7.4^2 * 0.55$$
$$= 9169.12 \text{ Newtons}$$
$$\text{Drag} = 0.5 * \rho * \text{Area of kite} * V^2 * C_D$$
$$= 0.5 * 1.2047 * 500 * 7.4^2 * 0.0091$$
$$= 151.707 \text{ Newtons.}$$

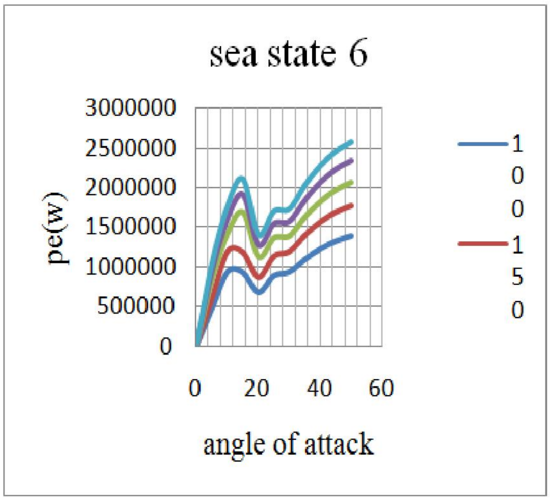
$$T_{af} = \sqrt{(lift^2 + drag^2)}$$
$$= \sqrt{9169.12 + 151.707}$$
$$= 9170.371 \text{ Newtons}$$
$$Thrust\_force = T_{af} \sin\theta = 6484.43 \text{ Newtons}$$
$$Power = T_{af} * V = 49930.124 \text{ watts}$$

THRUST AND POsWER AT DIFFERENT SEA STATES:
At 100m height:









At 300m height:

POWERING FROM TURBINE:

WITH SINGLE TUNNEL
Diameter of the pipe = 1.5m
LBP of the pipe = 295m
V = 15 Knots
S (wetted surface area) = 22417.68 m^2
P_E =12983.55 KW
<u>WITH FOUR TUNNELS</u>
Diameter of the pipe = 1.5m
LBP of the pipe = 295m

V = 15 Knots
S = 22661.88 m^2
R_T = 1701.01 KN
P_E = 13125.015 KW

Three rotors moving due to flow around them in each tunnel pipe:

a)ROTORS MOVING AT 5 m/sec VELOCITY OF ADVANCE
Blade radius = 1.3m
Flow speed = 5m/sec
Water density = 1.025 t/m^3
Rotor swept area = 5.30m^2
Power = $K*C_p*.5*1.025*A*V^3$
K = 0.000133
K is a constant to yield power in KW.
C_p is a maximum power coefficient.
C_p can be taken in range from 0.25 to 0.45
Take Cp = 0.4
Power = 0.000133 *0.4 * 0.5 *1.025 * 5.3 *5^3
= 0.0180630 KW
Three rotors in one tunnel
POWER = 0.054189187 KW
Totally Twelve rotors in ship:
Total Power =0 .21675675 KW

b)ROTORS MOVING AT 10m/sec VELOCITY OF ADVANCE
Blade radius = 1.3m
Flow speed = 10 m/sec
Water density = 1.025 t/m3
Rotor swept area = 5.30m2
Power = K*Cp*.5*1.025*A*V3
K = 0.000133
K is a constant to yield power in KW.
Cp is a maximum power coefficient.
Cp can be taken in range from 0.25 to 0.45
Take Cp = 0.4
Power = 0.1445045 KW
Three rotors in one tunnel
Power = 0.4335135 KW
Totally Twelve rotors in ship:
Total Power = 1.734054 KW

c)ROTORS MOVING AT 15m/sec VELOCITY OF ADVANCE
Blade radius = 1.3m
Flow speed =15m/sec
Water density = 1.025 t/m^3
Rotor swept area = 5.30m^2
Power = $K*Cp*.5*1.025*A*V^3$
K = 0.000133
K is a constant to yield power in KW.
Cp is a maximum power coefficient.
Cp can be taken in range from 0.25 to 0.45
Take Cp = 0.4
Power = 0.4877026 KW
For three rotors in one tunnel pipe
Power = 1.46310806 KW
FOR A TOTAL OF TWELVE ROTORS
Total Power = 5.852432 KW

Recommendatsssions

Generating Power using tunnel Turbines is a new technology which is incorporated inside the ships. Based on the theoretical calculations, power output of about 5 KW is generating which can be stored or utilized directly to cater for hotel loads and other onboard purposes. We can further explore by carrying out model testing which will give a more realistic estimation of power.In the fully loaded condition, when we donot want increase in draft, the valves in forward and aft can be closed and the water from inside the tunnel can be pumped out to maintain the tunnel pipe empty. Kites can be used onboard existing as well as new ships. In addition to Kites, sails can also be used onboard Ships to get additional Thrust Force. Model testing as well as Full scale trials can be conducted on board a designated ship with Kites and sails to find out Savings in Fuel consumption and compare the same with the above calculation. In addition to the above, the following may also be incorporated to reduce the frictional resistance of the ship and to give more speed. Reversal of Butt Weld and Seams can be done during the construction of bottom and side shell so that minimum weld projection is achieved to reduce the frictional resistance by 5 to 10%. This can be estimated by flow measurement experiments and using CFD analysis. Two no. Sails also can be used to produce Thrust in forward direction. Thus, further reduction in fuel consumption to the extend of 2 to 5% is possible to achieve.

Conclusions

The aim of this paper is to meet the installed power by using tunnel pipes and kites. Based on my analysis, using kites, I could achieve a power output of 800 to 1000 kW at sea state 4 and 5 in the chosen vessel, 5 KW power using Tunnel Turbines which works out to 4 to 5% of the required power. Therefore, Tunnel pipes / Turbines can be used at any loading condition. Kites can be used along with Main Engines as a Kite aided ship to Save Fuel by reducing the rpm of the Main engine and can be used at all conditions of loading. Thus, a saving up to 35% in fuel consumption is possible to be achieved by using Kite. Apart from fuel savings, harmful emissions such as Carbon Di Oxide (CO_2), Sulpher Di Oxide (So_x) and Nitrogen Di Oxode (NO_x) will be reduced with positive impact on environment.

REFERENCES

1) Ocean Energy, Tide and Tidal Power- By R. H. Charlier, Charles W. Finkl.
2) Analysis of tidal stream power – By Jack hardisty.
3) Paper on viability of tidal energy – By Jeremy Thake
4) http://www.seageneration.co.uk
5) http://www.marineturbines.comarrie
6) International conference on ship Drag reduction (SMOOTH-SHIPS) ISTANBUL TECHNICAL UNIVERSITY 20-21 may 2010 TURKEY.
7) Kite assisted ships technical level- The cargo vessel MS Beluga Skysails deploying its skysails kite.
8) www.skysails.info/english/production/the-skysails-technology
9) News.bbc.co.uk/2/hi/Europe/7201887.stm
10) gcaptain.com/maritime/blog/ocean-kites-top-10-green-ship-designs
11) Ships structure under sail and under gunfire by Prof.Francisco Fernandez – Gonzalez, Universidad politenica de Madrid
12) Engineering options for more fuel efficient ships
a) Karsten Hochkirch future ship Gmbh,
b) Volker Bertram, future ship GmbH,
13) Wave making resistance from Wikipedia the free encyclopedia the physics of wave making resistance
14) Wave making resistance retrieved from Wikipedia.org/wiki/wave making resistance on the subject of high speed monohulls, Daniel Savitsky, Professor Emeritus, Davidson Labosals steuens Institute of Technology.

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