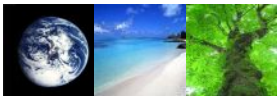
JASNAOE 2010 Spring Conference, Tokyo
Organize Session: Trends in the Marine Design Research and Development (IMDC)
7th June, 2010

Technical Review of Energy Efficient Concept Ships

Masato NOBUHARA, Katsuhiko MIZUNO, Hideyuki ANDO
MTI (Monohakobi Technology Institute), NYK Line Group

Monohakobi
Technology Institute

Background



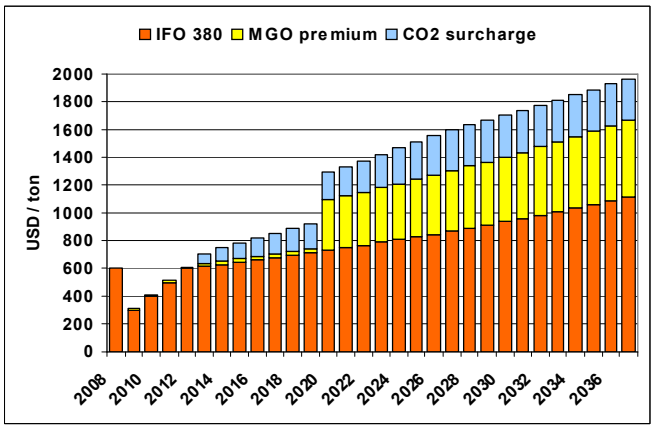
© Copyright 2010
Monohakobi Technology Institute

CO2 Emission and Reduction in Shipping

- CO2 emission from shipping industry is estimated as 870 million tons
- It is about 3 percent of global CO2 emission in 2007
- In IMO MEPC, international regulations and scheme to reduce CO2 emissions by ship design, operation and financial approaches have been discussed.
  - EEDI, EEOI and SEEMP
  - financial mechanisms
- 85% CO2 emission has to be cut per ton-mile by the year 2050
  - If global sea trade increases about 3% annually
  - And the target of CO2 emission cut is set as 50% from current shipping

Monohakobi
Technology Institute

Future Fuel Cost – scenario by G.L.



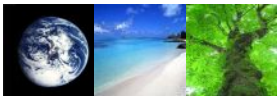
(Reference: http://www.internationaltransportforum.org/2009/workshops/pdf/Mws4-Braun.pdf)

Role of Future Conceptual Ships

- To achieve continuous improvement, strategic investment to R&D and realization will become more important
- One of the good approaches is to draw future conceptual ships and share them among industry and academy partners
- It is important to make and share roadmaps, R&D targets and milestones, for innovation in design and in operation

Monohakobi
Technology Institute

Examples of Future Conceptual Ships



E/S Orcelle, Wallenius Wilhelmsen

- Ship Type: Car Carrier
- Loa: 250 [m]
- B: 50 [m]
- Design draft: 9 [m]
- Height: 40 [m]
- Total height with sails: 95 [m]
- Design speed (service): 15 [knot]
- Design speed (maximum): 20 [knot]
- Capacity of Cars: 10,000 [cars]
- Deadweight: 13,000 [MT]
- Lightweight: 21,000 [MT]
- Ballast: No Ballast

Maximum Energy Output and Propulsion
- Fuel Cells: 10,000 [kW]
- Solar Panels (maximum): 2,500 [kW]
- Pod Propulsion: 2 x 4,000 [kW]

Dimensions of Natural Energy Utilization Device
- Solar Panels: 3 x 800 [m2]
- Wind Sail: 3 x 1,400 [m2]
- Wave Fin: 12 x 210 [m2]

(Reference http://www.2wglobal.com/www/pdf/Green_Flagship.pdf)

E/S Orcelle – Technical Points

- Energy Supply … the energy sources of the vessel are about 50 % from fuel cell and the rest are from solar, wind and wave energies.
- Propulsion … besides 2 electronic propulsion pods, 12 oscillating fins are applied for propulsion. The fins also expected to be used to retrieve energy from waves and also as ship motion stabilizer.

E/S Orcelle – Review of Solar Energy

- Solar Energy Potential
  - 1 kW/m^2 maximum (sunny daytime)
  - 0.11 kW/m^2 by average through a year
- The theoretical maximum efficiency is about 30 %
- Expected generating power
  - By using 2400 m^2 area of solar panels
  - the expected power generation
    - 720 kW (maximum)
    - 264 kW (average)

E/S Orcelle – Review of Wind Energy

- Potential of wind force

$$T = \frac{1}{2}\rho C_L V_a^{\,2} A$$

A : sail area [m^2]
Va : apparent wind speed [m/s]
C_L : lift coefficient

- Estimated thrust force: T=1,039 kN
  Conditions:
  C_L=1.8 (as sophisticated airfoil is up to the number)
  Va = 15 m/s

  If vessel speed is 15 knot, estimated output power is 7,792 kW.

E/O Orcelle – Review of Wave Energy

- Potential of wave energy

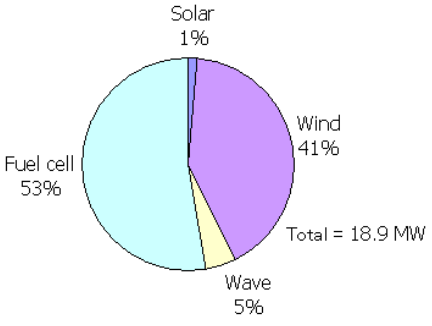
$$E = \frac{\rho g^2 H^2 T}{16\pi}$$

H: wave height [m]
T: wave period [s]

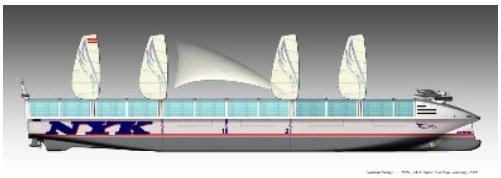
- Estimated thrust power : 860 kW
  Conditions:
  wave height = 3m, wave period = 10s
  expected potential energy is 86 kW/m
  If efficiency is considered as 20 %
  the fins retrieve energy breadth-wide of the vessel
  the expected power generation is 860 kW

Review of Energy Source Components

- Total Propulsion Energy 18.9 MW
- The estimated energy from natural sources is about 8.9MW.
- Wind energy is the prime source among natural sources
- It is largely affected by apparent wind speed and ship speed, wind sail technology would be key R&D area.



NYK Super Eco Ship 2030



With Garroni Design, ELOMATIC and MTI

•B(maximum):	54.6	[m]
•Depth: 43.5		[m]
•Design draft:	11.5	[m]
•Total height with sails:	78	[m]
•Design speed (maximum):	25	[knot]
•Cargo Capacity	8,000	[TEU]
•Deadweight:	70,000	[MT]
•Lightweight:	31,200	[MT]
•Ballast: No Ballast		

Maximum Energy Output and Propulsion

•Total Power	55,000	[kW]
•Propulsion Power	50,000	[kW]
•Power Plant Combined fuel cell and solar cell		
•Propeller Twin screw CRP		
•Fuel Cell:	50,000	[kW]
•Fuel (LNG):	2,000	[MT]
•Solar Panels (average):	1,600	[kW]

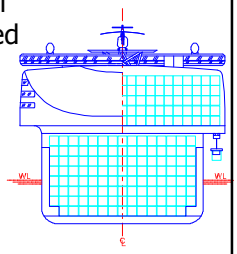
Dimensions of Natural Energy Utilization Device

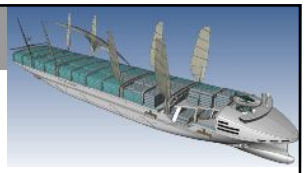
•Solar Panels:	31,000	[m2]
•Wind Sail: 6,000	[m2]	

Resistance Reduction – 27 % (1)

- Hull form optimization (2%) … Unconventional bow shape design is applied. The longitudinal buoyancy is located a bit more aft part of the ship than usual. Bulb shape optimization effect is also considered.

- Reduction of displacement (10%) … As about 80 % of total ship resistance is friction resistance even at speed of 25 knots, Fn = 0.22, displacement reduction of 20,000 tons was achieved by reduce lightweight and lighter deadweight. Lightweight reduction is achieved by smaller cross sections. Lighter deadweight is achieved by no ballast and light containers.





Resistance Reduction – 27 % (2)

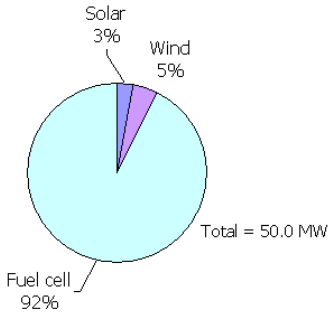
- Coatings (4%) … Future improvement of coatings, such as intelligent coatings and nano-scale textures, are considered.
- Air lubrication (6%) … Micro-bubbles effect is applied.
- Propulsion efficiency (6%) … The effect of CRP (Contra Rotating Propeller) is applied.
- Other items … Air resistance reduction (1%)

Fuel Cells

- Three types of fuels, LNG, H2, Methanol for fuel cells, and conventional diesel engine with HFO are compared in terms of its total "well-to-wheels" CO2 emissions.
- As the result, LNG is found as least CO2 emission fuel in 2030, whose emission is 301 g/kWh.

Use of natural energy sources

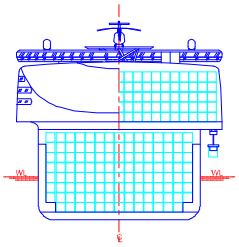
- From natural energy sources, similar amount of energy estimated for E/S Orcelle is expected. From solar enegy, 1,600 kW, 6 times larger than E/S Orcelle, generation is planned. This is mainly because NYK Super Eco Ship 2030 applies about 10 times wide area used.



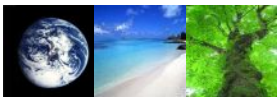
Monohakobi
Technology Institute

Operational Improvements

- To reduce cargo handling time at port, the ship has in-built loading system for loading/unloading containers in the cargo holds from the side hatch.
- To implement the cranes, fixed deck cover is applied. It also enhances the strength and stiffness of the ship hull, and it also contributes to reduce lightweight.



Summary



Monohakobi
Technology Institute

Summary

- A review of E/S Orcelle by Wallenius Wilhelmsen and NYK Super Eco Ship 2030 is shown.
- Among natural energy sources, wind energy is expected to be prime source. Power generation side, fuel cell with LNG is currently considered best technology in terms of CO2 emission reduction for year 2030.
- Continuous reduction of friction resistance is expected. Reduction of friction resistance is expecting area. Lighter lightweight by applying small mid-ship section and coating system needs to further study

Other issues – Operational improvement

- There are variety of potentials for innovations in operation.
- Optimum operation system, weather routing for wind sail, highly accurate weather forecast, optimum ship allocation, optimum trim simulation, remote maintenance, performance monitoring, vessel performance analysis, performance management system and traffic control systems are the examples.

DNV Concept Container Ship - Quantum

- DNV recently revealed their future concept container ship for 3-5 years later
- It covers comprehensive area regarding container ship design

Proposing agenda for coming IMDC in Tokyo

- We expect to have a session about "Future Concept Ship and Roadmaps" at IMDC 2012 in Tokyo
- To bring ideas from wide areas and update roadmaps
  - Prime energy sources
  - Reduction of resistance
  - Natural energy utilization
  - Operational aspects

Monohakobi
Technology Institute

Thank you very much for your attention !