



What is technological possible today to improve the GHG performance in the fleet?



by

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# 'Green Ship of the Future'



'Green Ship of the Future' is a Danish joint industry project aiming at developing and demonstrating technologies and methods for reduction of air emissions from shipping.

The aim of the project is to provide the necessary technologies and operational means to reduce emissions as follows for newbuildings:

- 30 % reduction of CO<sub>2</sub> emissions
- 90 % reduction of NO<sub>x</sub> emissions
- 90 % reduction of SO<sub>x</sub> emissions

*The base case is the emission level of the average global fleet in 2007 with a time frame of 10 years.*



# 'Green Ship Project Partners



Odense Steel Shipyard Ltd.



DESMI A/S



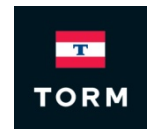
MAERSK



Dansk Center for Maritim Teknologi



MAN Diesel



GREENSTEAM



Danish Defence Acquisition and Logistics Organization



NORDEN



# Network Partners



Green Ship of the Future has established a network partnership agreement with the following Danish maritime organisations:

- Danish Maritime Authority
- Danish Shipowners' Association
- Danish Maritime
- Danish Marine Group
- Transport Innovation Network

The role of the network partners is to provide a network and to communicate events and project results to their respective members.



# 'Green Ship of the Future'



To meet the reduction targets, the following four groups are considered:

- **Machinery**
- **Propulsion**
- **Operations**
- **Logistics**

The project is coordinated by the Danish Centre for Maritime Technology (DCMT). DCMT is a partnership between the Technical University of Denmark (DTU) and FORCE Technology.

The coordination is funded by the Danish Maritime Foundation.



# Sustainable Shipping Award goes to....



Hans Otto Kristensen & Thomas Eefsen received the award on behalf of GSF

# "Low Emission Concept ship's"



**SEAHORSE 35**  
**35.000 DWT Bulk Carrier**  
**By Grontmij Carl Bro**

**A-Class**  
**8500 TEU Container Ship**  
**By Odense Lindø Shipyard**



# Technologies applied



# Technologies applied



1

## Advanced rudder and propeller system

A well-designed propeller and rudder system can save up to approximately 4% of the fuel oil consumption. Such a system could be a modern propeller combined with an asymmetric rudder and a so-called Costa Bulb.

With new propeller design methods modern propellers becomes more and more efficient. The Costa Bulb creates a smoother slipstream from the propeller to the rudder. With an asymmetric rudder, the rotational energy from the propeller is utilised more efficient compared to a conventional rudder.



2

## Speed Nozzle

Normally, nozzles are used to improve the bollard pull on tugs, supply vessels, fishing boats and many other vessels which need high pulling power at low speed.

This new kind of nozzle, called a speed nozzle, is developed to improve the propulsion power at service speed. Using the new speed nozzle concept has a saving potential of approximately 5%.



3

## Exhaust gas scrubber system

One way to fulfil the future regulations on sulphur emissions is to install an exhaust gas scrubber. This scrubber system use water to wash the sulphur out of the exhaust gas. Measurements have shown that SOx emissions are reduced with up to 98%. It is not only the sulphur which is reduced, also the content of harmful particles are reduced by approximately 80%.



4

## LNG auxiliary engines

Normally, the electrical power in harbour condition is supplied by using auxiliary engines running on heavy fuel or marine diesel. By using auxiliary engines running on LNG (liquefied natural gas) instead of conventional fuel, significant emission reductions can be achieved.

Emission reductions in the magnitude of approximately 20% on CO2, approximately 35% on NOx and 100% on SOx are the potential of switching from diesel to LNG.



5

## Hull Paint

The choice of the right hull paint is essential to keep the resistance at a minimum. Modern anti-fouling hull paint with a low water friction has a fuel saving potential in the region of 3 to 8%. The reduction of emissions is proportional to the fuel savings.



6

## Waste Heat Recovery system (WHR)

The waste heat recovery system utilises the heat in the exhaust gas from the main engine. The exhaust gas contains a lot of heat energy which can be transformed into steam. The steam can then be used for heating of the accommodation, cargo areas and fuel oil. The steam can also be used for power generation in a turbo generator. Depending on the configuration, a waste heat recovery system can reduce the fuel consumption by 7 – 14 %.



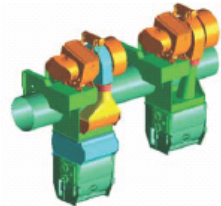
# Technologies applied



7

## Water In Fuel system (WIF)

The formation of  $\text{NO}_x$  is dependent of the temperature in the cylinder liner. By lowering the temperature the  $\text{NO}_x$  emissions are also lowered. By adding water to the fuel before injection, the temperature in the cylinder will be lowered. This will result in a reduction of  $\text{NO}_x$  by 30-35%.



9

## Pump and cooling water optimisation

By using an optimised cooling water system it is possible to save up to 20% of the electrical generated power, corresponding to approximately 1.5% reduction of the total fuel consumption.

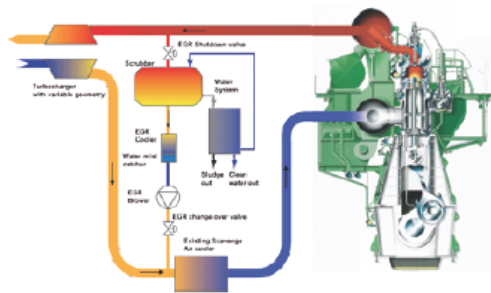
Studies show that the resistance in the cooling water system often can be reduced. When the resistance is reduced smaller pumps can be used and thereby saving up to approximately 90% of the power needed for pumps.



8

## Exhaust Gas Recirculation system (EGR)

The formation of  $\text{NO}_x$  emissions can be reduced by lowering the temperature in the cylinder liner of the main engine. One way of lowering the temperature is to recirculate some of the exhaust gas. Some of the exhaust gas is mixed with the scavenge air so that the oxygen content is reduced together with a lower temperature in the combustion chamber. Measurements have shown that this technology have a potential of  $\text{NO}_x$  reductions of approximately 80%.



# Conclusion from Study



## SEAHORSE 35 Bulk carrier, optimised with:

- Speed nozzle/optimized propeller
- Twisted spade rudder with Costa bulb
- Water in fuel (WIF)
- Exhaust gas recirculation (EGR)
- Waste Heat Recovery system (WHR)
- Exhaust Gas Scrubber
- Ducted/direct air intake for main engine
- Optimised coolers and cooling pumps
- Auxiliary engine operation on marine diesel oil (MDO)
- High capacity fresh water generator

Extra costs 5 mill USD (Corresponds to approx 20% of newbuilding costs)

### Goals

- 30 % reduction of CO<sub>2</sub> emissions
- 90 % reduction of NO<sub>x</sub> emissions
- 90 % reduction of SO<sub>x</sub> emissions

### Results

- **Achieved 7,2 %**
- **Achieved 98,6 %**
- **Achieved 79,1 %**

# Conclusion from Study



## 8500 TEU container vessel, optimised with:

- Water in Fuel technology (WIF)
- Exhaust gas recycling (EGR)
- Waste heat recovery exhaust boilers
- Power and Steam turbine technology
- Scrubber technology

Extra costs 10 mill Euro (Corresponds to approx 10% of newbuilding costs)

### Goals

- 30 % reduction of CO<sub>2</sub> emissions
- 90 % reduction of NO<sub>x</sub> emissions
- 90 % reduction of SO<sub>x</sub> emissions

### Results

- **Achieved 11-14 %**
- **Achieved 80 %**
- **Achieved 90 %**

# Main Conclusion from Study



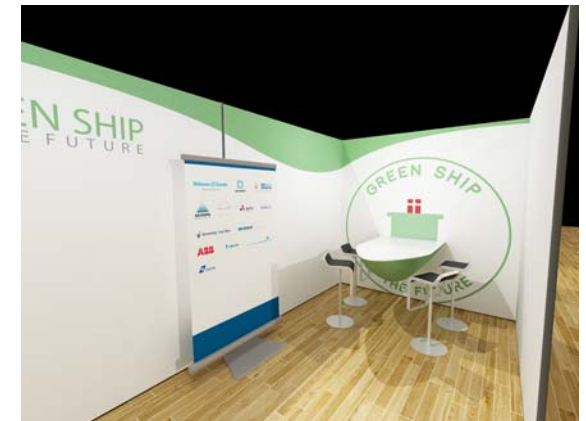
- With respect to NO<sub>x</sub> and SO<sub>x</sub> we have reached our goals
- Reducing NO<sub>x</sub> and SO<sub>x</sub> will in some case cost increased CO<sub>2</sub> emission
- With respect to CO<sub>2</sub> the study shows that we still need to work with technical solutions and operation
- Further reduction in CO<sub>2</sub> can be obtained through continued efforts to reduce vessel resistance, optimised operation, more effective propulsion systems, more fuel efficient engines, alternative fuel (LNG, Biofuel etc.) and addition of alternative “green” means of propulsion (fuel cells, wind, solar etc.)
- Further reductions in CO<sub>2</sub> will also reduce NO<sub>x</sub> and SO<sub>x</sub> emissions
- Retrofit challenges
- **The challenge continues**

# Bright Green on 12+13th December



Bright<sup>01</sup>  
Green

- The Bright green mess takes place in FORUM Copenhagen the 12th and 13th December.
- We will be at stand 78.
- A 30 min presentation on the GSF stand for several partners will be arranged and scheduled over the two days.



A screenshot of the Green Ship website displayed in a Windows Internet Explorer browser window. The browser title is "Det Maritime Danmark - Home - Windows Internet Explorer provided by FORCE Technology". The address bar shows "http://www.greenship.org/". The website features a large background image of a glacier in the water. On the left, a green sidebar contains a navigation menu: Home, About Green Ship, Green Ship Projects, Partners, Press, Green Ship Contacts, Calendar, Contact Form, and Login. On the right, a green box titled "Kalender" lists "Green Ship Status møde" on 18. May 2009 and "Bright Green" on 12. December 2009. Below this, a section titled "Green Ship Conference" includes a photo of a speaker and text describing the conference as the second of its kind in Copenhagen. To the right of the conference text, a list of goals states: "It is the aim of 'Green Ship of the Future' to:" followed by "30% reduction of CO<sub>2</sub>", "90% reduction of SO<sub>x</sub>", and "90% reduction of NO<sub>x</sub>". A final paragraph states: "'Green Ship of the Future' is a Danish Joint Industry project aiming at developing and demonstrating technologies for reduction of". The browser's status bar at the bottom shows "Internet" and "100%".