Green Bulkers Now and in the Future

Emission reduction, fuel efficiency, energy efficiency

Leif Jacobsen
Director, Grontmij Marine
Grontmij Group - Introduction

- Company founded in 1915
- Multi disciplinary Consulting & engineering company
- 350 Offices World Wide
- 11,000 professionals
- Head Office located in The Netherlands
- Turnover USD 1,5 Billion
- Flexible, dynamic organization
- Public listed on the Euronext, Amsterdam
Grontmij Marine Group - Introduction

- Ship Design since 1966
- Ship Design, Marine Engineering, Survey & Inspection
- 30 Professional Naval Architects & Marine Engineers
- Head Office located in Copenhagen, Denmark
- Offices in Copenhagen, Odense & Shanghai
Grontmij Marine Group – The History

- Ship design established in 1966 as Dwinger Marineconsult
- Dwinger Marine became part of Carl Bro in 1990
- From 2000 trading as Carl Bro Marine
- Since 2007 part of the Grontmij Group as Grontmij | Carl Bro A/S
- From 29th April 2011 company name changed to Grontmij
Grontmij Marine

Design of all ship types:

- Tankers
- Bulk Carriers
- Container Ships
- Gas Carriers (LPG / LNG / LEG)
- Ro-Ro vessels
- Passenger Ships
- Offshore Vessels
- Special purpose vessels
- Navy Ships
Grontmij Marine – Capabilities & Experience

- Competent staff with strong experience base
- Newest tools and calculation software available
- Cutting edge design, based on latest market trends.
- Nearly 300 vessels built according to our design
- Very strong setup in Asia - 150 vessels built in China
- Currently 18 shipyards is building according to our design
Grontmij Ship Design & Marine Engineering
What is a Green Bulker?

- Bulker with low emissions to the environment
- Bulker which reuses energy
- Bulker with an effective propulsion system
- Bulker with a ballast water treatment system
- Bulker where Opex and Capex are optimized
- Bulker where lines and capacity are optimized related to fuel consumption
- Bulker where the light weight is optimized
- Bulker with energy saving devices
Seahorse 35 - the vessel for case studies
Seahorse 35 – Contract Status

- 26 Effective contracts at 7 different shipyards
- Totally about 60 vessels ordered
- 1 Vessel delivered (August 2011)

- DaoDa Heavy Industries (DDHI), Qidong, Jiangsu
- Chengxi SY, Jiangyin, Jiangsu
- Zhong Chuan Heavy Industry (ZCHI), Zhoushan, Zhejiang
- Jiangdong Shipyard, Wuhu, Anhui
- Nantong Jinghua, Nantong, Jiangsu
- Yangfan Shipyard, Zhoushan, Zhejiang
- Guoyu Shipyard, Yangzhou, Jiangsu

- 2 more yards have signed SEAHORSE 35 contracts but not yet effective
## Main particulars – SEA HORSE 35

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length, OA</td>
<td>180.0 m</td>
</tr>
<tr>
<td>Breadth</td>
<td>30.0 m</td>
</tr>
<tr>
<td>Depth</td>
<td>14.7 m</td>
</tr>
<tr>
<td>Scantling draft</td>
<td>10.1 m</td>
</tr>
<tr>
<td>DWT scantling</td>
<td>35,000 ton</td>
</tr>
<tr>
<td>TPC</td>
<td>50.0 t/cm</td>
</tr>
<tr>
<td>Cargo hold capacity, grain</td>
<td>46,700 m³</td>
</tr>
<tr>
<td></td>
<td>(1,650,000 cft)</td>
</tr>
<tr>
<td>Cargo hold capacity, bale</td>
<td>45,800 m³</td>
</tr>
<tr>
<td></td>
<td>(1,617,000 cft)</td>
</tr>
<tr>
<td>Gross tonnage</td>
<td>24,366</td>
</tr>
<tr>
<td>Net tonnage</td>
<td>11,521</td>
</tr>
</tbody>
</table>
General Arrangement Plan 3/3

MIDSHIP SECTION

CARGO HOLD NO. 5

CARGO HOLD NO. 1

TRANSVERSE BULKHEAD
GREEN SHIP of the FUTURE (GSF):

- Danish Maritime Network works to reduce emission from ships
  - 30% reduction of CO₂
  - 90% reduction of SOₓ
  - 90% reduction of NOₓ

- GSF presented two demonstrator vessels at the BRIGHT GREEN Exhibition in connection with the COP15 Climate Conference held in Copenhagen December 2009
Regulations on emissions, Sulphur

**Figure 2.** MARPOL Annex VI Fuel Sulfur Limits
Regulations on emissions, NOX

**Figure 1.** MARPOL Annex VI NOx Emission Limits
Future regulations on CO2, EEDI-Index

\[ EEDI_{\text{Attained}} = \frac{C_F \cdot SFC \cdot P}{f_i \cdot \text{Capacity} \cdot V_{\text{ref}} \cdot f_w} \]
IMO energy efficiency design index Base line (35,000 DWT) : 6.54 g/t-nm

SH35 EEDI (HFO) : 5.85 g/t-nm (minus 11%)
SH35 EEDI (MDO) : 5.51 g/t-nm (minus 16%)
The casestudy

How low can we go on emissions for a Seahorse 35 Bulker with existing known green Technology?

Founded by the Danish Maritime Foundation
List of primary modifications

- 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
- Installation of Ballast Water Treatment System (BWT)
## Emission reduction

<table>
<thead>
<tr>
<th></th>
<th>normal at sea</th>
<th>annual basis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>total ship</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FO consumption</td>
<td>-7,7%</td>
<td>-7,2%</td>
</tr>
<tr>
<td>CO2 emission</td>
<td>-7,7%</td>
<td>-7,2%</td>
</tr>
<tr>
<td>SOx emission</td>
<td>-98,7%</td>
<td>-98,6%</td>
</tr>
<tr>
<td>NOx emission</td>
<td>-81,6%</td>
<td>-79,1%</td>
</tr>
<tr>
<td>PM emission</td>
<td>-90,9%</td>
<td>-86,0%</td>
</tr>
</tbody>
</table>
### Additional weight (estimate)

160 t

### Additional cost (estimate)

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed nozzle/optimized propeller</td>
<td>700,000</td>
</tr>
<tr>
<td>Twisted spade rudder with Costa bulb</td>
<td>160,000</td>
</tr>
<tr>
<td>Water in fuel (WIF)</td>
<td>200,000</td>
</tr>
<tr>
<td>Exhaust gas recirculation (EGR)</td>
<td>600,000</td>
</tr>
<tr>
<td>Waste Heat Recovery system (WHR)</td>
<td>1,250,000</td>
</tr>
<tr>
<td>Exhaust Gas Scrubber</td>
<td>1,200,000</td>
</tr>
<tr>
<td>Ducted/direct air intake for main engine</td>
<td>20,000</td>
</tr>
<tr>
<td>Optimised coolers and cooling pumps</td>
<td>150,000</td>
</tr>
<tr>
<td>Auxiliary engine operation on marine diesel oil (MDO)</td>
<td>-</td>
</tr>
<tr>
<td>High capacity fresh water generator</td>
<td>50,000</td>
</tr>
<tr>
<td>Installation of Ballast Water Treatment System (BWT)</td>
<td>810,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,140,000</strong></td>
</tr>
</tbody>
</table>

**Estimated price for a Seahorse 35 is 22-25 mill. USD**

(Chinese yard)
Where do we put it?
SW Scrubber installed in SH35

- Casing is extended
- Scrubber installed in casing
### Main system components

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight, (t)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dry</td>
<td>wet</td>
</tr>
<tr>
<td>Scrubber, stainless steel</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>System Pumps</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td>Water treatment plant</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Piping</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Control and monitoring</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total weight, loss of DW</td>
<td>11</td>
<td>15</td>
</tr>
</tbody>
</table>
## Investments

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (mio USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrubber</td>
<td>1.10</td>
</tr>
<tr>
<td>Water treatment system</td>
<td>0.10</td>
</tr>
<tr>
<td>Transport</td>
<td>0.02</td>
</tr>
<tr>
<td>Installation</td>
<td>0.05</td>
</tr>
<tr>
<td>Commissioning</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td><strong>1.29</strong></td>
</tr>
</tbody>
</table>

Est. cost is based on new build of ship at Chinese Yard
Cost scenario for MGO operation

- HFO price: 650 USD/ton
- MGO price: 900 USD/ton
- Annual consumption of fuel (main engine): 5600 t
- Annual consumption of fuel (DG’s): 800 t
- Annual fuel cost HFO: 4.2 mio USD
- Annual fuel cost converting to MGO: 5.8 mio USD
- Annual additional cost for MGO op.: 1.6 mio USD
Pay back for SW scrubber solution

- Total investments: 1.29 mio USD
- Additional fuel to operate scrubber: 110 t/year
- Annual fuel cost, scrubber operation: 0.1 mio USD
- Annual additional fuel cost, DG’s on MGO: 0.2 mio USD
- Total annual fuel cost: 3.9 mio USD
- Annual fuel cost if MGO operation: 5.0 mio USD
- Annual fuel cost saving for continuous operation on HFO / Scrubber: 1.1 mio USD
- Simple pay back: investment / Saving: 1.2 years
Green Bulkers

- What do we do as Design House for being ”Green”?

  - Optimized designs
    - Weight saving studies
    - Propulsion Systems
    - Use of High Tensile Steel
  
  - Following developments within Green Technology
  
  - Tank test with new features
Optimized Hullform

- Hull form generated through extensive CFD analysis and Model test
- Vertical Stem design
- Low resistance and optimized wake field – optimum propeller design
- Ice Classed vessel and Ice Model testing
Propeller

- NPT Propeller – New Profile Type

State of the art propeller design

- Low blade section area
- Low propeller weight
- Highly cavitation resistant
- Highest achievable performance
Fuel Oil Optimization

- MEWIS Duct
  ~4% - 6% Efficiency Increase

- Propeller Boss Cap Fin (PBCF)
  ~1% Efficiency Increase
Tanktest vs Sea Trial

SEAHORSE 35 - FORCE Tanktest vs DDHI DD017 Sea Trial

Engine Power [kW]

Speed [knots]
Tanktest vs Sea Trial - 3

- Conclusion: The measured result is “SPOT ON” the expected values measured in the model test basin.

- The test result confirms that we have obtained very accurate correlation between model test and full scale.

Popular Quote:
The vessel performed much better than expected – The design is very good.

Grontmij Opinion:
The achieved result is what we expected and what we have promised to Yard and Owner.

Nothing more, nothing less.

This is good design!
Fuel Oil Optimization

MAIN ENGINE - Specific Fuel Oil Consumption (SFOC)

- MAN 5S50MC-C7.1 TI
- MAN 5S50ME-B9.2 TII

M/E Power [kW]

SFOC [g/kWh]
Fuel Oil Optimization

SEAHORSE 35
Daily Fuel Oil Consumption (MDO, 42.700 kJ/kg) at Scantling Draft (T = 10,1m) incl. 15% Sea Margin

- M/E: MAN BW 5S50MC-C7.1 TI
  SMCR 7.500 kW @ 121 RPM
  5,54 m NPT Propeller
  24,3 t/day

- M/E: MAN BW 5S50ME-B9.2 TII
  SMCR 6.350 kW @ 110 RPM
  5,8 m Wärtsilä Propeller
  22,7 t/day

- M/E: MAN BW 5S50ME-B9.2 TII
  SMCR 6.350 kW @ 99 RPM
  5,9 m NPT Propeller
  21,9 t/day

- M/E: MAN BW 5S50ME-B9.2 TII
  SMCR 6.350 kW @ 99 RPM
  5,9 m NPT Propeller
  MEWIS Duct + PBCF (-5%)
  20,8 t/day
Future developments

- Sails
- Solar Cells
- Fuel Cells
- Using weather forecast to optimize route planning
- Low friction systems
- New painting systems
- Trim optimization
THE END

Thanks for your attention

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