Development of dual fuel LNG hopper dredgers

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The world’s first natural gas fueled dredgers
• Why LNG as a fuel? Why dual fuel?
• Emission reduction
• Examples: DEME’s new TSHD’s
• Development of LNG hopper dredgers
• Challenges in LNG
• Adopting LNG as a fuel - consequences
• Conclusions
Respect & care for the environment is a DEME core value →

Genuine interest in technology/solutions which:

✓ reduce carbon footprint
✓ reduce emissions in general

Reduction (in %) by change from MGO to natural gas, on an equal energy basis (in%):

<table>
<thead>
<tr>
<th></th>
<th>- Approx 25%</th>
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<tbody>
<tr>
<td>CO2</td>
<td>Approx 25%</td>
</tr>
<tr>
<td>SOx</td>
<td>Approx 99%</td>
</tr>
<tr>
<td>NOx</td>
<td>Approx 85%</td>
</tr>
<tr>
<td>PM</td>
<td>Almost eliminated</td>
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</table>
Emission reduction

- Exhaust gas emission regulations ($SO_x$, $NO_x$)
- Energy Efficiency Design Index ($CO_2$)
- $CO_2$ prestatieladder
- Sustainability ambitions
**Why LNG? Why dual fuel technology?**

DEME considers LNG as a fuel to be a future-proof and sustainable solution.

<table>
<thead>
<tr>
<th>ALTERNATIVES</th>
<th>HFO Low Sulfur (0.5% S)</th>
<th>Gasoil</th>
<th>HFO + Scrubber</th>
<th>LNG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product availability</strong></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>Infrastructure development</strong></td>
<td></td>
<td></td>
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<td>5</td>
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<tr>
<td><strong>Environment: IMO regulations and beyond</strong></td>
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<td>6</td>
</tr>
<tr>
<td><strong>Technology availability and impact in ship design</strong></td>
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<tr>
<td><strong>Operations, Maintenance and OPEX</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Price</strong></td>
<td>1</td>
<td>2</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Source: P Semolinos, “LNG as bunker fuel: challenges to be overcome”, Total gas & Power
Why LNG?
High Capex but low Opex

Forecast marine fuel price paths

Source: DNV-GL, 2011

→ who can predict fuel prices?
→ delta is what it’s all about!
Why LNG? Why dual fuel technology?

Dual Fuel because:

- LNG bunker infrastructure far from mature. If LNG not available vessel can work on MGO. **Eliminates LNG supply risk**

- LNG tank capacity kept at certain limited level to protect the profitability of the business case. On long transits **MGO acts as range/autonomy extender**
DEME: ongoing investment program – vessels with natural gas as a fuel

1. “Minerva”
   - TSHD. Hopper of 3,500m³
   - Lpp x B x D = 76m x 18m x 7,5m
   - 4,8 MW prime power. Dual fuel engines:
     - 2 x ABC 16DZD, MCR 2,4MW each.
   - 200m³ LNG tank, 1 week autonomy
3500 m³ TSHD “Minerva”

200 m³ C-type LNG tank
DEME : investment program – vessels with natural gas as a fuel

2 “Scheldt River”

- DP TSHD. Hopper of 8.000m³
- Lpp x B x D = 110m x 25m x 9m
- 10,5 MW prime power. Dual fuel engines:
  - 4,5 MW MCR Wartsila 9L34DF
  - 6,0 MW MCR, Wartsila 12V34DF
- 630m³ LNG tank, 1 week autonomy
8,000 m³ TSHD “Scheldt River”
Dredging International

630 m³ C-type LNG tank
8.000m³ TSHD “Scheldt River”

Drive trains
- Engine directly drives centrifugal dredge pump.
- Wartsila sep 2014: “DF OK!”
- Hybrid drive
- Wartsila tests late 2015: dynamic behaviour “as diesel engine”
DEME: investment program – vessels with natural gas as a fuel

3 “Bonny River”

- TSHD. Hopper of 17,000m³
- Lpp x B x D = 139m x 30m x 13,7m
- 16,0 MW prime power. Dual fuel engines:
  - 2 x Wartsila 16V34DF, each MCR=8,0 MW
- 630m³ + 380m³ LNG tanks, 1 week+ of autonomy
15,000m³ TSHD "Bonny River"

- 630m³ C-type LNG tank
- 380m³ C-type LNG tank
Innovation at Royal IHC

- Emission regulations
- Fuel saving
- CO₂ reduction
- Underwater sound
- Turbidity reduction

Sustainability
LNG hopper research
Challenges

LNG storage:

→ Large impact on vessel layout
→ IGF code adds extra complexity
Challenges

**Tank size** (for comparable energy content)

<table>
<thead>
<tr>
<th>630m³ LNG tank</th>
<th>length</th>
<th>diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimensions in m</strong></td>
<td><strong>height</strong></td>
<td><strong>width</strong></td>
</tr>
<tr>
<td>Stainless steel shell</td>
<td>19,10</td>
<td>6,58</td>
</tr>
<tr>
<td>Box *</td>
<td>20,20</td>
<td>8,10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7,20</td>
</tr>
</tbody>
</table>

→ 1178m³

* Box in which the tank + insulation + saddle fits

A 630m³ LNG tank contains a heat value of:

= approx 630m³ x 0,95 x 22GJ/m³ = 13,167,- GJ

The box shape equivalent bunker tank filled with MGO (DMA ISO 8217) contains:

= approx 1178m³ x 0,95 x 35GJ/m³ = 39,169,- GJ

→ On board, LNG requires approx 3 times more space than MGO
LNG hopper dredgers
Challenges

Load step capability:

- Diesel engines have better load step capability than LNG engines
Challenges

Load step capability:

- Diesel engines have better load step capability than LNG engines
- Additional measures might be needed (e.g. temporary energy storage, control systems)
- Load step capability dependent on engine type
- IHC performed load step tests on several DF engines:
  - Wärtsilä 6L20DF + 6L34DF
  - ABC DF 16 DZD
Challenges

Availability of LNG

Source: DNV

LNG Bunkering infrastructure in Baltic & North Sea

Existing:
1. Florø
2. CCB
3. Hallhjem
4. Snurrevarden
5. Risavika
6. Stockholm
7. Bodø
8. Vestbase
9. Moskenes
10. Lødingen

Planned:
11. Turku
12. Øra
13. Lysekil
14. Tallin
15. Hirtshals
16. Brunsbüttel
17. Hamburg
18. Rotterdam
19. Antwerp
20. Zeebrugge
21. Ghent
22. Mongstad
23. Gothenborg
24. Helsingborg
25. Copenhagen
26. Aarhus
27. Lübeck
28. Roscoff
29. Helsinki
30. Rotterdam
31. Swinoujscie
32. Rostock
33. Cuxhaven
34. Grain
35. Tornio
36. Klaipeda
37. Hou Harbour
Challenges

Bunkering - methods

• Truck
• Bunker ship
• Bunker station (gate terminal)
• Containerized

LNG bunker ship Rotterdam (6500 m³, 2016)
LNG Bunkering

Bunker connection - size of filling line?

2”?  4”?  6”?  8”?  
50m³/h  200m³/h  400m³/h  800m³/h

Bunker barges: “2” max 50m³/hr. Too slow......”

Bunker station on both sides?

Vapour return lines?

Standards?
Bunker frequency – how to optimise?

• Trailing suction hopper dregder with DF is a particular case
• Taking only LNG on board: high bunker frequency
• Take also MGO on board: lower bunker frequency but average fuel cost increases
• Very low bunker frequency: high average amount of fuel on board and corresponding loss of deadweight and high fraction of MGO consumption

→ Optimum frequency to be found
→ Optimum LNG // MGO to be found
Adopting LNG as a fuel – consequences for ship owner

Crew training & qualifications & staff training
Problem: no well established rules with most flag states
........can also be considered as an opportunity.

Shift from sail to steam | steam to oil | oil to gas
Multi-disciplinary approach to prepare and support conversion
Challenges

- Volume LNG storage vs. autonomy
- Position LNG tank
- Load step capability
- Ship design and configuration
- Regulation and certification
- Commissioning
- Availability of LNG
- Bunkering
- Maintenance and operational use
LNG hopper dredgers
LNG hopper dredgers
Conclusions

- Emission regulations have impact on ship design
- LNG storage has large impact on ship design
- Load step capability can be critical, additional measures might be necessary
- LNG class rules add extra complexity to design and engineering
- LNG is a economical viable alternative, due to its earn back potential on fuel price (subject to evolution of fuel prices and cost to bring LNG to ship’s bunker flange)
- LNG is a sustainable and feasible answer to strict emission regulations
Thank you for your attention