The development and approval process of the first GRP car ferry in Norway

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E-LASS Bremen 30-01-2020
Barmen ferry project

- April 2018: 10 year contract awarded from the Norwegian road administration (Statens Vegvesen) to shipowner Vidar Hop Skyssbåter
- Building contract awarded to Maaloy shipyard

The isle of Barmen
30 permanent residents
Maaloy shipyard

- Composite shipyard in north-west between Bergen and Ålesund
- 20 employees

Vidar Hop Rederi

- Family owned shipowner in Sogn in western Norway
- 13 vessels
- 29 employees

Sub-contractors:
Main data

- Name: «Barmen»
- Build: 23
- Design: Easyform / Sea Technology
- Length: 29.98
- Width: 11.00
- Tonnage: 239
- Propulsion: All electric
- Material: GRP Sandwich
Why composites?

<table>
<thead>
<tr>
<th>Material</th>
<th>Estimated relative weight difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon fiber sandwich</td>
<td>30%</td>
</tr>
<tr>
<td>Glass fiber sandwich</td>
<td>40%</td>
</tr>
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<td>Aluminium</td>
<td>50%</td>
</tr>
<tr>
<td>Steel</td>
<td>100%</td>
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</table>

Source: DNV GL HSLC - Panel calculations by cDynamics

### Specific strength

<table>
<thead>
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<th>Material</th>
<th>Specific strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass fiber, uni-directional, quadraxial</td>
<td>Steel, Aluminium</td>
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### Estimated relative weight difference

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Source: DNV GL HSLC - Panel calculations by cDynamics

### Parameter Comparison

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Steel Ferry (Estimated)</th>
<th>GRP Composite ferry (Barmen ferry)</th>
<th>Cost effect</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull material (CAPEX)</td>
<td>Steel hull weight 125 tonne</td>
<td>GRP Sandwich hull weight 50 tonne</td>
<td>+10 MNOK</td>
<td>Building cost hull</td>
</tr>
<tr>
<td>Hull material (OPEX)</td>
<td></td>
<td></td>
<td>-6.2 MNOK</td>
<td>Maintenance cost reduction: -0.5 MNOK pr year</td>
</tr>
<tr>
<td>Battery pack (CAPEX)</td>
<td>250 kWh</td>
<td>150 kWh</td>
<td>-0.25 MNOK</td>
<td>Smaller battery pack</td>
</tr>
<tr>
<td>Propulsion (CAPEX)</td>
<td>2 x 250 kW (2 x 4000 kg)</td>
<td>2 x 150 kW (2 x 2300 kg)</td>
<td>-0.2 MNOK</td>
<td>Smaller engine</td>
</tr>
<tr>
<td>Lifetime energy consumption</td>
<td>1167 MWh x 20 = 23 TWh</td>
<td>700 MWh x 20 = 14 TWh</td>
<td>-5.8 MNOK</td>
<td>Energy consumption reduction: -0.47 MNOK pr year</td>
</tr>
<tr>
<td>Total cost reduction</td>
<td></td>
<td></td>
<td>+2.45 MNOK</td>
<td></td>
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</tbody>
</table>

Assumptions:
1) Steel ferry total operational displacement: 200 t
2) GRP ferry total operational displacement: 120 t
3) Battery pack and thruster capacity increases linearly by weight (simplification)
4) Energy cost: 1 NOK/kWh
5) Present value interest rate: 5%
6) 20 years, 3000h/year, 70% of installed effect, 10% power loss during charging

...and it looks nice too!
Laws and regulations

- The ferry is all-electric, constructed in GRP material and will carry dangerous goods
- Not covered by existing laws and regulations

-> A risk based design approach acc. to MSC.Circ 1455 was therefore required by Norwegian Maritime Authorities (NMA)

MSC.Circ 1455 Process

Preliminary design phase
  - Alternative design description
  - Hazid
  - Test and analysis plans

Review by authorities
  -> Approval basis established

Final design phase
  - Perform tasks defined in approval basis (tests and engineering analysis)

Review by authorities
  -> Approval (or not..)

Overall goal: The alternative solution shall have an equivalent safety level as prescriptive design!
Preliminary design scope

• Process to be performed with approved expertise
• Hazid
• Identify consequence for all types of ADR goods
  • Class 1 (Explosives)
  • Class 2 (Gases)
  • Class 3 (Flammable liquids)
  • Class 4 (Flammable solids)
  • Class 5 (Oxidizing agents and Organic Peroxides)
  • Class 6 (Toxic and Infectious Substances)
  • Class 7 (Radioactive Materials)
  • Class 8 (Corrosive Substances)
  • Class 9 (Miscellaneous dangerous goods)
• Preliminary design report
  • Functional description of alternative design
  • Hazid report
  • Risk assessment plan
  • Testing and analysis plan

Final design scope

• Preliminary design accepted. A simplified process was conducted from this point based on NMA review.
• Perform approval tests and engineering analysis phase
• Final report
  • Test reports
  • Final risk analysis covering passive and active fire protection describing all measures in-line with and beyond prescriptive requirements.
Specification and design drivers

• 10 cars or 1 truck
• All-electric
• Max axle load 13 tonne
• Shall carry all types of ADR dangerous goods
• 3 m zone around dangerous goods to doors, hatches, ventilation etc.

Approval basis – design rules

• Norwegian regulations
• Dispensation sought for use of alternative design standard for fire safety.
• Fire safety acc. to IMO HSC2000 Ch.7

<table>
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<tr>
<th>Discipline</th>
<th>Design basis</th>
</tr>
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<tbody>
<tr>
<td>Structural design</td>
<td>Forskrift 01. juli 2014 nr. 1072 om bygging av skip</td>
</tr>
<tr>
<td></td>
<td>§4 (Ships in domestic traffic): The construction requirements of a renowned classification society shall be used.</td>
</tr>
<tr>
<td></td>
<td>Structural design acc. to DNV GL HSLC rules. The vessel is not classed.</td>
</tr>
<tr>
<td>Subdivisions and stability</td>
<td>Forskrift 1. juli 2014 nr. 1072 om bygging av skip</td>
</tr>
<tr>
<td>Machinery and electrical</td>
<td>Forskrift 1. juli 2014 nr. 1072 om bygging av skip</td>
</tr>
<tr>
<td>installations</td>
<td>DNV GL RU-SHIP Pt.6 Ch.2 (2018)</td>
</tr>
<tr>
<td>Battery systems</td>
<td>Forskrift 01. juli 2014 nr. 1099 om brannsikring på skip</td>
</tr>
<tr>
<td>Fire safety</td>
<td>Dispensation from the regulation acc. to §19 to use HSC2000 rules.</td>
</tr>
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</table>
Barmen ferry - Fire safety design

- Exterior surface system
- 60 min fire barrier/load bearing capacity on car deck and towards deck house
- Foam capacity and deluge nozzle coverage better than prescriptive design
Summary

• Composite is a good choice for small and medium size car ferries
• Less maintenance cost, less power consumption and full design freedom are the selling arguments
• But... Some work to be done in the approval process.
Next project: Cost-effective Fire-Resisting material

• Budget 1.15 million € (50% financed)
• Direct spin-off from the Barmen ferry project
• Funded by Norwegian Research council
• Partners:
  • Sea Technology/Maaloy verft - Shipyard
  • Libra plast – Manufacturar of ship doors and hatches
  • cDynamics – Project management and consultancy
  • RISE – Develop new fire models and perform fire tests
• The outcome of the project will be new solutions for composite panel and door constructions, complying to the International code for application of fire test procedures (FTP Code).