Composite experience of a shipyard
Content:

- Short introduction Damen Shipyards: Facts & Figures

- Presentation Damen Schelde Naval Shipbuilding  
  \(\text{(MSc Aerospace L. Morel)}\)
  
  “Composite research projects – DSNS”

- Presentation Damen Shipyards  
  \(\text{(MSc Aerospace O. de Swart)}\)
  
  “An overview of composite products and technologies at Damen from past to future”

- Questions & Answers
DAMEN SHIPYARDS GROUP
FACTS AND FIGURES

- Annual turnover: €1.8bn
- 41 yards worldwide
- Over 6,000 employees
- Annual deliveries: 160 vessels
- More than 5,000 vessels delivered since 1969
- Stock hulls: > 150
- Over 1,500 repair jobs per year

**TURNOVER**
- Newbuilding 70%
- Repair 14%
- Services 6%
- Components 3%
- Building on site 7%

**NEWBUILDING**
- Harbour services and Shipping 22%
- Offshore support 20%
- Security and Patrol 20%
- Naval 20%
- Public transport 5%
- Dredging 5%
- Yachts 6%

**EXPORT**
- The Netherlands 24%
- Rest of Europe 33%
- Americas 11%
- Middle East 7%
- Africa 12%
- Asia 13%
Damen Schelde Naval Shipbuilding

Composite research projects - DSNS

Frigates, Corvettes & Patrol Vessels

Amphibious Support Ships, Naval Auxiliaries & Complex Commercial Vessels
"The Stone Age did not end because of lack of stones"

"Commercial" research projects: BESST & Groot Composiet

"Naval/defence" research projects: CONVINCER & HARDCORE

This is a selection of projects, not a complete overview!
**Composite research projects - DSNS**

- "**Commercial**" research projects

Projects:

**BESST**: “Breakthrough in European Ship and Shipbuilding Technologies”

*Follow-up project on:*

**DE-Light**: “Complex lightweight modules for ships and railway using risk based design methods”
**BESST-project:** “Breakthrough in European Ship and Shipbuilding Technologies”

- Outfitting, namely cabling, foundations, isolation, penetrations, etc.
- Modifications and repair

- Fire protection \( \rightarrow \) Full-scale flash-over fire on the DE-Light demonstrator
  \( \rightarrow \) only passively protected. No active fire protection
Composite research projects – DSNS
“commercial”

**BESST-project:** “Breakthrough in European Ship and Shipbuilding Technologies”

- Steel-composite connection is fully optimized and already applied on a real naval ship (Indian project by Kockums).

- Alternative stiffener system
  - Easier outfitting
  - Reduced deck height
  - Fulfillment of strength and stiffness requirements
Groot composiet: “Failure modes of sandwich structures under dynamic out-of-plane loads”

- Very detailed modeling in order to predict:
  - Crack initiation in the matrix between the fibres
  - Failure of the fibres
  - Delamination between the layers
  - Failure of the foam core

Modeling will be validated by means of drop testing.

Also, all the material properties were determined by strictly following the test procedures described in the corresponding norms and standards. It could be concluded that there is a large discrepancy between the material data sheets of the supplier and the measured properties.
CONVINCE:

“Vulnerability Reduction Technologies for Large Maritime Composite Structures”

Period: 2009-2013

Follow-up project on:

Euclid 3.8: “Composite Structures - Naval Application Technology”

Period: 1994-1999

Euclid 3.21: “Survivability, Durability & Performance of Naval Composite Structures”

Period: 2000-2004
CONVINCER: Equivalent blast & fire resistance of composite bulkheads

COPing with Naval Vulnerability through INnovative Composite Engineering

Application Case: Composite Superstructure
CONVINCE: Equivalent blast & fire resistance of composite bulkheads
CONVINCe: Equivalent blast & fire resistance of composite bulkheads

- Halve scale blast tests at TNO

JOINT X: PASS

JOINT Y: FAIL

Problem: passive fire protection does not survive blast YET!
active fire protection? TBD

Fire resistance?!?
Design fire scenarios = Peace-time scenarios + Weapon-induced scenarios

**Peace-time scenario**
- external fires: helicopter re-fuelling, helicopter crash, replenishment
- hangar fire
- interior fires: classic cases according to SOLAS

*Lessons learned in other projects (~ BESST, …)*

**Weapon-induced scenario**
- burning propellant from an un-detonated missile (~ hydro-carbon fire)
- fires initiated by weapon impact (~ big fire combined with large damage)

ASSUMPTION = fragments are not considered as fire ignition source, but only as a damage source to fire protection systems, components and structures.
**Hardcore-project:** fire and fragment resistant blast bulkhead

Various protective concepts, utilizing different materials, were developed and tested, as to create comparative results.
Questions at the end of presentation

1. Birth
   Form question in your mind

2. Evaluate
   Is it a reasonable question?

3. Remember
   Until you can ask the question

4. Courage
   To ask the question out loud
Contents

An overview of composite products and technologies at Damen from past to future
Introduction of composites at the yard

Production processes
- Hand lamination

Assembly processes
- Lamination

Structures
- Plywood stiffeners
- Robust solid laminate
- First experiments with sandwich laminates

1960’s-80’s: Patrol vessels & Tenders
External production and engineering

Production processes
  - MDF plugs
  - Spray up
  - Core bonding
  - Hand lamination
Assembly processes
  - Lamination
  - Introduction of bonding
Structures
  - Sandwich & solid laminates
Worldwide production based on previous experience &
Enhanced external and internal engineering capabilities

- Production processes
  - Vacuum infusion of sandwiches
- Assembly processes
  - Bonding
- Structures
  - Mainly sandwich laminates
  - Bonded stiffeners
- Analysis
  - FEA analysis natural frequencies
Fundamental and applied research & development
Collaboration and built up experience

Production processes
- Moulding all composite components including frames
- CNC milled foam plugs

Assembly processes
- Bonding of complete stiffening structures
- Very tight tolerances

Structures
- Fully orthotropic laminates
- Bonded stiffeners
- Hybrid laminates
2010 – Now: Pilot vessels & Passenger ferries

**Industrialization & scale up**

**Production processes**
- Vacuum infusion of large hull sections

**Assembly processes**
- Bonding of complete stiffening structures

**Structures**
- Bonded stiffeners
- Carbon fiber
- Fully orthotropic laminates

**Analysis**
- FEA full structures, sound & vibrations
Prototyping and advanced production processes

Production processes
- RTM
- Infusion
- Pultrusions

Assembly processes
- Underwater adhesive applications

Analysis
- FEA Structural details with solid cores
- FEA Fin breakage
Focus on production, industrialization & mass customization

Production processes
- Design for production
- Infusion
- RTM

Assembly processes
- Design for assembly
- Modular assembly process

Structures
- Fire resistance certification according to EC
- Design for cost
Enhanced scale & weight management

- Production processes
  - Full CFRP technology
  - 3D Infusion
- Assembly processes
  - Focus on weight
- Structures
  - Full structural weight optimization
  - Advanced robustness analysis and insight
## Damen Gorinchem Composite Products overview

<table>
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<th>Recently built</th>
<th>Under construction</th>
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<tr>
<td>• DFF1004: Carbon fiber</td>
<td>• SAR 1906: Superstructure</td>
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<tr>
<td>• DI 1102: Glass/carbon fiber hybrid</td>
<td>• SPi 2205: Glass fiber</td>
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<tr>
<td>• FCS 1204: Superstructure</td>
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</tr>
<tr>
<td>• FCS 1605: Superstructure</td>
<td></td>
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<tr>
<td>• FCS 1905: Superstructure</td>
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<table>
<thead>
<tr>
<th>In development</th>
<th>Requests</th>
</tr>
</thead>
<tbody>
<tr>
<td>• FCS 1605: Glass fiber</td>
<td>• Fast Ferries up to 45 m: Carbon fiber</td>
</tr>
<tr>
<td>• Modular Waterbus: Glass fiber</td>
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STANDARD OF EXCELLENCE
Q&A
You have Questions
We have Answers