KOFS

Composites for Sustainable Shipping

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and Zhiyuan Li (Chalmers Uni. Of Tech)

RISE Fire and Safety

Study Background

- S-LÄSS (Swedish E-LASS)
- Focus on remaining barriers of composite utilization
    - Ice capabilities
    - Regulation (Fire Safety)
    - Design and competence
    - Sustainability (circularity)

Study Method

- Five thematic workshop sessions with all project partners
  - Fire Safety - Regulation 17
  - Noise, Vibration and Harshness
  - Sustainability and Circularity
  - Lightweight as an electrification enabler
  - Fire Safety – High Speed Craft Code
- FTP Part 5 tests (Spread of Flame), 5 samples
- Ice condition and hull response calculations

Study participants

- Swede Ship Composites
- Green City Ferries
- SAAB Kockums
- BPAB
- Teknos AB
- Chalmers Uni. of Tech.
- RISE AB (coordinator)

Swede Ship Composites

Green City Ferries

SAAB Kockums

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Focus areas – background

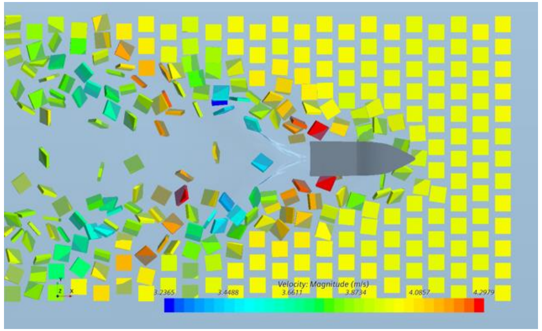
Focus area 1:
Ice condition capabilities simulation

In 2016 the S-LÄSS supported study: *”Lightweight vessels in winter conditions”* – J. Edvardsson concluded that:

1. It is possible to build lightweight vessels for most of the winter conditions.

2. It is important to put the ambition on the right level to avoid to trade-off too many of the advantages of the lightweight vessel.

Chalmers tested their method to optimize hulls in this study



Focus area 2:
Industry needs in terms of regulations

- Increase the efficiency and transparency of the approval process (R.17 and HSC)

- Combinations of fire resistance (passive) and fire fighting (active)

- State of the art fire restricting coatings and panels

  - Revisit and complement the KOMPIS-project results (ELASS #15)

Focus area 3:
Design, competence and sustainability

Input from the members of S-LÄSS:

- There is still hesitancy in adopting large scale composite structures in the maritime domain, due primarily to fire safety regulations.

- Not enough skilled composite technicians in our industry and knowledge of composite manufacturing in Asia is low.

- As drivetrains become dominantly electrified the sustainability requirements of composites becomes more important as the lightweight will not reduce the otherwise detrimental fossil fuel consumption over a vessel lifetime.

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Ice condition capabilities simulation

Zhiyuan Li

Chalmers University of Technology

Ice condition capabilities simulation

Hull structure: Carbon fibre / epoxy laminate and girders (Hat-profiles)

Conditions: Fractured Ice Field

<u>Simulation procedure:</u>

1. Ice modelled using DEM, Discrete Element Method
2. Air and Water resistance = Volume of fraction, CFD
3. Simulated in STAR-CCM+ that combines CFD
4. FEM of loads on the hull using ABAQUS

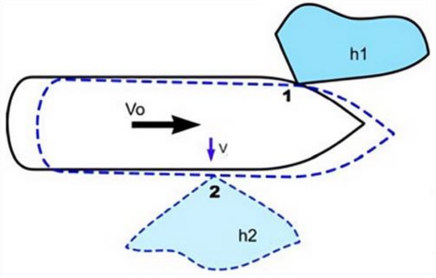
The case study vessel

(model courtesy: POSEIDON KONSULT AB)

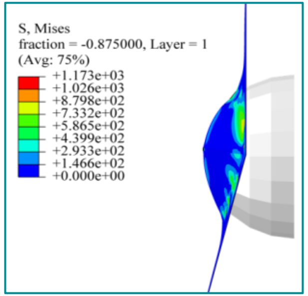
Length over all (LOA) [m]	13.6
Length waterline (LWL) [m]	12.5
Beam over all (BOA) [m]	4.5
Beam waterline (BWL) [m]	4.4
Displacement [ton]	15.5
Draft [m]	0.92
Service speed [kn]	45+

Ice condition capabilities results

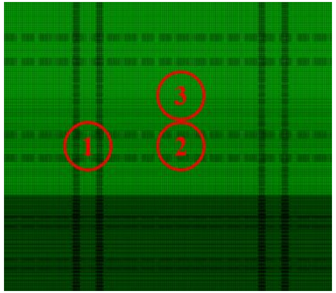
- The ship's speed is critical to the ice resistance and subsequent ice loads on the hull.
- Method of calculation can be used to design operation and condition to find suitable laminates and girders.
- The method can also determine suitable speeds for existing vessels for certain ice-conditions.



The ice collision scenario



Resulting skin-stress



Test locations (1) on girder (2) and (3) middle of girders

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Fire test results
Spread of flame

Anna Sandinge

RISE Fire and Safety

KOMPIS project

Partners:

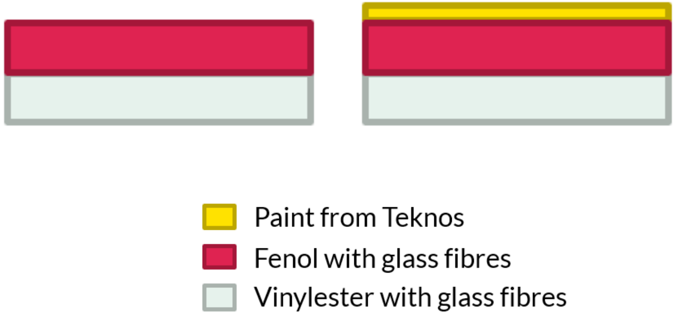
Objective of the project

- Increase the knowledge and usage of composites of regional companies

- Evaluate mechanical and fire performance of selected composite materials.

Material selection in the KOMPIS project

- Hybrid with vinylester and phenol
  - Reinforced with glass fibres
  - Phenolic skin acting as fire barrier
  - Vinylester provides strength

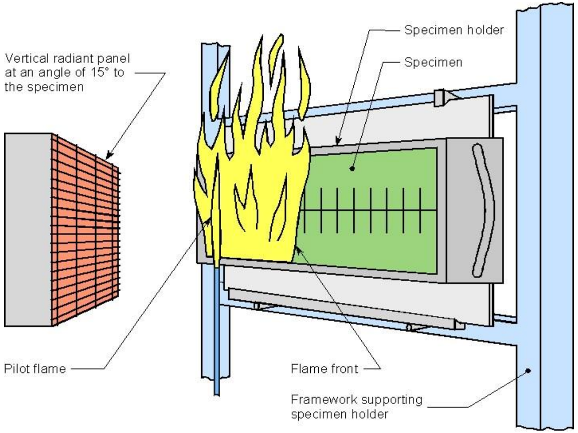


- Fibre content: 52 %

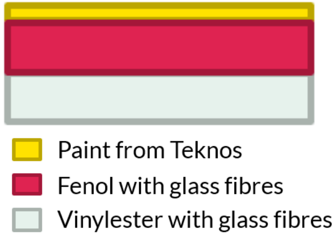
Surface flammability, Spread of flame – IMO FTP Code Part 5

The specimen is vertically positioned during test and exposed to heat radiation from a radiation panel and a pilot flame.

The time when the specimen is ignited and the time when the flame reaches every 50 mm mark along the specimen is noted. Time to flame out of the flame front on the center line, burnt length and any occurrence of burning droplets are noted.

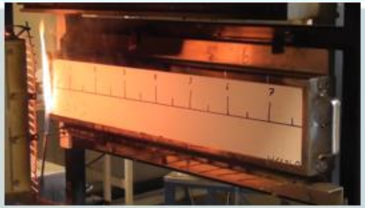
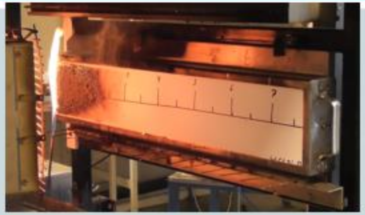
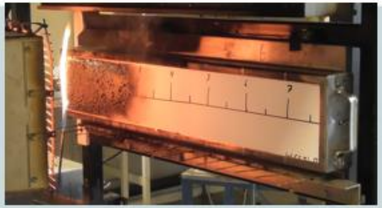
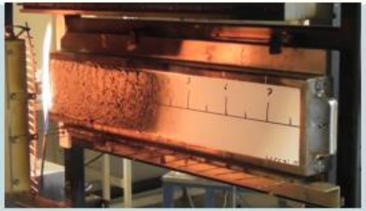


KOMPIS project – fire test results



- No ignition of the sample in the IMO Part 5 test, Spread of flame test.
- The product fulfilled the criteria for all fire test parameters.

→ Successful fire test!

Time in test 30s	1 min	2 min	10 min
			

Tested products – KOFS

Product 1 – Vinylester/Carbon fibres

Material:
4 lager kolfiber Bx 0600 impregnerad med Vinylester Dion 9100-M700 (härdare Trigonox 239)

Product 2 – Vinylester/Glass fibres

Material:
4 lager glasfiber Bx 0600 impregnerad med Vinylester Dion 9100-M700 (härdare Trigonox 239) .

Product 3 – Phenol /Carbon fibres + Vinylester/Carbon fibres

Material:
2 lager Bx 0600 kolfiber , impregnerat med Fenolplast Hexion Cellobond J2042X01 (härdare Phencat 10)mot formyta.
2 lager kolfiber Bx 0600 impregnerad med Vinylester Dion 9100-M700 (härdare Trigonox 239) .

Product 4 – Phenol/Carbon fibres + Primer + Vinylester/Glass fibres

Material:
2 lager glasfiber Bx 0600 impregnerad med Vinylester Dion 9100-M700 (härdare Trigonox 239) .
Primad med SIKA Primer -215
2 lager Bx 0600 kolfiber , impregnerat med Fenolplast Hexion Cellobond J2042X01 (härdare Phencat 10)mot formyta.

Surface flammability, Spread of flame – IMO FTP Code Part 5

Product		CFE (kW/m²)	Qsb (MJ/m²)	Qt (MJ)	Qp (kW)	Burning droplets
Criteria acc. to IMO Part 5		≥ 20.0	≥ 1.5	≤ 0.7	≤ 4.0	No
Fenol Vinylester (KOMPIS)	*Test 1*	*>50*	*NI*	*NI*	*NI*	*No*
Product 1 – Vinylester/Carbon fibres	Test 1	37.5	6.7	1.9	1.3	No
Product 2 – Vinylester/Glass fibres	Test 1	46.6	-**	1.3	1.8	No
	Test 2***	46.6	-**	0.5	0.7	No
Product 3 – Phenol /Carbon fibres + Vinylester/Carbon fibres	Test 1					
Product 4 – Phenol/Carbon fibres + Vinylester/Glass fibres	Test 1					

** Not calculated since the flame front did not reach the 175 mm mark.
*** Additional pre-treatment of laminate surface before application of coating.
NI = No Ignition

CFE – Critical Flux at Extinguishment
Qsb – Heat for sustained burning
Qt – Total heat release
Qp – Peak heat release rate

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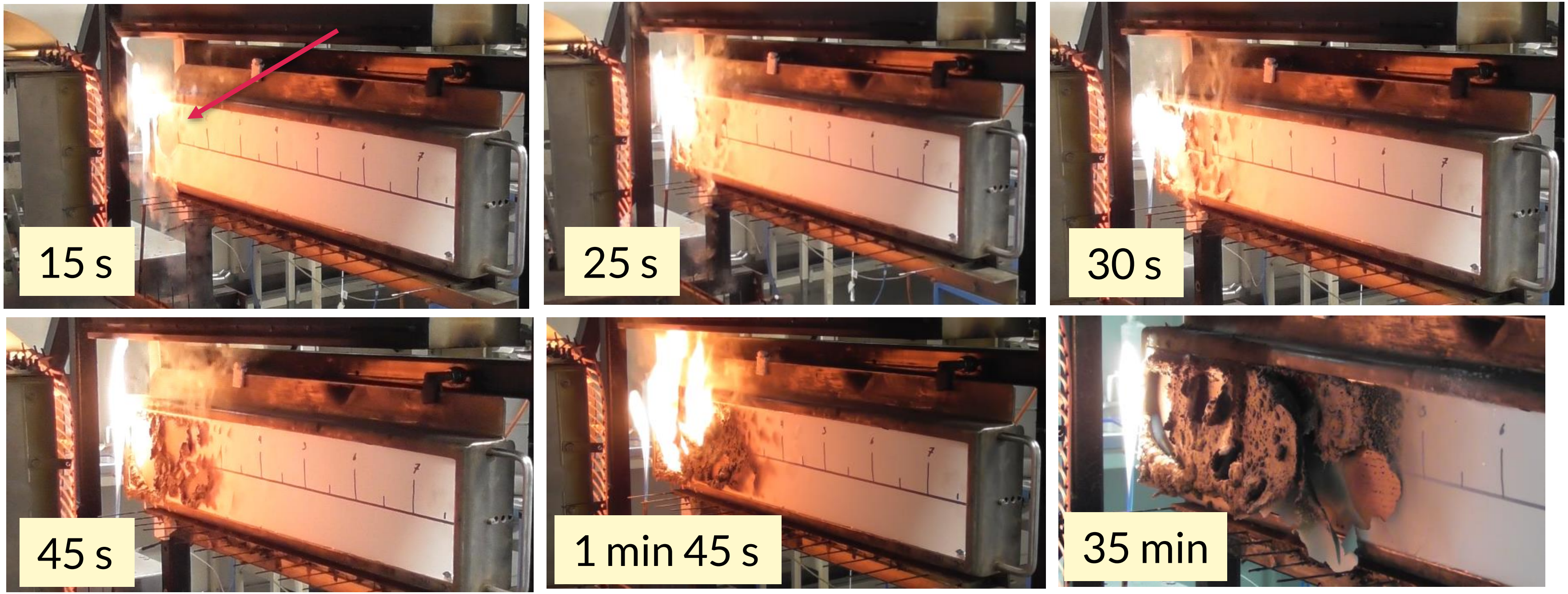
Flame spread – KOFS panel, Product 2

Vinylester/
Glass fibres

Large piece of coating fell from specimen after 15 s and 25 s.



Surface flammability, Spread of flame – IMO FTP Code Part 5

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	Test 2***	46.6	-**	0.5	0.7	No
Product 3 – Phenol /Carbon fibres + Vinylester/Carbon fibres	Test 1	No data was recorded due to early termination of test. Pieces of laminate shot out from the sample and stuck to the radiation panel. Due to risk of damage to equipment, the test was terminated.				
Product 4 – Phenol/Carbon fibres + Vinylester/Glass fibres	Test 1	No data was recorded due to early termination of test. Pieces of laminate shot out from the sample and stuck to the radiation panel. Due to risk of damage to equipment, the test was terminated.				

** Not calculated since the flame front did not reach the 175 mm mark.
*** Additional pre-treatment of laminate surface before application of coating.
NI = No Ignition

CFE – Critical Flux at Extinguishment
Qsb – Heat for sustained burning
Qt – Total heat release
Qp – Peak heat release rate

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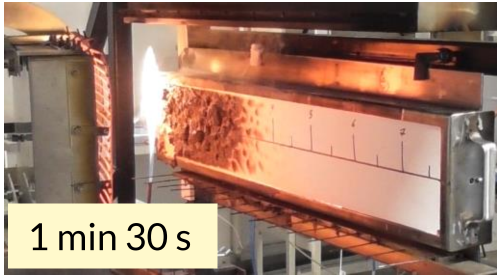
Flame spread – KOFS panel, Product 3

Phenol / Carbon fibres + Vinylester/Carbon fibres

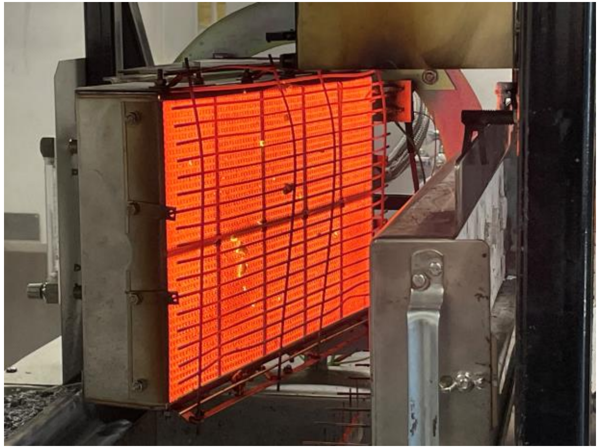


1 min 30 s

2 min 15 s

2 min 20 s

Sample after test



Small pieces of laminate shot out from the specimen and stuck to the radiation panel.

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General study conclusions

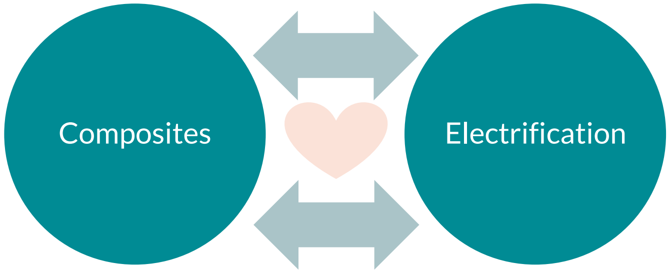
Study Conclusions 1, Regulations

- There is still no intumescent paint system that meets the requirements of FRM – Room Corner – FTP Part 10.
- FTP Part 5 for studied intumescent paint, issues are largely related to adhesion to the laminate.
- FTP Part 5 tests should be re-designed to fit the needs of composite materials, especially sandwich combinations due to the current exposed edge.
- To democratize R.17-analyses, a fire safety method guide ought to be developed.
- Scalable test could be used in development. The SBI test (EN 13823) could be used.

Study Conclusions 2: Electrification

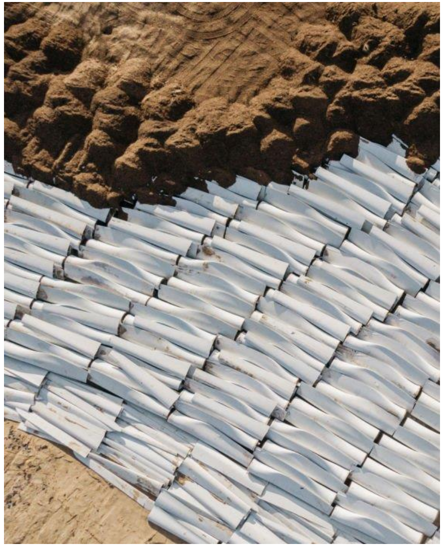
- Composite materials are becoming more important for novel naval architecture applications related to:

    - Foiling craft (Green City Ferries, Candela, Manatray, Artemis, Flying Foil etc.) (Magnus Wikanders presentation)
    - Lightweight due to operational range of electric alternatives to fossil fuels
    - Structural batteries
    - Previous issues of noise and vibration are lessened by electrical propulsion systems
    - Composite hydrogen tanks (Erwan Juins presentation)
    - Wing Sails e.g. Ocean Bird



Study Conclusions 3: Sustainability

- As electric drivetrains become more commonplace this increases the demands on composite vessels end of life treatment, a circular design approach should be adopted.
- Fibre of higher value e.g. carbon over glass, increases the circular incentive at end of life.
- Future studies ought to investigate chemically solvable matrices for maritime application.



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Thank you!