Fire retardant Composite Materials and Manufacturing Technologies for Railway and Mass Transit: Experiences and advanced Concepts meeting EN 45545, GOST...

MODERN TRENDS OF FIRE PROTECTION IN ROLLING STOCK, CIK, WARSOW 2014

P. Wartenweiler, BU Manager Composites
Fire retardant Composite Materials and Manufacturing Technologies for Railway and Mass Transit: Experiences and advanced Concepts meeting EN 45545, GOST...

1) Introduction
2) Manufacturing Technologies for Railway and M.T.
3) Composite Materials for Railway and Mass Transit
4) Experiences and advanced Concepts meeting EN 45545
5) Outlook
Typical Inside Applications

- Ceilings
- Internal doors
- Walls
- Window frames
- Luggage racks
- Seats and tables
- Driver descs
- Toilet cabins
- ...
Typical Outside Applications

- Front
- Boogie protection
- ...
Introduction

Making high quality fire resistant, low smoke and low tox. Composites

• Manufacturing processes typically used in other markets (e.g marine) are not always applicable
• FST (Flame, Smoke, Tox.) materials are normally highly filled materials…
• Great manufacturing differences between countries/factories
• EN 45545-2 requires higher performing materials
• Developments are ongoing, hurdles are taken…
• (Focus of presentation on closed mould applications)
Fire retardant Composite Materials and Manufacturing Technologies for Railway and Mass Transit: Experiences and advanced Concepts meeting EN 45545, GOST...
Manufacturing Technologies for Railway and M.T.

Hand Laminating

Low investment, labour intensive
Vacuum Infusion

(Fronts of Trains, lighter than made by HL)
Resin Transfer Moulding Light (RTMlight)

normally smaller parts: not yet fully mastered if no core for flow tunnels

3AC
Resin Transfer Moulding (RTM)

RTM Production von Wagon Window Frames

Process
- Cleaning / Release Agent: 10 Min.
- Gelcoat Application / drying
  up to 5 Layers 580g/m2: 20 Min.
- Injection time: 5 Min.
- Curing 50 DC: 25 Min.
- Demolding: 5 Min.

Total: about 1h
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2) Manufacturing Technologies for Railway and M.T.
3) Composite Materials for Railway and Mass Transit
4) Experiences and advanced concepts meeting EN 45545
5) Outlook
Making quality fire resistant, low smoke and low tox. Composites

1) Coating/Primer… or colored Gelcoats
2) Flame retardant Gelcoat
3) Flame retardant (UP) Resins
4) Suitable Reinforcement materials (Glass, CF..)
5) (Suitable Core Materials (PET)

FR-Mechanism:
- Halogens and Antimony
- Inorganic Hydroxides eg. ATH
- Intumescent Systems
Resin must have sufficient low viscosity / good wetting properties

**Resins**

- “Common” not halogenated ATH filled resins do not full fill the highest requirements
- or are too high viscous for modern/closed processing methods

**Challenge:**
Problems with highly filled halogen-free UP Resins
Mäder Solution “Giralyse” to have lower viscosity/faster wetting:
Mäder in Railway

- Paints for Rollingstocks
- Paints for buildings
- Composites
MÄDER is the European leader in Railways coatings.
# Regional Trains

<table>
<thead>
<tr>
<th>Project</th>
<th>Operational country</th>
<th>Builders</th>
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<tbody>
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<td>FLIRT Veneto - Emilie Romagn</td>
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<td>AnsaldoBreda / Stadler</td>
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## Mäder in Railway, References

### Tramways

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<td>Roma Viterbo</td>
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<td>AnsaldoBreda &amp; Firema</td>
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</table>
Composites with Mäder Gel Coat and Resins pass GOST
Nuvopol Gel Coat 80-60 TGP (A)
Giralithe SOMA 1106 XP

Front / Trimings & Ins. Parts of Foxtrot Warsow, PESA
(Painted) Composites with Mäder Gel Coat and Resins pass EN 45545-2 HL 2 (R 1, R 17)
Nuvopol Gel Coat 37-05 TGP (Intumescent)
Giralithe Ditra GL 2109-10 XP

Front / Trimings & Inside Parts FLEXITY II De Lijn, Bombardier
(Painted) Composites with Mäder Gel Coat and Resins pass EN 45545-2 HL 2 (R 1, R 17)

Nuvopol Gel Coat 37-05 TGP (Intumescent)
Giralithe Ditra GL 2109-10 XP

Driver Cabin Parts TRAXX, Bombardier
(Painted) Composites with Mäder Gel Coat and Resins pass EN 45545-2 HL 2 (R 1, R 17)
Nuvopol Gel Coat 37-05 TGP (Intumescent)
Giralithe Ditra GL 2109-10 XP
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5) Outlook
EN 45545 requires more advanced materials to:
1) pass more stringent tests
2) be processable (highly filled resins, other resins)
3) coating even more important

GRP’s according to EN 45545 will be more expensive:
1) new gelcoat technology, other core materials
2) processing
Mäder develops and produces full Systems

Coating
Resins
Gelcoats
Primers
...

Resin + Gelcoat + Primer + Top Coat = System Package
must pass the Fire and Smoke Tests

Tests with Material and Components in End-use Condition!
Experiences / EN 45545 requires intumescent Gelcoat (Nuvopol 37-05)

High fire protection through intumescent effect:

- Intumescence = swelling, foaming of a carbon rich foam layer
- Has a heat insulating effect
- Reduces further oxygen access
- Reduces fuel transport into the flame
- Prevents dripping
Mäder Intumescent Gelcoat Nuvopol 37-05

High fire protection trough intumescent effect:
Intumescent Gelcoats (New NORM EN 45545)

- Not every intumescent gel coat is resistant to humidity / only for inside
- Intumescend gel coats are much more expensive
- Depending from supplier thickness up to 0.8 -1 mm, processing?
Difficult to pass: T02 - DIN EN ISO 5659-2 Smoke Test

Determination of optical density by a single-chamber test

- 25 kW/m² with Pilot Flame or 50 kW/m².
- Samples: (75 * 75 * ≤ 25) mm
- Smoke sampling for Toxicity
- Smoke det. after 4 til 8 min.
- Max. Value from the 2 Samples
Inside R1: DS4     Outside R17 DS max!

\[ D_S(4) = 129 \]

\[ D_S \text{ max.} = 197 \]

\[ VOF4 = 260 \text{ min} \]

Trapezregel - Zeitintervall \( \Delta t = 1 \text{ min} \):

\[ VOF4 = \sum_{n=0}^{n_3} \frac{\Delta t(D_S(n) + D_S(n+1))}{2} \]

7,8 min
Coatings Influence flammability and smoke development

HL 3 System with Gelcoat and Resin

Toxic Gases
Smoke Density
VOF4
Smoke Density
Heat Release
Spread of Flame

HL 3

NUVOPOL Gelcoat 37-03 int.
on GIRALITHE DITRA 2109-10XP
CEN TS 45545 Performance with / without Coating

…becomes a HL2 System when painted

- Toxic Gases
- Smoke Density
- VOF4
- Smoke Density
- DS 4
- Heat Release
- Spread of Flame

NUVOPOL Gelcoat 37-03 int. on GIRALITHE DITRA 2109-10XP

NUOVERN AQUA Primer + Topcoat

HL 3 ➔ HL 2

HL3   HL2   HL1
Points re Closed Mould Processes

Part size in m²

- INFUSION
- RTM LIGHT
- RTM / COLD PRESS
Opposite to hand laminated parts several points have to be considered

1) production strategy
2) resin has sufficient low viscosity / wetting properties
3) used glass products
4) used core materials
5) Requirements depend of part (eg. Inside or outside use (R1 or R17 !))
Closed Mould Basics

Influence of Glass Permeability

Permeability of Reinforcement

CSM  Multimat  Unifilo  fabrics
### Standard Core Materials with PP flow media fail Flame Test

Internes RTM – light Verfahren (4mm)  
Ergebnisse Brandprüfung Epiradiateur NF F 92-501

<table>
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<tr>
<th>Bezeichnung Harz:</th>
<th>Ditra GL 2109-11 XP</th>
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<tbody>
<tr>
<td>Kernmaterialen:</td>
<td>1x Rovicore R 450/D3/450</td>
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<tr>
<td>Probendicke in mm:</td>
<td>3.8 - 4.2</td>
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<tr>
<td>Nachbehandlung:</td>
<td>15 h Raumtemperatur</td>
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<td></td>
<td>Im Umluftofen beidseitig frei</td>
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<tr>
<td></td>
<td>3h 40°C</td>
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<tr>
<td></td>
<td>3h 60°C</td>
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<td>8h 80°C</td>
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### Auswertung:

<table>
<thead>
<tr>
<th>Mittelwert: Klassierung:</th>
<th>q= 25.6 M3</th>
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</thead>
<tbody>
<tr>
<td>RTM light (4mm)</td>
<td></td>
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</tbody>
</table>
Closed Mould Basics „ 100% „ Glass Solutions needed

Specialist / 100% Core Materials pass Flame Test

Bezeichnung Harz: Ditra GL 2109 - 11 XP
Kernmaterialien: 1x Rovicore FR 450/D3/450
Probendicke in mm: 3.8 – 4.2
Nachbehandlung: 15 h Raumtemperatur
Im Umlufthofen beidseitig frei
3h 40 °C
3h 60 °C
8h 80 °C

Auswertung:
Mittelwert: q = 0.8
Klassierung: M1
Basic Strategies for Lightweight Composites

- by design/concept
  - FST gelcoat / none fire retardant resin
  - use sandwich constructions...

Beam Effect for stiffness
Mäder approach

1) CORK Sandwich Concept for Railway Composites, meeting EN 45545 HL2 (R1)
Current concept achieves a weight reduction of 35%
Mäder High Strength (HS) Concept, also for large Parts

- up to 70% Glass Fiber
- High flow FST resin NUVOCRYL FR 60-60 G passes M1, EN 45545 HL 2 R1, R6, R17, painted
- Scrimp Infusion Technologie

eg. for
Production of Fronts
Production of light weight Train Fronts

Vacuum Infusion / RTM assisted
Innovative Composite Materials and Manufacturing Concepts for Railway, Mass Transport…

- Innovative, easy to process Resins for closed Mould Process

NUVOCRYL

- Low viscosity
- High flow
- Tough
- Low smoke
- Fast Curing
- Ready to use products/systems
Innovative Composite Materials and Manufacturing Concepts for Railway, Mass Transport…
- Innovative, easy to process Resins for closed Mould Process
Case 2: Placing the high permeability flow medium OUTSIDE the laminate stack to be infused (Scrimp Techn. pat.)
Basics Infusion

Flow tests

Without Net  External Flow  ROVIFLOW

Source: Chomarat
Why use the infusion process?
Comparison hand laminat versus Infusion of Train Front
CASE 1: 10 sqm, single skin, 3.6 mm

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<tr>
<th></th>
<th>Hand lay up</th>
<th>Infusion</th>
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<tr>
<td></td>
<td>Weight/m2</td>
<td>Weight/m2</td>
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<tr>
<td></td>
<td>kg</td>
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<tr>
<td>Gelcoat</td>
<td>0.80</td>
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<td>Lam. Glas</td>
<td>1.50</td>
<td>1.50</td>
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<tr>
<td>24% / 27%</td>
<td>51% / 70%</td>
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<tr>
<td>Resin</td>
<td>4.00</td>
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<tr>
<td>Total / m2</td>
<td>6.30</td>
<td>2.95</td>
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<tr>
<td>Total Front</td>
<td>63 kg</td>
<td>30 kg</td>
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50%
Mäder High Strength (HS) Concept, also for large parts

- up to 70% Glass Fiber
- High flow FST resin NUVOCRYL FR 60-60G passes M1 Q= 0, EN 45545 HL 2 R1, R6, R17, painted
- Infusion Technologie
WHAT ADVANTAGES WITH MINERAL COMPOSITES?

- New material which combines the flexibility in design of resins with the properties of a ceramic.
- Ideal matrix for incombustible fibre reinforced composites.
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Carbon Fiber Market Development

Carbon Fiber Market Revolution

(Ktons/year)


Start of Manufacture of Torayca

Artificial Satellite

Tennis Racket and Carbon Golf Shaft Boom

Selected for Primary Structure of Boeing 777

Selected for Primary Structure of Airbus A320

Full-scale expansion in Industrial Application

Full-scale expansion in Aerospace Application

Industrial Application

Aerospace Application

Sporting Goods Application

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Carbon Fiber Applications: Cars

BMW i3
Pultruded curved Profiles

ITV-Thermoplastic-Braid Pultrusion Technology with curved die
Roboter assisted UV Curing Systems
Roboter assisted UV Curing Systems
Roboter assisted UV Curing Systems
Roboter assisted Tape Placement
Fire retardant Composite Materials and Manufacturing Technologies for Railway and Mass Transit: Experiences and advanced Concepts meeting EN 45545, GOST…

- The new EN45545-2 norm requires more expensive, more difficult-to-process materials.

- The project pre-study should be as early as possible (Process, R-Level)

- RTM light: The choice of glass product core materials and the coating is vital for successful production and passing the tests.

- Technologies are there, better ones will follow

- As with other FST requirements certain working principals apply
Technologies and materials are somewhat more complex, but available, make following points sure:

- Material Concept meets Norm Requirements
- Materials meet Production Concept / Requirements
- Handling of Resins and Gel Coats
- Production / Processing
- Post Curing
- Coating
- ...
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INNOTRANS / Berlin  
23-26 September

Mäder Coating and Composites Solutions
Mäder Customer training (new) FST Technologies

- Infusion, RTM
- Structural
- Processing Methods to assure constant quality
Innovative Composite Materials and Manufacturing Concepts for Railway, Mass Transport…
… and a dedicated team to assist you with your projects
European Service Centers in Switzerland and France

Paul Wartenweiler  
BU Manager Composites

Jürg Bützer  
Senior Tech. Sales

Michel Osterwalder  
R&D Manager
Thank you