Thermoplastic composite structural part for truck market application

- High-performance materials,
- Simulation expertise
- Innovative process technologies
Summary

- Presentation of Solvay

- Context and objectives

- Technical description of structural composite module

- Scale ¼, Mini-prototype
  - Objectives
  - Correlation test vs simulation

- Scale 1, Composite firewall
  - Manufacturing
  - Assembly in truck environment
  - Correlation test vs simulation: static/NVH/crash

- Conclusion
Lead Solvay into new Growth Territories

Innovative Solutions towards **Sustainable Mobility**

**Powertrain Efficiency**
- High performance fluoroelastomer for fuel injectors
- High temperature resistance materials for air induction & turbo systems
- Specialty polymer grades for thermal management systems

**Light Weighting**
- High performance polyamide, and composite materials for semi-structural and structural parts
- Full range of structural and 3D-moldable high-performance foams

**Electrification**
- New generation of electrolytes, salts, binders and separators to improve Li-ion battery performance
- Products for fuel cell vehicles

**Clean & Green Technologies**
- Highly dispersible silica
- Rare Earth oxide formulations for catalysis systems
- Rare earth recycling in permanent magnets

---

Research & Innovation
2015
Located in Axel’One collaborative platform dedicated to innovative materials in Lyon, France

Develop sustainable polymer solutions thanks to an approach based on:

- Processing / structure / properties relationships understanding
- Multi-scale modelling and experiments

- Lightweight structural materials: thermoplastic composites, structural foams, …
- Bio-based polymers: formulation, processing and applications
- Reinforcement and toughening of polymers

- Joint Unit with CNRS
- Academic labs in Europe, US and Japan
Composite structural module for Truck

Presentation: context and objectives

Technical description and OEM’s specifications

Scale ¼, Mini-prototype: test vs simulation

Scale 1, firewall: manufacturing and assembly
Composite structural module for Truck presentation

- **Perimeter:** front structural parts of the cab

- **Objectives:**
  - Metal replacement by composite Evolite
  - 25% of Weight saving
  - Nb parts/2 with function integration

- **Partners:**
  - OEM (Truck)
  - Solvay: material supplier and strong support in crash/static simulation
  - HBW-Gubesch: thermoplastic form-joining combined with single pressing process
  - Sika: adhesive supplier
  - Bollhoff: Fastening supplier

- **Timing:** January 2011 – end of 2015
Composite structural module for Truck partnership

- OEM for Global Architecture & Development Cab:
  - Synthesis Simulation
  - All interface fastening development
  - Prototypes for Verification & Validation Cab TEST RIGS

- Tier1: HBW-Gubesch
  - Design recommendation for feasibility parts
  - Manufacturing & finalization Parts

- Material supplier: Solvay
  - Material numerical law for mechanical simulation
  - Support on design and crash/static simulation (FEA)
  - Support on process & design feasibility parts

- Adhesive Materials supplier: Sika
  - Adhesive law for Synthesis simulation in support with SOLVAY
  - Adhesive recommendation for Prototype phase (composite module & interface)
  - Prototyping support for OEM

- Assembly fastenings supplier: Bollhoff
  - Prototyping support for OEM
Composite structural module for Truck

Presentation: context and objectives

Technical description and OEM’s specifications

Scale ¼, Mini-prototype: test vs simulation

Scale 1, Firewall: Manufacturing and assembly
Composite structural module for Truck
Technical description

Current solution in metal
All of parts are in steel assembly by spotweld and screws

VS

SOLVAY/OEM solution: Composite Firewall
- Organo sheet in composite Evolite
- Ribs: overmolded by PA6 SGF V30
- Assembly with glue or specific rivets

Composite parts
Ribs + overmolded parts in PA6 SI V30

- 25% of weight saving
- Nb of parts / 2 by function integration

21 parts in metal
Composite structural module for Truck
Technical description / Materials

New and unique composite semi-products based on high-flow PA 6 and PA 6,6 resins on a range of glass & carbon reinforcements

- Lightweight
- High-mechanical performance
- Cost-efficiency
- Short cycle time processing
- Function integration
- Recyclability

Pre-impregnated fabrics  Unidirectional tape  Consolidated plates and laminates
Composite structural module for Truck
Technical description / Materials

• Performed by

• Material supplier
  • Organo sheet: Evolite PA6 based glass Fiber 50% in volume woven fabric - balanced
  • Ribs: injected plates in Technyl ® C246SIV30 (PA6 SGF 30)

• Description:
  • 40 organo sheet 1980 x 1200 mm / thickness of 2,8 mm
    -> stamping process
  • Ribs: 400 plates 360 x 100 mm / thickness of 5 mm) injected with Technyl C246 SI V30 (PA6) used as GMT material
    -> Single pressing process
Composite structural module for Truck
Technical description / Materials

- Performed by SOLVAY
- Supplier of numerical law for crash simulation
  - Composite Evolite: orthotropic multilayer
  - Tension 0°
  - Compression 0°
  - Tension 45°

Full characterization to identify composite material law

- Ribs: Technyl® C246 SI V30
Composite structural module for Truck specifications / presentation

- Front crash ECE 29:
  7.57 mm/ms (30 km/h) - 44 kJ

- NVH correlation:

What?
- Evaluation of Occupant Protection
- Respect for the survival space

How?
- Shock absorption by the structural parts to reduce the intrusion into the passenger compartment

What?
- NVH analysis (Noise Vibration and harshness)

How?
- Modal analysis only w/o equipment
- Dynamic stiffness measurement and vibration transfer on BIW w/o equipment

Design and check of specifications of composite parts done on FEA simulation
Composite structural module for Truck

Presentation: context and objectives

Technical description and OEM’s specifications

Scale ¼, Mini-prototype: test vs simulation

Scale 1, firewall: Manufacturing and assembly
Composite structural module for Truck reduced scale ¼ : mini-prototype

• **Context:**
  - Design a representative reduced front module of a truck
  - In a representative of a truck front crash (ECE 29)

• **Actors:**
  - OEM and Solvay with Sika support for adhesive bonding
  - In Solvay’s lab: 2 phases of tests: june and december 2013

![Diagram of A pillar, Front module, Floor, Metal supports (for A pillar), Composite Evolite, Metal part (for floor)](image)
Composite structural module for Truck reduced scale ¼ part : mini-prototype

- Objectives of this dynamic test
  - Composite material: validation of the numerical mechanical behaviour law for crash simulation
  - Evaluate adherence of glue on composite Evolite (cohesive and not adhesive rupture)
  - Assembly: integration of adhesive numerical law (with Sika’s support)

From the simulation…..

…..To the reality
Composite structural module for Truck
reduced scale ¼ part : mini-prototype results

Good in force level
Good in stiffness
Good at break
Composite structural module for Truck

Presentation: context and objectives
Technical description and OEM's specifications
Scale ¼, Mini-prototype: test vs simulation
Scale 1, Firewall Manufacturing and assembly
Composite structural module for Truck Manufacturing pre-prototype

- Objectives: validation of « one-shot » process:
  - Scale up single pressing process
  - Testing material compatibilities ribs/ organo sheet
  - Optimization of process parameters: limitation of warpage

⇒BE MORE Confident for Prototypes at scale 1

- Manufacturing in « one-shot » for ribs and stamped composite

How will be the process?

Input needed:
- sheet (thickness: 3 mm, width: 250 mm, length: 350 mm)
- GMT-Material: plates (thickness: 5 mm, width: 40 mm, length: 175 mm)

Heated up sheet and GMT Material

Positioning the GMT-Material first on the cavity lay down the sheet -> closing the tool

Hold on the pressure while cooling

Demoulding the part

OK for processability
Composite structural module for Truck pre-prototype / Analysis

• Objectives

  • Ribs with short Glass Fibers -> by microtomography
    • Evaluation of cavities’ size
    • Fiber orientation
  • Organo sheet in Composite Evolite -> by microtomography
    • View of the link overmolding / composite stamped
  • Surface aspect of flange for Gluing process -> by topography (laser scan)
  • Geometry analysis: CAO vs real part -> by metrology

⇒ BE MORE Confident on part technical properties
Composite structural module for Truck pre-prototype / analysis results

• Microtomography

• Global view

• Detailed view in a rib

Colors function of orientation function of colors

Orientation function of quantity of fibers

Short glass fibers
Composite structural module for Truck pre-prototype / analysis results

- **Metrology**
  - to evaluate the difference of shape CAO vs real part

- **Topography:**

![Composite module image]
Composite structural module for Truck Manufacturing - scale 1

- Performed by
  
- Objective: support of HBW to manufacture the stamping’s tools

- Stamping simulation of composite

A simple model to composite part for truck
Composite structural module for Truck Manufacturing - scale 1

• Performed by GUBESCH

With OEM and Solvay’s support

• One shot pressforming

Top Beam punch

Top Beam out of tool

Top Beam after machining
## Composite structural module for Truck Manufacturing - scale 1

<table>
<thead>
<tr>
<th>From the simulation...</th>
<th>.....to the reality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper beam</td>
<td><img src="image1" alt="Images of Upper beam" /> <img src="image2" alt="Images of Upper beam" /></td>
</tr>
<tr>
<td>Lower beam</td>
<td><img src="image3" alt="Images of Lower beam" /> <img src="image4" alt="Images of Lower beam" /></td>
</tr>
<tr>
<td>plate</td>
<td><img src="image5" alt="Images of Plate" /> <img src="image6" alt="Images of Plate" /></td>
</tr>
</tbody>
</table>
Composite structural module for Truck assembly - bonding

- Performed by Sika®

With OEM and Solvay’s support in HBW’s plant

- Adhesive: one component elastic polyurethane

- Steps:
  - Parts preparation
  - Adhesive application
  - Hold position and curing
  - Release machining

Firewall assy = 15,8 Kg
Composite structural module for Truck assembly - fasteners

• Performed by BÖLLHOFF With OEM and Solvay’s support

• Fasteners: RIVKLE® SFC ONSERT®

Threaded inserts Overmoulding possibility
Bonded screws UV curing Good behaviour Routing application
Composite structural module for Truck assembly in truck cabin

- Performed by OEM, Solvay and

[Image: composite parts in cabin environment]

- Composite parts in cabin environment

- Composite Evolite parts

[Image: Removed current metal part on existing truck]

- Removed current metal part on existing truck

[Image: Replacement by composite parts module]

- Put all truck’s equipment: pedals, dashboard, steering column, electrical beams

C.DEMAIN
Composite Evolite for Truck market application
Composite structural module for Truck

Presentation: context and objectives

Technical description and OEM’s specifications

Scale 1/4, Mini-prototype: test vs simulation

Scale 1, firewall: correlation test vs FEA
Composite structural module for Truck specifications - Results

• Front crash ECE 29:
  • Test done on June, the 17th,

• FRF correlation:

  Correlation test vs simulation: on going

  Correlation test vs simulation: done by OEM
Composite structural module for Truck specifications - Results

- Front crash ECE 29:
  - Composite firewall after ECE 29 real crash:

  ECE 29 specifications:
  - Survival space -> OK
  - Integrity of composite firewall -> OK
  - The cabin’s doors can be opened -> OK

  small rupture near bolt area
Composite structural module for Truck specifications - Results

- Modal analysis: free - free modes

1st mode

2nde mode
Conclusion

Designing lightweight solutions for truck structural parts has been succeeded

- Metal replacement for lightweight:
  - 25% of weight saving
  - Number parts/2 with function integration

- To fulfill OEM’s requirements, design and simulation are key
  - Advanced material database for Composite Evolite, PA6 Short Glass Fiber and adhesive
  - Design adapted to thermoplastic composite parts
  - Advanced simulation for composite and assembly to predict strength, stiffness and fracture initiation area

- Prototyping and part testing
  - To correlate numerical composite and adhesive laws

- A success story with a real partnership of actors of the value chain: OEM, Tier1 (Manufacturing), assembly suppliers (fasteners and adhesive), Chemist (Materials)