Continuous Production of Honeycomb Sandwich Panels

All Aboard with Light and Cost-efficient Technology

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Innovation Day of CFK Valley Belgium – Composites and RailWay
29 June 2016, Brussels

Introduction: Sandwich construction by nature

The efficient use of material and energy is a fundamental principle of nature.

Nature set the examples – let’s save resources
Sandwich in Construction and Transportation

Important historical examples of sandwich construction in transportation

**Stephenson 1830**
- Sandwich frame in locomotive by Stephenson

**Chanute 1894, 1903 (Wright flyer)**
- Bi-plane wing construction by Chanute

**Fairbairn 1845**
- Tubular Bridge design by Stephenson and Fairbairn

**Junkers 1915**
- Sandwich metal wing design by Junkers

Sandwich constructions are composed of
- Two thin facings (skins, liners)
- One thick low density core
- Bonding layers (adhesive)

Sandwich applications
- Aerospace
- Trains
- Recreational vehicles
- Building
- Packaging

Target: Cost reduction
Potential of Sandwich Construction

Effect of the sandwich thickness:

- Geometrical definitions (symmetrical sandwich materials)

<table>
<thead>
<tr>
<th>Sandwich effect on bending stiffness and cost</th>
<th>monolithic</th>
<th>thin panel</th>
<th>optimized</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$h_1 = 2t_1$</td>
<td>$h_1 = 1.2h_1$</td>
<td>$h_1 = 2.4h_1$</td>
</tr>
<tr>
<td>Relative thickness</td>
<td>1</td>
<td>1.2</td>
<td>2.4</td>
</tr>
<tr>
<td>Relative bending stiffness</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Relative weight (core density 20 mass %)</td>
<td>1</td>
<td>0.345</td>
<td>0.177</td>
</tr>
</tbody>
</table>

- Economic advantage depends on low core material cost and low production cost:

- 82.3% weight saving
- 82.3% cost saving

Core material types

Core types

- Sandwich core materials
  - Homogeneous support of the skins
    - Foam cores
  - Structured (non-homogeneous) support of the skins
    - Punctual support
      - Textile-pin cores
    - Regional support
      - Cup shaped cores
    - Unidirectional support
      - Corrugated cores
    - Bi-directional support
      - Honeycomb cores

- ... but high manufacturing costs
Conventional honeycomb production processes

Thermoplastic honeycomb production by extrusion

Tubular honeycombs

Extruder → Extrusion of single tubes → saw → Collecting the tubes → Welding to a block → Cutting to a honeycomb

From: Tubus Waben, Polycore, Plascore, Hexacor

Out-of-plane extruded honeycombs

Extruder → Extrusion small honeycomb blocks → saw → Welding to a bigger block and cutting to a honeycomb

From: Nidaplast, Nida-Core

Both processes

• require the production of blocks and the cutting from blocks
• result in a low degree of automation and in relatively high costs

ThermHex: Continuous production process

• Honeycomb cores from a continuous film through a step-by-step in-line process

Aerospace

Internal structure and mechanical properties

⇒ Best mechanical properties
⇒ Major cost reduction

New Honeycomb Cores

ThermHex
Thermoplastic Honeycomb

Packaging Industry

Production concept and machinery

⇒ Automatic production
⇒ Low production costs

• Automated in-line production leading to very low production costs
• Direct lamination of skins allows in-line production of panels
EconCore N.V. – ThermHex Waben GmbH

- EconCore N.V. – technologies for cost efficient production of honeycomb core and sandwich parts
  - founded: 22.12.2005

ThermHex

- ThermHex Waben GmbH – production of thermoplastic honeycomb cores
  - production start: 01.04.2010

EconCore Technology - ThermHex

Continuous production of ThermHex honeycomb panels

Schematic view on the film fed ThermHex panel production line

...or by direct polymer film extrusion
Value chain

Sandwich production value chain

- Core material producer
- Sandwich panel producer
- Part producer
- Assembly plant

1. Core production
2. Sandwich constituents (core, skin and bonding layer)
3. Sandwich panel (sandwich material)
4. Forming
5. Sandwich part
6. Assembling
7. Sandwich structure

- In-line core preparation
- Sandwich material producer
- In-line post processing
- End user

Low cost value chain

Summary – ThermHex Applications

- Automotive
- Transportation
- Skin material
- Furniture / Interior
- Packaging Logistics / Graphical
- Building Construction
- Other
ThermHex production lines - references

1 EconCore (Belgium) - Lab Line – 400mm width
   Started in 2005, For PP, PET, ABS, PC, PA, etc.

2 EconCore (Belgium) Demonstration Line – 1400mm
   Operational since 2006 – improvement & modification ongoing

3 Gifu Plastics (Japan) PP Core + PP skins – 1400mm
   Operational since mid 2009,
   2nd line started in 2012

4 ThermHex Waben (Europe) PP Core only – 1200/1400mm
   Since 2010, Daughter Company of EconCore

5 Karton (Europe) PP Core + PP skins – 1400mm
   Operational since September 2010

6 Renolit GOR (Europe) PP and composite skins– 1500mm
   Operational since 2013

7 RoPlast (Turkey) PP and composite skins– (2100mm)
   Operational since 2014

8 TATA Steel (Europe) Metal skins – (1550mm)
   Operational since Nov 2015

Web link to Teccell
http://www.risu.co.jp/teccell/index_e.html

ThermHex – PP honeycomb panels

PP-ThermHex parts – by TECELL
http://www.risu.co.jp/teccell/index_e.html
ThermHex – PP honeycomb panels

- PP panels for packaging and sign & display markets
- Karton is a number 1 producer of fluted PP board in Europe
- Karton annual revenue 200 Million Euro/year
- www.karton.it
ThermHex – automotive solutions

• WPC-ThermHex board – GORCELL

Automotive & furniture

Web link to Renolit - Gorcell

MASERATI GHIBLI

FIAT 500L

courtesy of Renolit
**Aluminium Composite Panels**

**Flexural Stiffness.** 3 point bending, 1000 mm span length, 300 mm panel width, 10 N load

<table>
<thead>
<tr>
<th></th>
<th>Solid Aluminium</th>
<th>Traditional Aluminium Composite Panel with solid PE core</th>
<th>ThermHex Composite Aluminium Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel thickness (mm)</td>
<td>3.0</td>
<td>4.0</td>
<td>4.2</td>
</tr>
<tr>
<td>Skin thickness (mm)</td>
<td>-</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Flexural deflection (mm)</td>
<td>4.6*</td>
<td>4.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Panel weight (kg/m²)</td>
<td>8.1</td>
<td>4.8</td>
<td>2.1</td>
</tr>
</tbody>
</table>

*When placed on the supporting beams, the panel shows already significant initial deflection due to high weight of the panel roof. Value stated in the table represents only deflection produced on top of the initial deformation and hence actual total deflection of the loaded panel is higher.*

Over 50% weight savings of ThermHex Panel compared to traditional Aluminium Composite Panel

**Steel Composite Panels**

3 November 2015

Tata Steel unveils unique addition to its strip product portfolio at Biochemo 2015

Tata Steel has launched *Coronotec®,* its latest range of steel products, at the Biochemo in Stuttgart, Germany. The innovative product is expected to be a game-changer in the future in the bio-economy with applications in a wide range of sectors in the manufacturing and construction industries. The unique feature of the product is that it can be used in a variety of applications.

*Coronotec®* is available in a thickness of 10mm and combines two high-performance materials: a polymer core and a high-grade steel. The combination of the two materials provides excellent performance in terms of strength, flexibility, and durability. The product is designed to meet the needs of various industries, including construction, automotive, and manufacturing. It is also suitable for applications in the aerospace and automotive industries, where lightweight and high-strength materials are required.

Tata Steel's *Coronotec®* is a result of innovative research and development efforts aimed at creating sustainable and eco-friendly products. The company continues to invest in research and development to meet the growing demand for sustainable and innovative products in the global market. Tata Steel's *Coronotec®* is a testament to the company's commitment to innovation and sustainability.
Metal Composite Panels

Applications:
- building facades
- roofing / flooring
- interior cladding / cleanrooms
- separation walls
- visual communication
- solar energy modules
- furniture
- automotive
- mass transportation interiors
- lightweight (airfreight) containers
- ...

ThermHex – PP honeycomb cores – composites industry

• ThermHex Products

Polypropylene honeycombs for the composites industry in 3 – 30 mm thickness

Machinery at ThermHex:
- Width: 1,4 m (standard 1,2m)
- Max. speed: 10 m/min
- Annual output: > 1 million m²

Production hall in Halle/Saale
- Available area: 4000 m²
ThermHex PP cores with PET nonwoven

- for large complex composite parts
- for wind pre-fabricated modules in buildings and energy generation (bathroom pods, windmill covers, ...), yachts, swimming pools, trucks, automotive, ...
PA honeycomb and "organicsheet" developments

ThermHex sandwich panel for heavy duty applications

ThermHex honeycomb with 0/90° UD Glass fiber / PP composite skins

ThermHex honeycomb with woven glass fiber / PP composite skins

ThermHex honeycomb with woven Carbon fiber / epoxy composite skins
ThermHex organosandwich – mechanical performance

- Weight reduction (cost reduction)
- Rigidity increase

ThermHex organosandwich – thermoforming/overmolding
ThermHex panel edge closure and fixtures

For panels with thermoplastic skins:
Edge closures are easy to integrate in the step of part thermoforming

Insert solutions available
Friction welding and over-injection is proven possible

Honeycomb - Properties

Thermal insulation e.g. for wall or inner cladding

A thermal barrier against conduction created by still air and PP
Air movements suppressed or rather eliminated – air entrapped in the cells
Radiative effects limited – conductive skins separated
Honeycomb - Properties

**Acoustic absorption** e.g. for wall cladding, separation walls

![Diagram showing acoustic absorption process](image)

- Steel skins
- Air filled, one side open ThermHex cells
- Sound waves
- Damping of the noise (acoustic vibrations are transferred to the opposite skin – panel stiffness driven)

Tests proved good sound absorption ability of the ThermHex core

Dissipation of the sound waves in the one side open honeycomb structure

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Honeycomb - Properties

**Fire resistant parts / elements**, e.g. ship building, public transportation...

ThermHex PP – metal skin
No modifications needed to achieve class B, according to EN13823
B – s2 – d0 / B – s1 – d0 (TATA)

ThermHex PP – steel skin (TATA)
Passenger vehicles
UN R118 annex – PASS (TATA)

PET honeycomb based
ThermHex panel tested according to the railway interior-designed DIN 5510-2
S4-SR2-ST2
FST thermoplastic honeycomb development

(FR / FST qualified) PC material based honeycomb core

- Fire resistance performance competitive to conventional and expensive NOMEX honeycombs
- Target applications include aircraft interiors and parts for mass transportation

Development work initiated with DIEHL AIRCABIN, leading supplier of aircraft interior components

Aircraft applications requirements are similar but tougher than the railway applications requirements

Cost saving requirements are more evident in the railway sector

Thanks to European Commission for the support under INCOM EC FP7, Grant agreement no: 608746
Key requirements of sandwich cores for cabin interiors

<table>
<thead>
<tr>
<th>Property</th>
<th>FST Thermoplastic Honeycomb</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density</strong></td>
<td><strong>FST</strong></td>
</tr>
<tr>
<td>Target value</td>
<td>29 - 48 kg/m³</td>
</tr>
<tr>
<td><strong>Surface quality</strong></td>
<td>Few surface defects</td>
</tr>
<tr>
<td><strong>Mechanical properties</strong></td>
<td>Compression strength, Shear strength, Shear modulus</td>
</tr>
<tr>
<td><strong>Drapability</strong></td>
<td></td>
</tr>
<tr>
<td>Satisfactory drapability for the manufacture of complex geometries</td>
<td></td>
</tr>
<tr>
<td><strong>Thermal resistance</strong></td>
<td>Permanent: -20°C to 55°C, Temporary: -40°C to 70°C</td>
</tr>
<tr>
<td><strong>Media resistance</strong></td>
<td>Resistance to high humidity and Skydrol</td>
</tr>
<tr>
<td><strong>Costs</strong></td>
<td></td>
</tr>
</tbody>
</table>

FST Thermoplastic Honeycomb development

**Vertical – 60s Ignition Time**

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Burn Length [mm]</th>
<th>Flame Time [s]</th>
<th>Drip Flame Time [s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>58</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>59</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>58</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean</td>
<td>58</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Limit/Max.</td>
<td>152</td>
<td>15</td>
<td>3</td>
</tr>
</tbody>
</table>

**Fire Resistance Test Results**

<table>
<thead>
<tr>
<th>No.</th>
<th>Weight [g]</th>
<th>HRR* [kW/m²]</th>
<th>HR** [kW min/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46,7</td>
<td>28,12</td>
<td>161</td>
</tr>
<tr>
<td>2</td>
<td>46,9</td>
<td>28,38</td>
<td>136</td>
</tr>
<tr>
<td>3</td>
<td>46,6</td>
<td>28,59</td>
<td>155</td>
</tr>
<tr>
<td>Mean</td>
<td>46,7</td>
<td>27,70</td>
<td>22,51</td>
</tr>
<tr>
<td>Limit/Max.</td>
<td>65</td>
<td>---</td>
<td>65</td>
</tr>
</tbody>
</table>

*Less than 0.5 kJ/m² for a peak HRR rate of 20 kW/m²
**Less than 65 kW min/m² for a 2-minute total heat release (for the average of triplicate sample measurements)
Materials choice – application depending

ThermHex Core Material Type

- Processability on the core production level PROVEN
- Processability on the core production level needs further investigations / investment

Summary – ThermHex Technology

MINIMAL ENVIRONMENTAL IMPACT
MINIMAL WEIGHT
MINIMAL COST

- Biobased materials make the core ALIGNED TO AN INTERNAL STRUCTURE ILLUSION TO CLASSICAL ADDITIVE MANUFACTURING
- Lighter core makes the core ALIGNED TO AN INTERNAL STRUCTURE ILLUSION TO CLASSICAL ADDITIVE MANUFACTURING, REDUCING COST AND IMPACT UNDERSIZED TO A MACHINING LINE.
Let’s build the future of honeycomb sandwich materials together!

Thank You!