Advanced Materials for a Smart Lightweight Design

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Content:

- What is “Smart Lightweight Design”?
- Manufacturing of materials
- Material grades
- Processing
- Applications
- Recycling solutions
- Summary and future aspects
**Target definition: weight saving without increasing part or system costs**

- Conventional approaches:
  - Reduction of wall thickness
  - Reduction of material costs by downgrading

- Disadvantage: loss of properties / performance

- Smart and cost effective lightweight design:
  - Integration of functions and simplification of processes by high performance materials
  - Reduction of material density by tailored consolidation of selfexpanding composites

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**TAILORED CONSOLIDATION**

All specimen have same weight but different thickness and density --> significant reduction of deflection under the same load

- \( h = 3.6 \text{ mm}, \rho = 0.37 \text{ g/cm}^3 \)
- \( h = 2.4 \text{ mm}, \rho = 0.55 \text{ g/cm}^3 \)
- \( h = 1.2 \text{ mm}, \rho = 1.1 \text{ g/cm}^3 \) (Conventional design)
TAILORED CONSOLIDATION

Flexural modulus as function of thickness:

Areal weight: 1400 g/m²

Structural stiffness as function of thickness

\[ E \times I = f(h^2) \]
Manufacturing process of fleeces (carding):
- Manufacturing of mixed fiber fleeces out of natural and thermoplastic fibers ("Nafcoform")
- Manufacturing of sandwich-fleeces by thermobonding ("Loprefin")
- Manufacturing of customer tailored blanks or delivery as rolls

Manufacturing process of consolidated fleeces (airlay):
- Manufacturing of mixed fiber fleeces out of reinforcement and thermoplastic fibers
- Online consolidation and impregnation of reinforcement fibers ("SymaLite")
- Lamination of functional layers on the surfaces (films, adhesion films, fleeces, ...)
- Online cutting of customer tailored blanks
Manufacturing of Materials

Carding process

Airlay process

Material Grades

Fleeces (Nafcoform, PP/glass):

- Weight per area: 300 - 1700 (5000) g/m²
- Natural fibers (Kenaf, Hemp, Flax, Sisal, Jute) / PP: content of natural fibers: 20 - 80 %
- Glass fibers / PP: content of glass fibers: 20 - 40 %
- Natural fibers / acetates: content of natural fibers: 20 - 80 %
Fleeces (Lopre fin, PP/glass):

- Weight per area: 300 - 1700 (5000) g/m²
- Sandwich-fleeces with surface layers (Lopre fin):
  - core: PP / natural fibers
  - surface layers: PP / PET - 70 / 30
- Synthetical sandwich-fleeces:
  - core: PP / PET - 30 / 70
  - surface layers: PP / PET - 70 / 30
**Fully consolidated fleeces (SymaLite):**

- Basis grades: glass fibers / PP
  - Weight per area: 600 - 3000 g/m²
  - Fiber content: 20 - 60%
  - Different functional surface layers available
- Advanced grades: glass fibers / PET / PBT / PA
  - Same product range, higher HDT

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**SymaLite as delivered (1400 g/m² = 1.5 mm):**

![SymaLite as delivered](image1)

**SymaLite after heating (1400 g/m² > 8 mm):**

![SymaLite after heating](image2)
- Heating with contact press (pressure needed for impregnation): Nafcoform and Loprefin
- Heating with infrared or hot air: SymaLite
- Stacking with decorative layers > one step decoration process
- Automized transfer into the mold
- Part stamping with low-pressure-molding (< 5 bar) -> sensitive materials like foam possible
- Molds from aluminum (serial tools), wood or plastic (prototypes) -> low cost production process

Processing of Loprefin:

Loprefin, 3-layers, 1600g/m²

- Contact heating press
  - Pressure 6 - 6.5 Kg/cm²
- Low pressure press
  - Pressure 1 - 2 Kg/cm²

- cover material (foil, cloth or fleece)
- heated and pressed Loprefin
- moulded part
Processing of Loprefin Air:

- **Loprefin Air, 3-layers**
  - Air-proof foam
  - Contact heating press
    - Pressure 6 - 6.5 kg/cm²
  - Low pressure press
    - Pressure 1 - 2 kg/cm²

- **Loprefin Air, 3-layers**

- **Blow nozzle**

- **Blow moulded part**

Processing of SymaLite:

- **SymaLite, 3-layers, 1300g/m²**
  - Infrared heating oven
  - Heated and lofted SymaLite
  - Low pressure press
  - Moulded part
Applications

**INTERIOR APPLICATIONS**

Natural or glass fibers / PP, PET / PP:
- Hat rests
- Door panels
- Roof liners
- Instrument panels
- Center consoles
- Pillar cladding
- Luggage compartment cladding
- Surface layers for sandwich parts like load floors

**PP/glass fleece: hat rest of BMW 3-series:**
Applications

Loprefin: Door insert of Ford Mondeo:

PP/NF fleece: Load floor of Mercedes C-class:
SymaLite: Door panel

In mold graining: molding of PP-film with foam-back in sequence with low pressure forming of structural back with blank of SymaLite (alternative: Nafcoform)

Cross sections show excellent 3-d-drapability and homogeneity of wall thickness - no collapsing of foam layer
EXTERIOR APPLICATIONS

Glass fibers / PP
- Big underfloor parts with high toughness PP-films for protection against stone chipping
- Structural part for exterior body panels with a surface skin out of
  - coil coated aluminum
  - incolored plastic film, thermoformed or injection molded

Natural fibers / PP
- Wheel housings

SymaLite: Underbody parts
Applications

Structural roof module out of SymaLite:

Coil-coated aluminium
Adhesion layer 50 g/m²
SymaLite 2000 g/m²

Generic cross section

Recycling

Glass / PP with PP-film:
- Coarse granulation (particle size: 20 mm)
- Use as raw materials for GMT-production or inhouse LFT compression or injection molding process

Natural fibers with different decoration materials:
- Fine granulation (particle size: 3 mm)
- Use as center layer of sandwich fleeces
- Use as raw materials for injection molding process
Summary

Advantages of materials for lightweight design by tailored consolidation:

- High specific structural stiffness
- Good acoustic properties (noise absorption)
- High specific energy consumption (toughness)
- One-step-decoration with sensitive materials like films and textiles with a foam backside
- Simple process technology and low investment cost due to low pressure molding
- Fast and low cost production of prototypes with final material (wooden or plastic tools)

Future Aspects

HIGH END APPLICATIONS (DEVELOPMENT)

Glass, aramide und carbon fibers / engineering and high performance thermoplastics:

- Underbody shields with higher operating temperature (GF/PET/PBT)
- Online paintable structural parts (CF/PET/PBT)
- Big interior parts for buses, trucks and railways (GF / flame retardant thermoplastics)
- Aircraft interior parts: sidewall panels, hat racks, floor panels and roofliners (CF/PEI)