Natural fiber reinforced thermoplastics

Tailored for interior applications

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Quadrant Plastic Composites

Outline

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- Natural fiber reinforced materials
- Component manufacturing
- Key performance
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- Development trends
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Application overview

Door inserts

Natural fiber reinforced thermoplastic composites are worldwide becoming increasingly popular in automotive interiors.

This paper concentrates on natural fiber reinforced thermoplastics as a substrate material for automotive interior parts with decorative surfaces. Typical examples of such parts are door inserts, trunk liners, pillar trims, parcel shelves and load floors.

Parcel shelves

Load floors

Blended Fiber Mat (PP and NF)

Raw Materials - Natural fibers are grown worldwide, typical fibers suitable for automotive interiors are bast fibers such as Jute, Kenaf, Flax and Hemp, each having its own property profile.

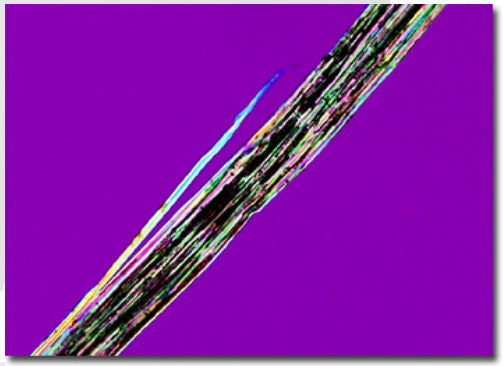
Jute and Kenaf are typically grown in China, India, Pakistan and Bangladesh.

Hemp and Flax are typically grown in North America, Europe and Russia.

Natural variations in fiber properties are equalized when natural fibers from diverse origins are blended into the composite.

Kenaf plantation

Kenaf fiber (microscopy)

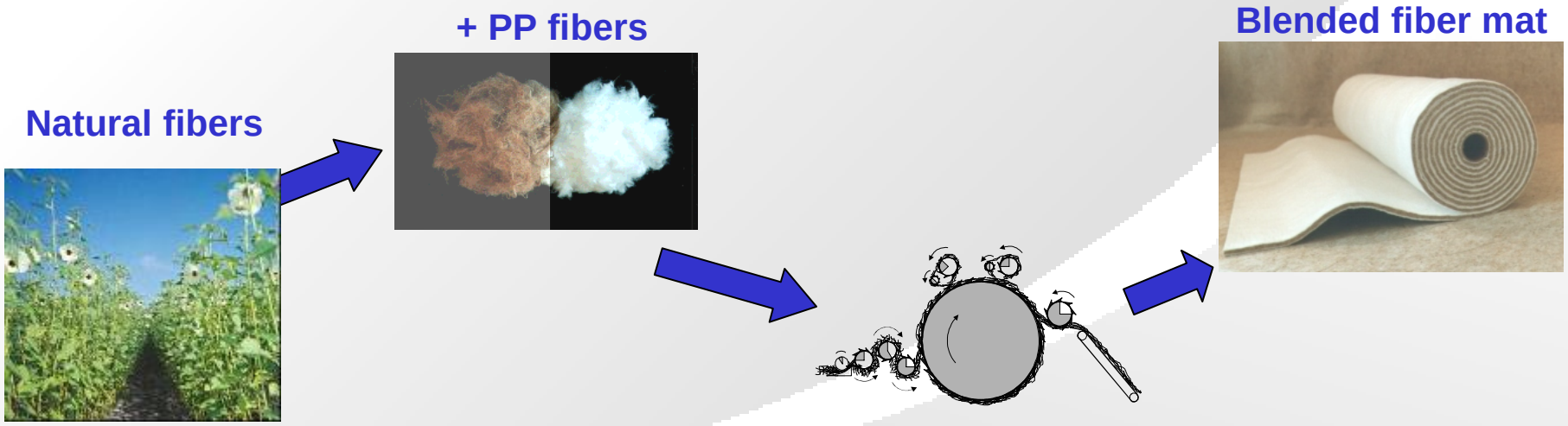


Blended Fiber Mat (PP and NF)

Raw Materials

Natural fiber reinforced thermoplastics in the form of multilayer sandwich fleeces are produced by:

- Blending of several grades of natural fibers with PP-fibers.
- The blend is processed in a mat forming process to form a fleece material consisting of long natural fibers, blended with PP-fibers.
- Several layers are combined through melt bonding or needling to form a multilayer sandwich.

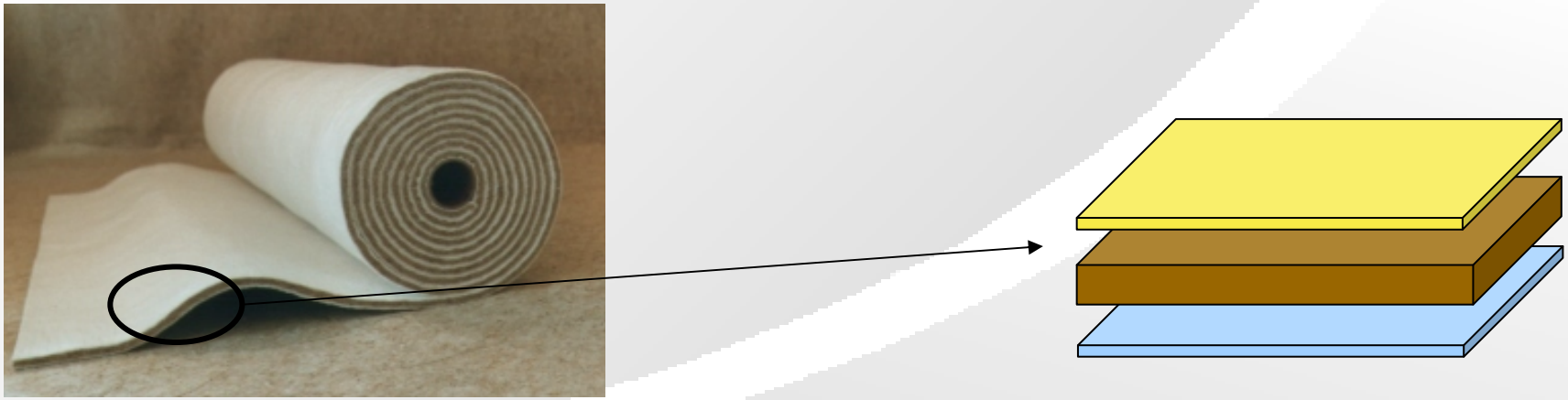


Blended fiber Mat (PP and NF)

Multilayer Formulation - The formulation of the multilayer sandwich is critical for the performance of the application in which it is used as a structural material. The know-how factors to attain a high-quality end product lie in several factors:

- The selection of natural fiber blend and the chemical composition of the PP.
- The mat formation technology to attain good blending and therefore high mechanical properties and a good formability.
- The proper combination of several layers to meet component requirements.

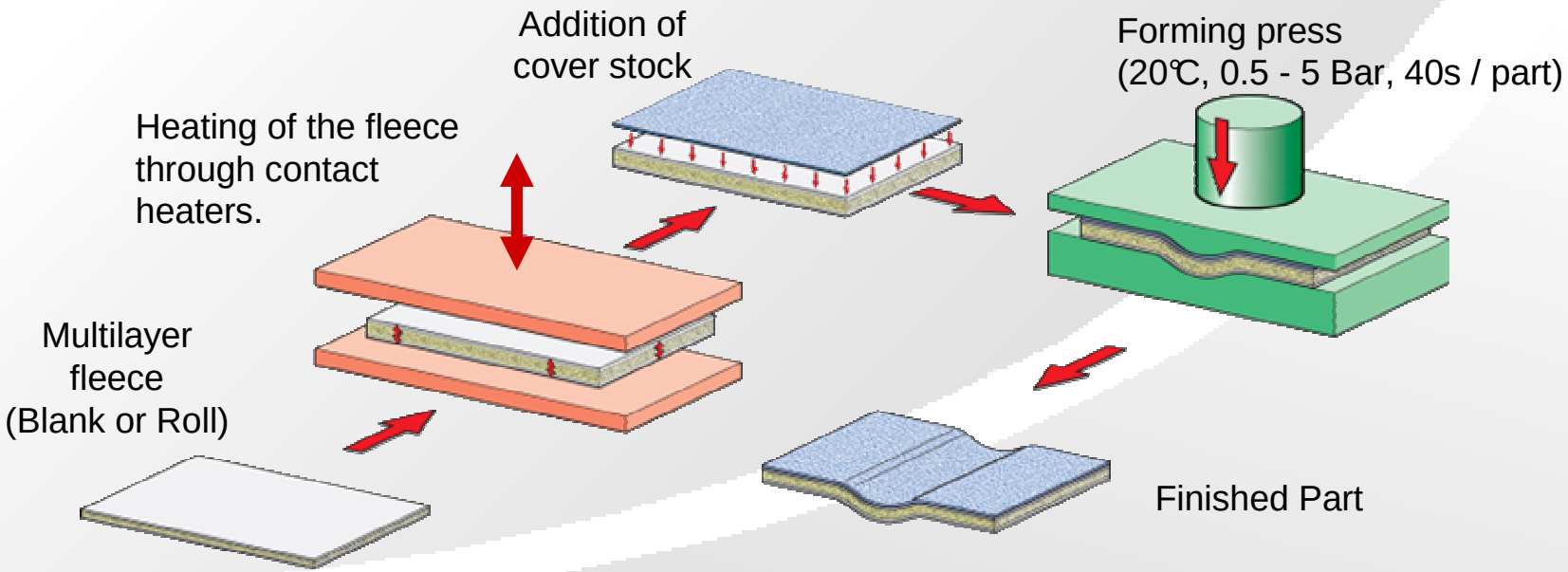
Typical multilayer fleeces used for interior applications in Europe contain layers of pure natural fibers and PP with area weights between 300-2000 g/m² as the core layer. The outer layers often are acoustically functional PET fiber fleeces, adhesive or barrier films, or protective scrim layers.



Part Manufacturing

Process Description - Natural fiber reinforced thermoplastics in the form of multilayer sandwich fleeces allow the combination of a fast and easy component production with good part performance based on the high specific properties of long natural fibers.

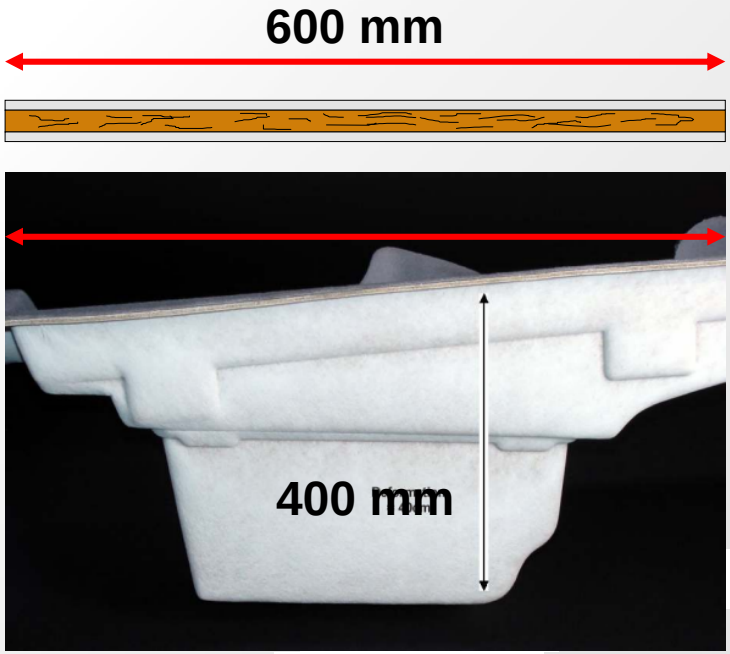
Components are typically produced in a one-shot process where the cover stock is attached to the hot substrate during the forming and in-tool edge cutting of the part, thus producing finished components with a cycle time of 30 to 60 seconds in a single step. The cycle time depends on the area weight of the composite, where 1500 g/m2 results in a cycle time of 40 seconds.



Part Manufacturing

Formability - The car designers and component manufacturers want to have a material with which difficult shapes can be produced with a high productivity and without losing the material properties.

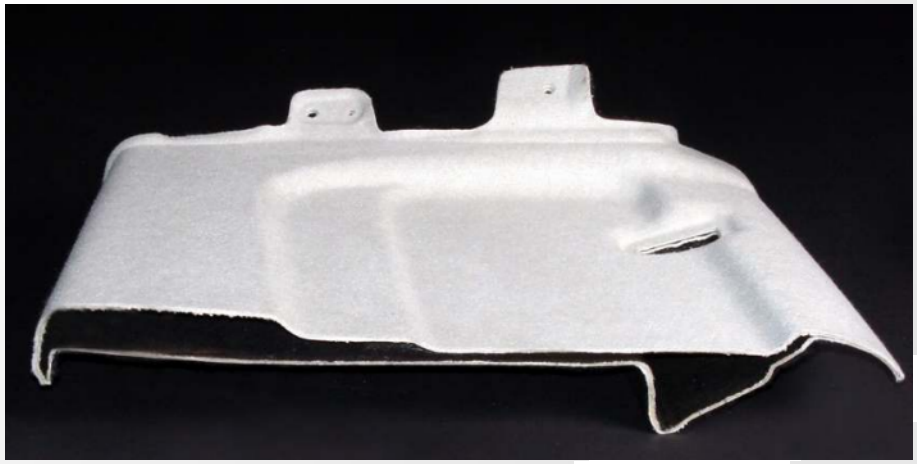
One major achievement in the last years has been the development of natural fiber reinforced sandwich fleeces which form at very high draw ratios, without the formation of thin areas or wrinkles. This potential has not yet been fully explored. Current designs are still very conservative compared what these materials actually can do.

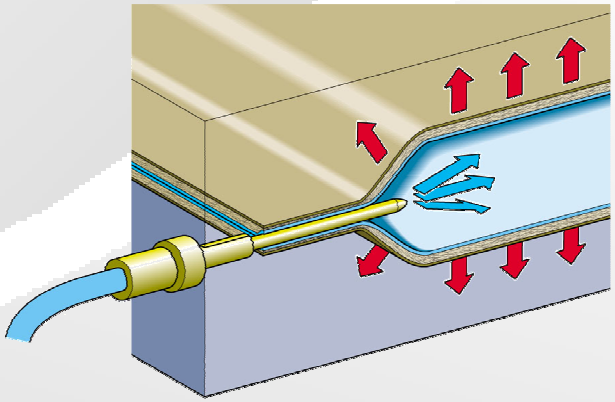


Part Manufacturing

Twin Sheet Molding - Multilayer fleeces can be formed by classic forming as shown in previous slides. It is also possible to use air pressure in the forming. This allows air assisted twin sheet forming, or blow molding, to be carried out. The blow molding technology allows thicker parts with increased stiffness. Compared to single layer forming, the process is equally advantageous, allowing the decorative layers to be introduced in a one-shot process.

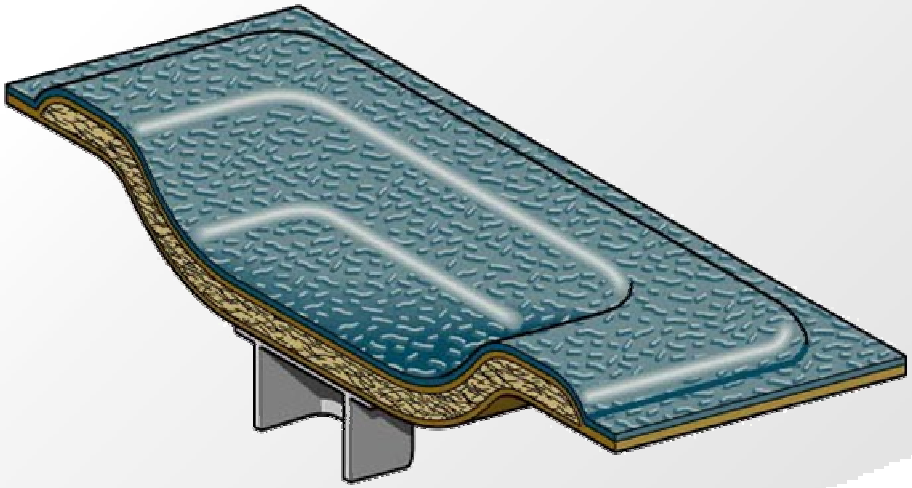
The stiffness and strength of a blow molded part will be determined by the use of attachment points between the upper and lower layers, providing a shear resistance of the part when loaded. Typical applications are different types of shelves and floors with need for a high flexural stiffness.





Part Manufacturing

Molding with Inserts - When forming multilayer fleeces as shown in the previous slides, it is possible to add inserts into the tool. If injection molded parts are added in the stamping process, it allows for a reduction of the assembly work. Typical suitable insert parts are retainers or cable clips. Since the matrix material of the composite is PP, insert molding of injection molded PP components also omits the use of adhesives for add-on parts, they are welded on while forming the part.

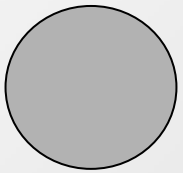


Material Performance

Natural Fibers compared to Glass Fibers - Natural fibers have very high specific properties such as for example stiffness and strength, often higher than glass fibers at equal weight. Natural fibers are also very efficient in terms of raw material cost and the availability is abundant. Drawbacks are, however, their sensitivity to thermal exposure during processing and that the fiber length has to be sufficiently long for the fibers to carry loads efficiently. If the fiber length is maintained to values in the range between 25mm and 100mm and the thermal exposure during processing is kept within a given range, the natural fibers show a good property level.

Section of a glass fiber

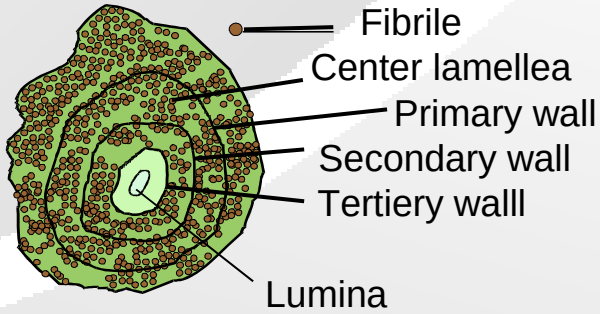
Diameter 15µm



Density = 2,5 g/cm³

Section of an elementary flax fiber

Diameter: 20-25µm



Density = 1,5 g/cm³

Material Performance

Natural Fibers compared to Glass Fibers - As in any case, it is important to pair raw materials, processing and design to achieve the best performing and lowest cost system. The one-step forming process of multilayer sandwich fleeces based on natural fibers with a thermoplastic matrix, together with a decorative cover stock has proven to be a very efficient process for the production of interior components. The freedom of choice in raw material constituents (such as fiber length, fiber grades, polymer matrix and so on) allows a great flexibility to pair material to the part manufacturing process and component requirements. The limited thermal exposure in the forming process allows the natural fibers to maintain their original properties in the component.

⇒ **Natural fiber composites need :**
- ⇒ **Long fibers**
- ⇒ **Limited temperatures in processing**

⇒ **One-step molding of long fiber reinforced thermoplastics:**
- ⇒ **Tailored properties to application needs**
- ⇒ **Long fibers**
- ⇒ **Limited thermal exposure**

Material Performance Comparison

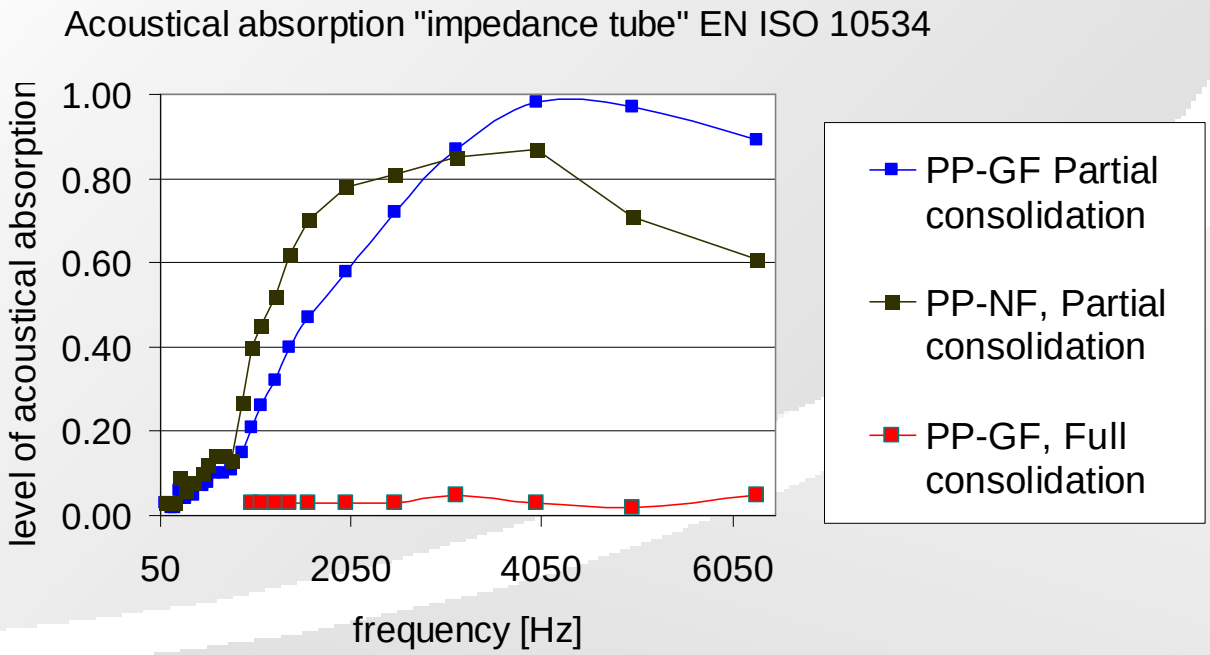
	Formed Long NF -PP	Injection Molding Short NF – PP	Long NF Thermoset	Formed Long GF - PP
Material cost	++	++	+	+
Production costs	+	+ & -	-	+
Load Carrying (Rigidity)	+	-	+	+
Density	++	+	-	++
Weight	+	+	-	+
Acoustics	+	-	-	++
Design freedom	+	++	-	+
Ductile failure	++	-	-	++
Glass Free	++	++	++	-
Smell and emissions	+	+	-	++
Thermal recycling	++	++	-	+

=> Low cost, low density, glass free and safe in crash!

Acoustic Properties

One increasingly important property for interior components in automotive applications, where natural fiber reinforced composites have performance advantages, is the acoustic absorption.

Natural fiber reinforced thermoplastics as structural material in an interior component have an open cell structure. It will therefore contribute to sound absorption and may result in a reduced need for absorbers. Multilayer fleeces further offer many possibilities for tailoring the acoustic absorption of the system. For instance by integrating a PET fiber absorption padding into one of the layers.



Volatile Emissions

Volatile emissions relate strongly to the quality impression of a vehicle. Natural fiber reinforced thermoplastics can be tailored to fulfill the highest current requirements in the industry.

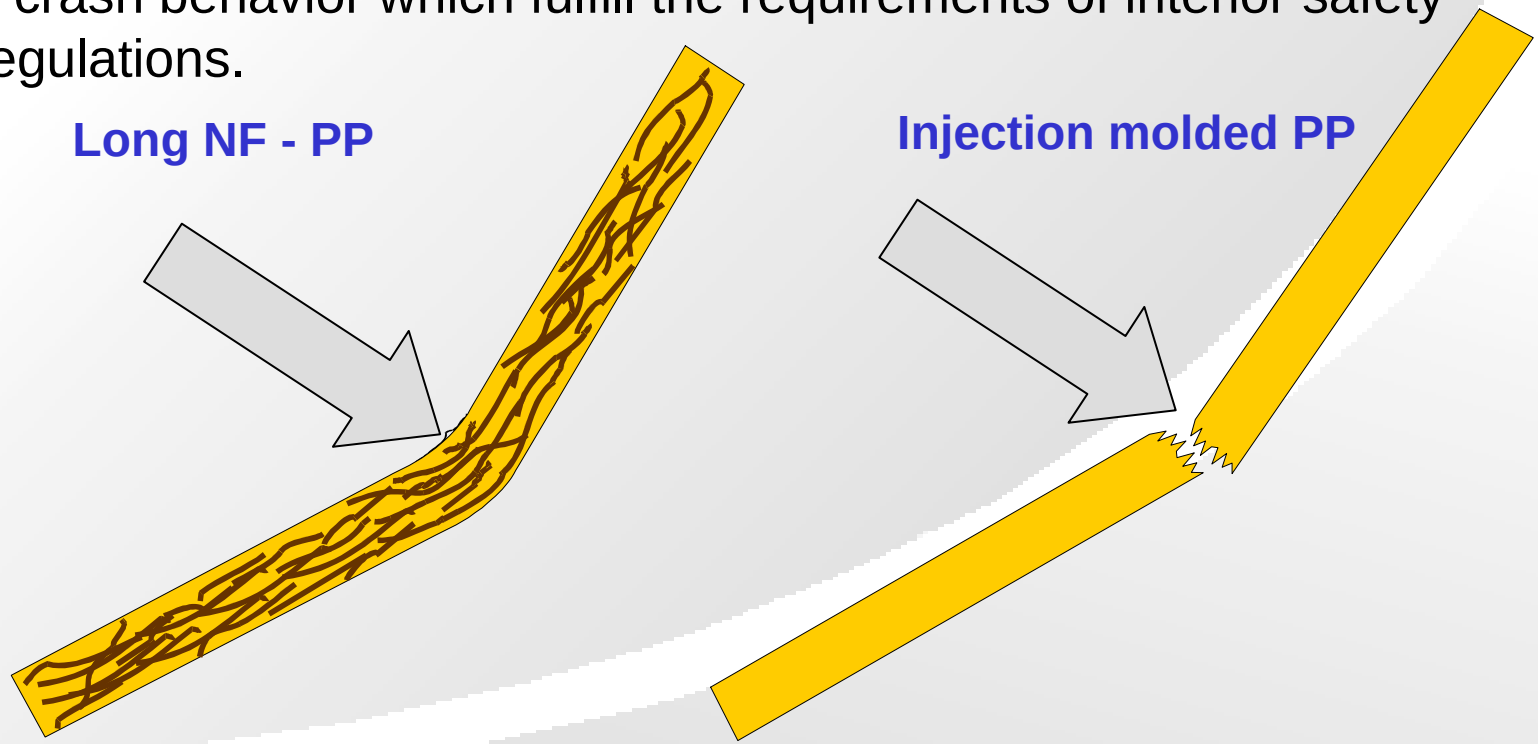
Extended exposure to high temperatures may increase the smell of natural fibers. The processing time needs to be short and the processing temperature should be held to a minimum.

The Polyolefin matrix also helps to improve the smell and emissions if compared to thermoset materials containing residual catalysts or other chemicals.

Crash Safety

Safety - In the case of a head or knee impact or, an airbag deployment, no open, sharp edges (which may injure the occupants) should appear and no loose fragments should detach from the part.

The tenacity of natural fibers and the thermoplastic matrix result in a crash behavior which fulfill the requirements of interior safety regulations.



Case study – Load floor

Load floor (VW Touareg and Porsche Cayenne)

Material Description:
Sandwich construction
Surface layers: Long NF-PP, 1200 gsm
Core layer: EPP foam
Cover stock: PET carpet

Part description:
Weight: 3.5 kg
Size: 950mm x 870mm
Thickness: 25 mm

Advantages to other materials / processes:
High stiffness due to sandwich construction
One shot process, Short cycle time
Dimensionally stable
Low weight
Thermal recycling without residues

Case study – Door insert

Door insert (Mitsubishi Space Star)

Material Description:
Multilayer construction
3 layers Long NF-PP, 1850 gsm
Cover stock: PET weave with foam backing

Part description:
Weight: 0,56 Kg
Dimension: 850 mm x 350
Thickness: 3,5 mm

Advantages to other materials / processes:
Very good side impact behaviour
No splintering and sharp edges, even at low temperatures.
Low weight
One shot process
Thermal recycling without residues

Future Trends

Future trends - Natural fiber composites will be driven by cost optimization, environmental effects, scrap reduction, recycling requirements and functional integration. The results of these drivers are novel material systems and processing routes.

Conclusions

- Natural Fiber reinforced Thermoplastics:
  - → Are being used in several Automotive Interior Applications
  - → Low Density
  - → Low Cost
  - → Glass Fiber Free
  - → Safe in the Event of a Crash
  - → Enormous unexplored Potential

- One shot process of Natural fiber reinforced Thermoplastics:
  - → Fast and Economic Component Production
  - → Combination with Decorative Layers (films or fabrics).
  - → Very Complex Shapes, including Deep Draws are possible
  - → Blow Molding and Sandwich Molding for increased Stiffness
  - → Insert Molding (EPP blocks or Injection Molded Parts)