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Dissemination Level		
PU	Public	√
PP	Restricted to other programme participants (including the Commission	
RE	Restricted to a group specified by the consortium (including the	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Contents

1 Introduction

This report defines guidelines to design and manufacture 3D panels using the innovative material developed in the Brigit project.

Brigit project realised a demo case based on an interior pillar for a truck (see Deliverable D7.4) to test and validate process, but the following information can be applied to any kind of component in different sectors of application where the fully biocomposite material could be adopted conveniently.

2 BRIGIT material

The material is provided in laminated sheets suitable for a thermoforming process using a “core and cavity” mould.

The composite material is composed by different layers:
- the blend =B, (PHB/PBS(40/60)+20% FR and 10%mineral filler)
- flax fibres = F, (Woven flax fabric 50/52 with FR, Sd= 316g/m^2)
- and cork = C,(corecorkNL11, 2mm thickness, FR treatment, d=16 kg/m^3)

The final structure of the panel is F/B/F/B/F/C/F/B/F/B/F. Which means that are used 4 layers of blend, 6 layers of fibre and 1 core (cork).

In the figure below (figure 1) the layers of the different materials before and after the lamination have been shown. This way, when the thickness of the blends maintained, the proportion of blend/fibres is about 50%.

The standard panels are 550 mm width, 800 mm length and 3,8 mm of thickness.

Other combinations of layers and dimension could be possible upon request.

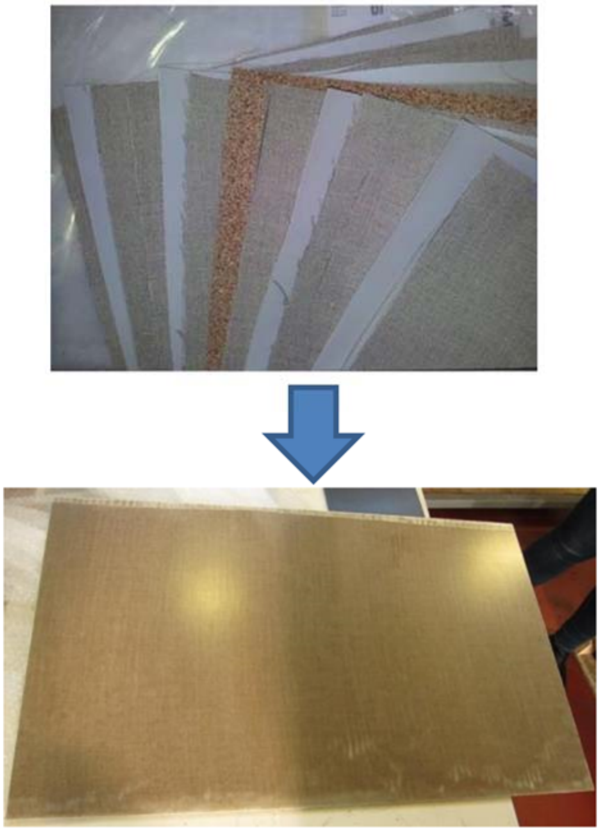

Figure 1. Layers of the different materials before and after compression moulding (Brigit panel)

The standard panels are 550 mm width, 800 mm length and 3,8 mm of thickness.

3 Design guidelines

The use of the laminated sheet is suitable for components characterized by an extended area and a single nominal thickness all over.

The laminated sheet is subjected to a thermoforming-like process similar to deep drawing of a metal sheet. During the design phase the typical factors affecting thermoforming have to be considered.

First rule in the part design is to avoid undercuts. They are features protruding from or into the tool surface, which would prevent removal of the part from the tool. A removal direction without undercuts will define the mould closure plane. When the part geometry makes impossible to find such direction movable cores pulls in the tool could be adopted with an increase of mould cost and complexity.

In order to facilitate the ejection of the part from the mold a draft angle of at least 2° must be taken into account.The deeper the feature or rougher the surface texture, the more draft is required.

It is also beneficial in the part geometry definition to maintain large radii in the drawing features to allow a better material distribution and avoid possible cracks.

As typical in thermoforming, a 3 to 1 ratio has to be considered the maximum draw ratio.The draw ratio expresses the relationship between the beginning surface area of the unformed sheet which covers the opening of a feature, and the ending surface area of the interior of the feature once formed. It is also important to avoid multiple tall features too close to each other. Generally, the distance between two features, like ribs, needs to be no less than 2 times the material thickness. A caution about corners is also suggested: avoid intersections of walls that are >90º, as it can be very difficult to get material to flow into that feature.

In the structural dimensioning of the part, designer can refer to the following material properties:

Table 1 – Material datasheet. Blend composition PHB/PBS (40/60)+20wt%FR+10wt% mineral filler.

Panel structure	F/B layer ratio	Blend thickness (µm)	Cork thickness (mm)	Panel final Thickness (mm)
F/B/F/B/F/C/F/B/F/B/F	3:2	600	2	3.773±0.082

Formulation: PHB/PBS (40/60)+20wt%FR+10wt% mineral filler		
Property	**Value**	**Standard**
Flexural modulus (MPa)	5360 ± 210	UNE-EN ISO 178 (September 2011).
Flexural strength (MPa)	70.2± 2.1	UNE-EN ISO 178 (September 2011).
Deflection at flexural strength (mm)	7.6 ± 0.5	UNE-EN ISO 178 (September 2011).
Charpy Unnotched impact strength (KJ/m^2)	30 ± 3	UNE-EN ISO 179-1 (April 2011)
Heat deflection temperature, HDT method B (0.45MPa) (ºC)	129.3 ± 1.1	UNE-EN ISO 75-2 (January 2005)
UL 94 horizontal burning Classification	HB	UL94 (July 1997).
Speed of flame spread (mm/min)	0	
Bulk density (kg/m^3)	1300	Mass / Volume
Water absorption (%)	7.6 ± 0.2	UNE-EN ISO 62 (October 2008)

4 Process guidelines

The mould equipment could be a typical set for thermoforming process. Two halves representing core and cavity made of metal like steel or aluminium. In the picture below is shown the mould used for the realisation of one of the Brigit project prototype.

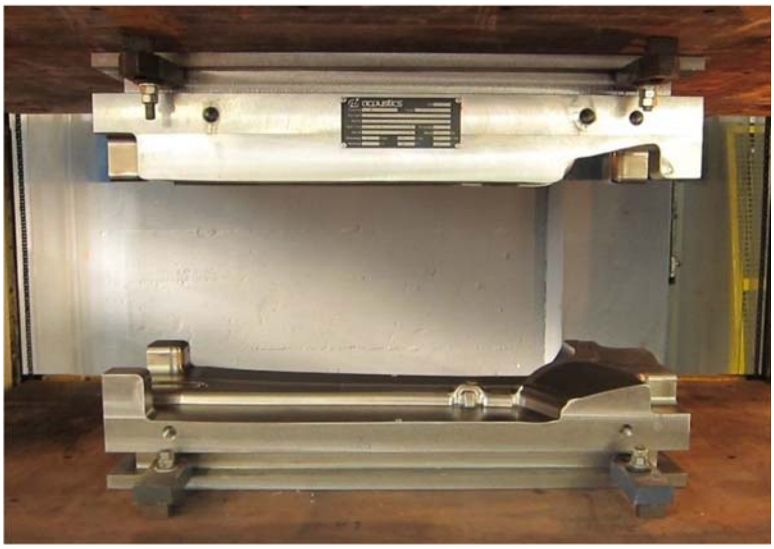

Figure 2. Steel mould properly realized to process Brigit demonstrator

The first step of the process is to heat the sheet in an oven. To avoid the sticking of material on hot plates a release paper has to be employed.

When the component to be realised has not an aesthetical requirements, the material can be used as is.

When the component requires an appearance anonwoven fabricslike TNT (Textile Not Textile) can beapplied to cover the surface of the panel. These fabric-like materials made from long fibers of polyester and viscose, bonded together (figure 3). In the Brigit demonstrator ablack TNT is applied in direct contact with panels before the heating process.

Figure 3. Application of black TNT

The aesthetical TNT (figure 4) is applied on the black TNT during the molding process.

Figure 4. Aesthetical TNT

Both the nonwoven fabrics have been applied also in order to limit the leakage of the resins (blend) avoiding the sticking of the panels on hot plates and mould and to prevent aesthetical defects on the component surface.

The panel has to be positioned on the hot plate and heated at 170°C as shown in figure 5.

From an industrial processing point of view the best combination of parameters is to heat the panel for 1 minute and to use a heating plate gap of 4 mm.

Figure 5. Heating press used for the heating step before the moulding of the component

After heating, the sandwich panel has to be transferred from heating press towards the moulding press. To maintain a good temperature for the forming the shifting has to be long no more than 10 seconds (manually or automatically).

The panel has to be positioned on the mould and covered by the aesthetical TNT (figure 6), then the mould is closed and a clamping pressure is applied to the mould.

Figure 6. Application of aesthetical TNT on component before the moulding process

The mould can be at room temperature.

Clamping force and cycle time are dependent from the geometry of the part. In the case of the Brigit demonstrator 200 bars (120 ton force) for 45 seconds (t_c) was applied.

As an example, below is shown the Brigit demonstrator after moulding and cut of external scraps.

Figure 7. Component realized using Brigit material

5 Conclusion

Brigit project has developed a new type of laminated sheet based on renewable resources.

The new material can be conveniently processed through a thermoforming process.

Material datasheet has been provided to allow designer to dimension parts and process parameters for the manufacturing purpose as well.