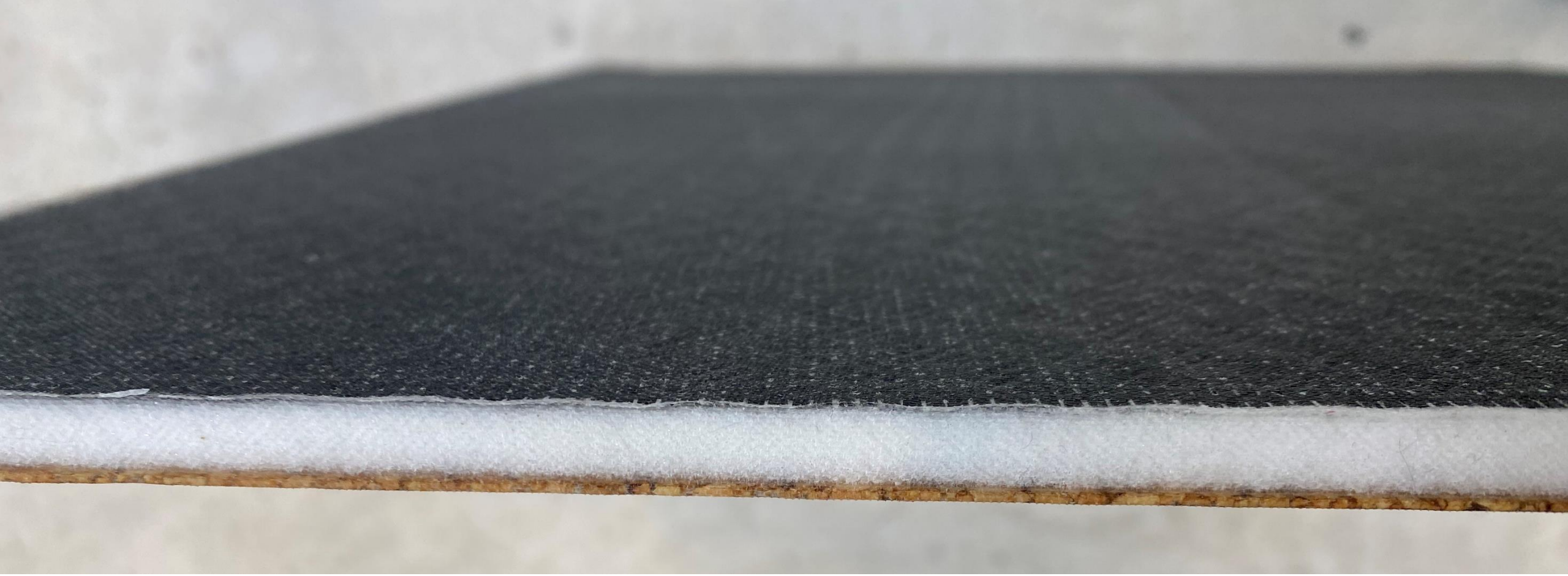

NEW CONCEPTS TO REDUCE THE ENVIRONMENTAL IMPACT OF FLOOR PANELS IN CIVIL AIRCRAFTS

R. Emmerich[1], A. Dimassi[2], P. Huber[1], C. Uthemann[1] , J. Dietrich[2], F. Teichmann[3], S. Özcelik[3], P. Abel[3] and T. Gries[1]
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ITA Group International Centre for Sustainable Textiles

ITA | RWTH AACHEN UNIVERSITY

Introduction: Sustainability within the aeronautic Sector

Sustainability and Economic Efficiency as main Stakeholder

- Rising interest to implement sustainable concepts within the aeronautic sector caused by different drivers:

Legislation	Manufacturers are forced to demonstrate recycling options for their parts
Social	Increasing social awareness for sustainability
Market	Competitiveness combined with sustainability

Three action areas to increase sustainability within the aeronautic sector

Planification → Production → Use

- **Planification**: Weight, Choice of Materials
- **Production**: Production process efficiency
- **Use**: Route planning, weight restrictions, Fuel

Introduction: Sustainability within the Aeronautic Sector

Choice of the part within the aircraft and action area

Planification → Production → Use

Assumptions:
- Optimised production concepts as the smallest part of the emission along the life cycle
- Use phase is considered as optimised under the given use case of an highly used aircraft

DEMONSTRATION PART:
Floor panels of civil aircrafts

LOAD CASE:
Semi-Structural part

CRITICALNESS:
Classification as an B-part regarding the criticalness

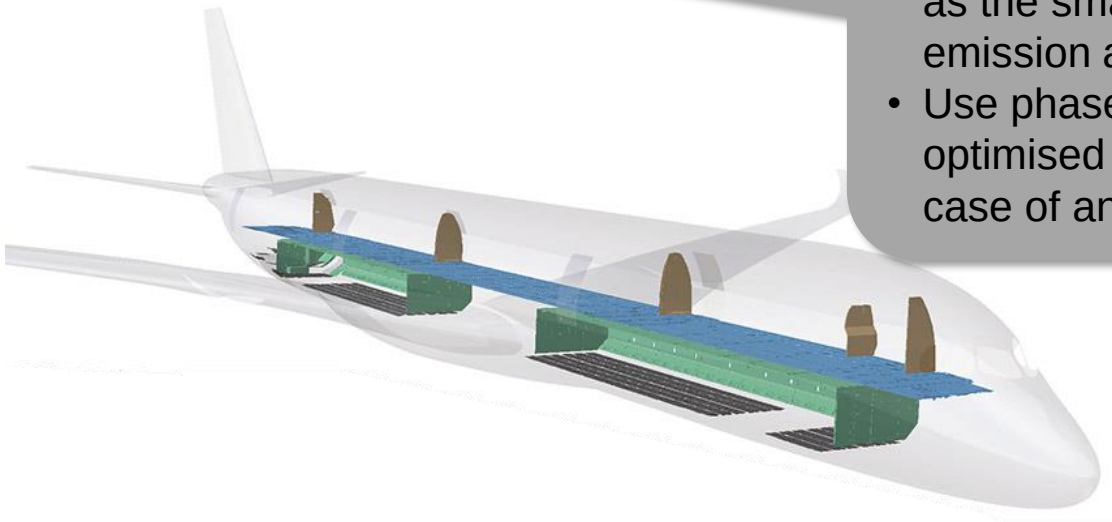


Figure 1: The area of the floor panels is marked in blue [1]

[1] Elbe Flugzeugwerke GmbH, https://www.elbeflugzeugwerke.com/en/composite-solutions/compo-site-components/aircraft-aftermarket-solutions/replacement-panel/

The development of Floor Panels over the years

A Timeline of used Materials within Floor Panels

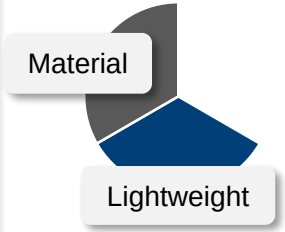
Past

USE OF STANDARD MATERIALS WITHOUT EXCELLENT PROPERTIES

Facesheets:
- GF-Preforms as textile top layers
- Aluminium metallic top layers

Core:
- Honeycomb plates as core material

Present

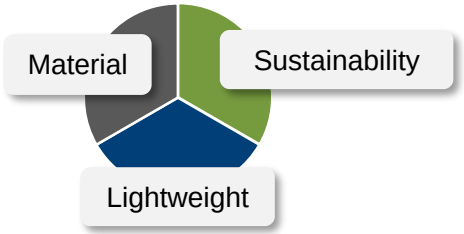


USE OF EXCELLENT MATERIALS TO ACHIEVE LIGHTWEIGHT

Facesheets:
- CF-Preforms as textile top layer

Core:
- Honeycomb plates as core material

Future



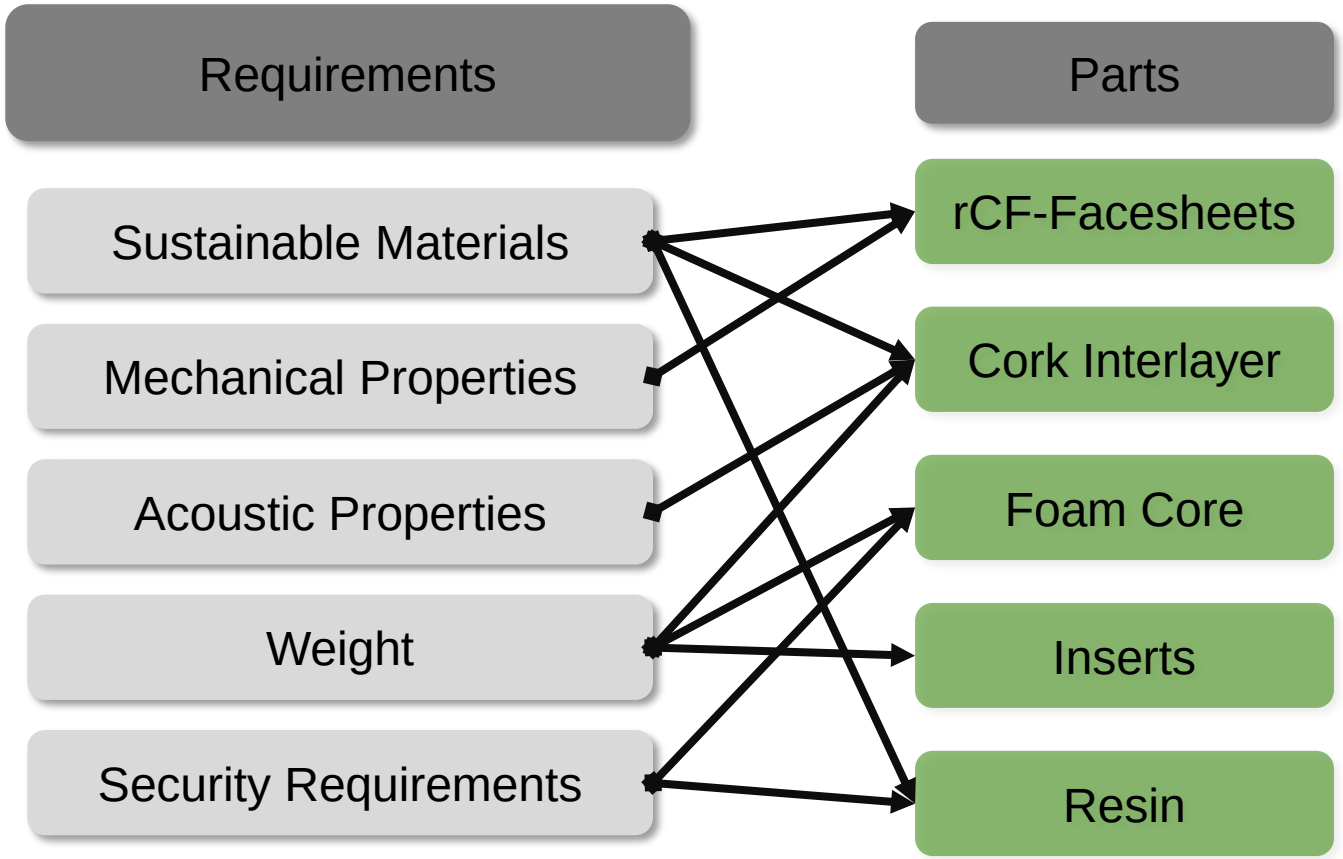
HOW TO ADDRESS ALL CRITICAL ASPECTS IN THE FUTURE?

Challenges:
- ? Weight of the part/reduction
- ? Load cases and load initiation
- ? Material production
- ? Material sourcing
- ? Certification
- ? Fire Smoke and Toxicity

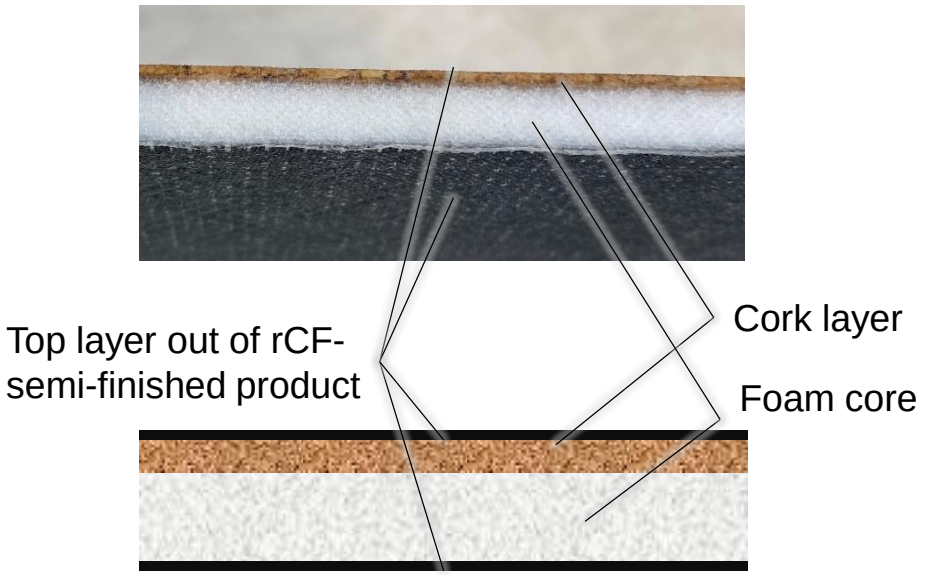
GF = Glass Fibres
CF = Carbon Fibres

The EcoFloor Concept

Different Challenges are addressed by the Concept



First Sample of EcoFloor Panel

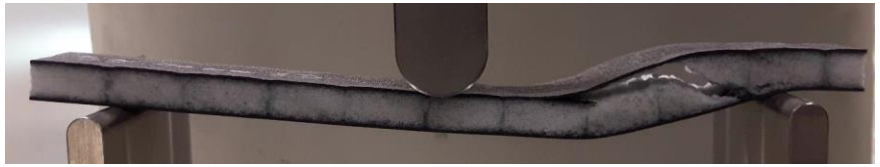


GF = Glass Fibres
rCF = recycled Carbon Fibres

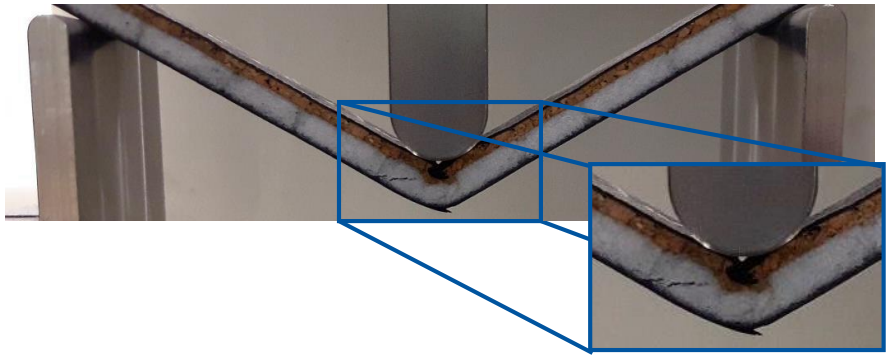
Approach and preliminary Tests

DAMAGE INVESTIGATION OF CORK REINFORCED SANDWICH PARTS

Casual sandwich panel

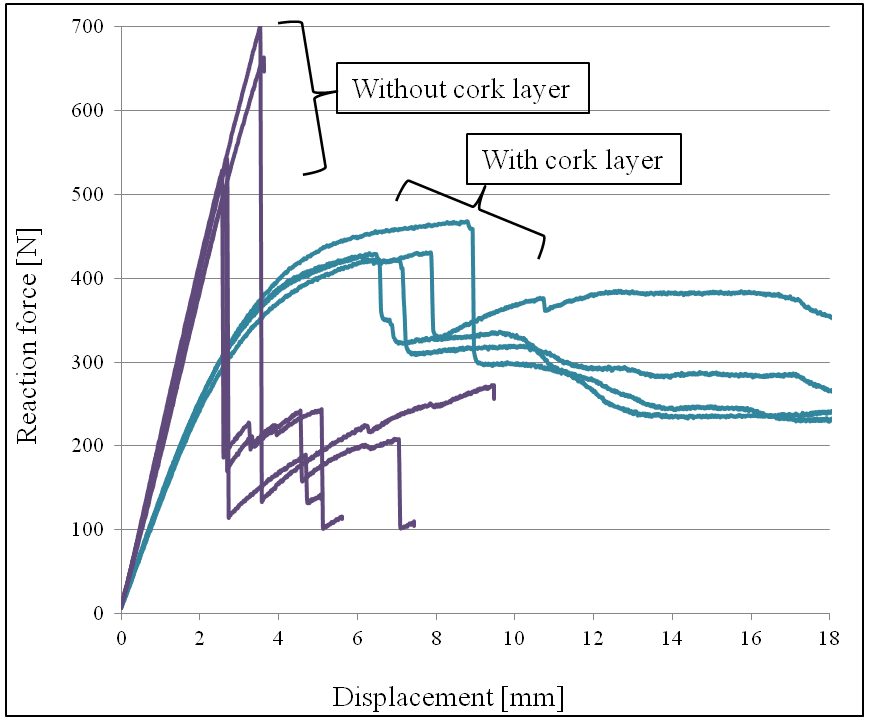


Cork reinforced sandwich panel



© FIBRE

The damage behaviour and the fracture strain were largely improved under 3 points bending loads, but the bending stiffness and strength were reduced.



Panel	Bending strength [MPa]	Failure strain [%]
3D_10	47.9 ± 7	26.3 ± 4
cork	36.8 ± 1.6	62.9 ± 11

Dimassi, M. A.; Dunker, T; Brauner, C.; Nakouzi, S.: IMPROVEMENT OF THE IMPACT BEHAVIOUR OF FOAM CORE SANDWICH THROUGH THE USE OF A CORK LAYER AS IMPACT SHIELD; 12th International Conference on Sandwich Structures (ICSS-12); 08/2018

Different semi-finished Parts as Textiles for the Face Sheets

rCF-Yarn production and rCF- Non-Crimp Fabrics

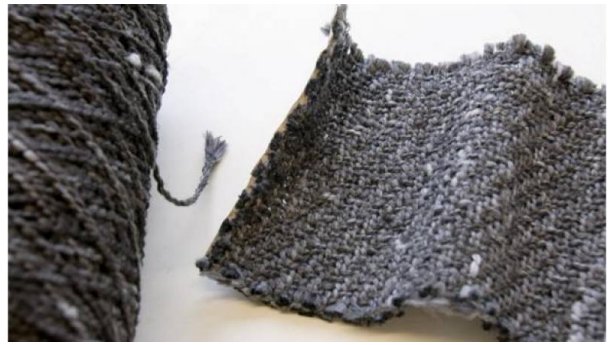
Fibre preparation → Carding → Drawing → Yarn spinning → Weaving → Woven fabric

Opening of rCF
optional: mixing with thermoplastic fibres
Mixing ratio rCF/CoPA: 90/10 %

Increasing the fibre orientation

Sliver formation

Solidification



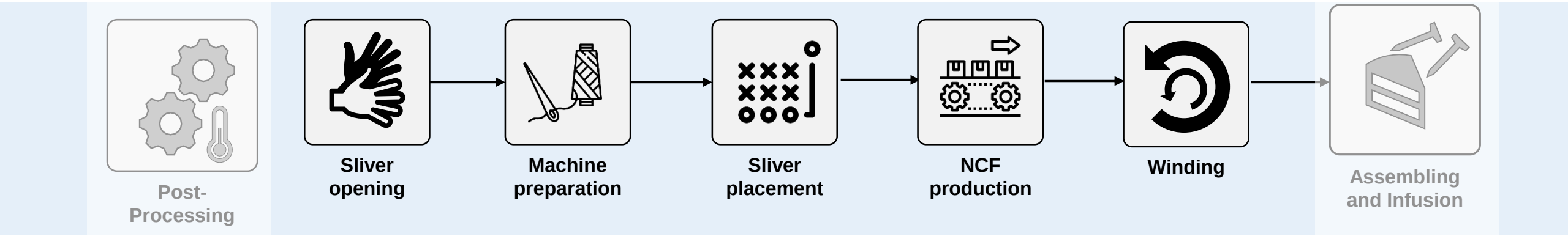
Suitable for further processing into components using standard composite production processes

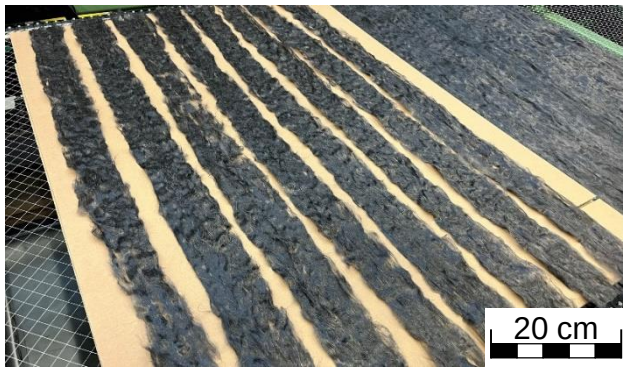
© CarboYarn

Yarn and fabric production is **feasible**, but the **quality** of the produced yarns is crucial for good results.

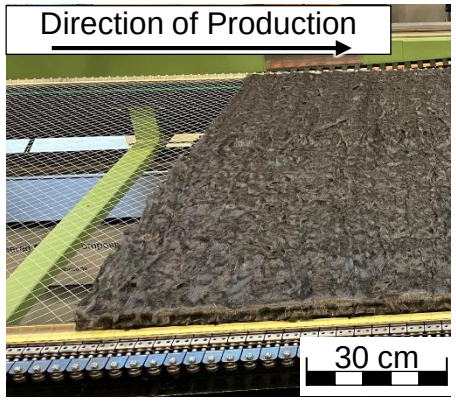
Different semi-finished Parts as Textiles for the Face Sheets

Non-Crimp Fabric production from rCF-Slivers

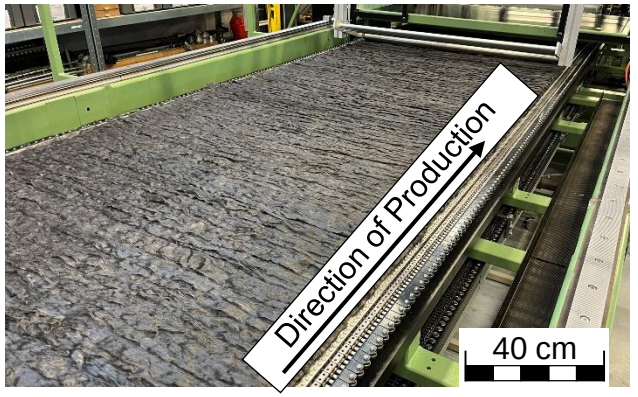




Opened slivers on a card board



Prepared Machine with first placed slivers

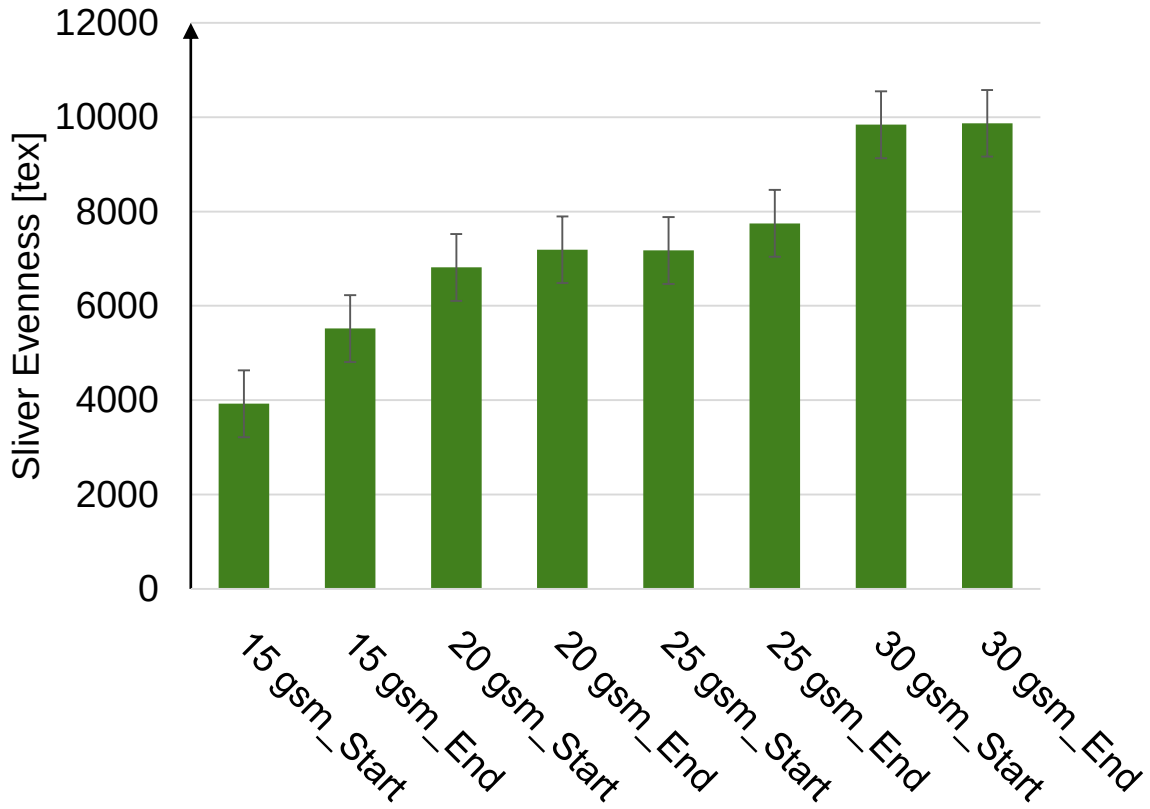


Positioned slivers on Non-Crimp Fabric machine

Warp-knitted semi-finished part

Evenness of rCF Slivers as main Impact to achieve high mechanical Properties

Evenness of produced Slivers after Drawfting

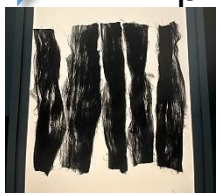


[Tex] = [g/ 1000 m]

Results:

- Measurement of sliver pieces after processing
- Continuous process of sliver production vs. discontinuous testing method
- Between 7 and 18 % standard deviation
- The higher the set areal weight the more stable gets the process between the beginning and the end phase

First good results, but:
Sliver evenness and **fibre alignment** have to be improved



15 gsm slivers on a light table

30 gsm slivers on a light table

Manufacturing and Testing of the developed Concept

Validation of the Concept following an ascending testing Pyramid

Validation Approach

I. Characterisation of slivers or yarns

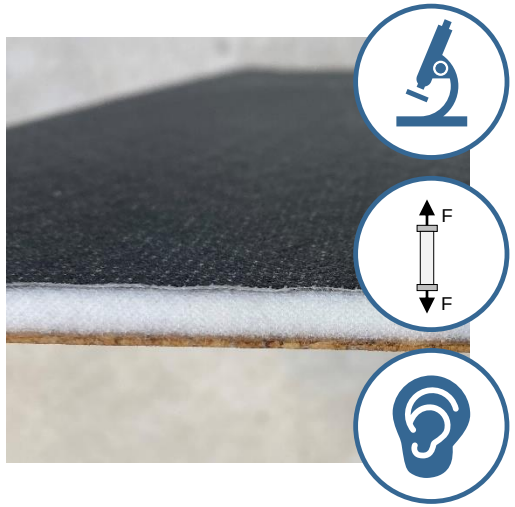
II. Characterisation of semi-finished parts

III. Testing of flat composite structures

IV. Testing of sandwich plates

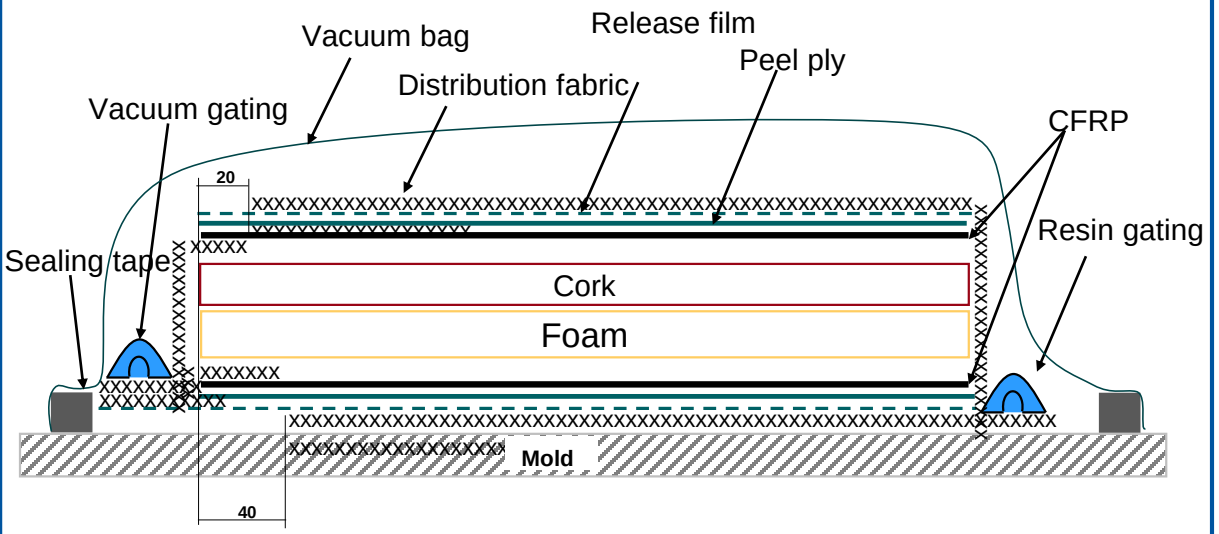
Tested Properties

- Evenness
- Tensile Properties
- Impact Properties
- Acoustic Properties
- Insert Properties
- Peeling Test
- 4-Point Bending Properties
- Further



Advantages of the concept using vacuum infusion

- No need to adapt the layup due to the porosity of the cork layer
- Insert potting not necessary due to the foam core



CFRP = Carbon Fibre Reinforced Part

Conclusion

Novelity of the Floor Panel Concept

Material:

- ✓ Using rCF-Facesheets and cork as an interlayer
- ✓ Bio-based resin-systems

Lightweight:

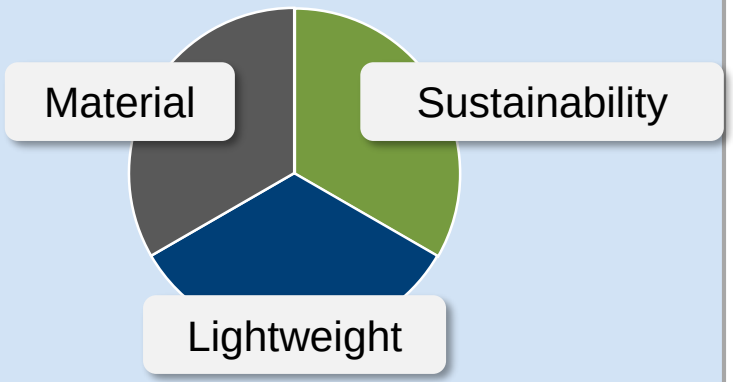
- ✓ Cork interlayer improves the impact properties
- ✓ Foam core erases the need for potting of inserts

Sustainability:

- ✓ Bio-based and recycled materials

Open points:

- ○ Reproducibility depending on the input material flows
- ○ Evenness of the input material
- ○ Mechanical properties



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