Chris McHugh

Sigmatex

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Textile Technologies

Advanced Flexible Materials

Design as a key driver of competitiveness in the Technical Textile (Advanced Materials) industry

29th April 2014
Bentley Motors

Chris McHugh – Technical Manager
Sigmatex

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Application and Processing of Complex Technical Textile Designs using Carbon Fibre materials

Introduction to Sigmatex

What does Design mean at Sigmatex
- Crimp reduction – 2D, Tape
- Nodal Design – 3D
- Blade Design – 3D
- Optimising Design & Materials – 3D

Recycled materials

R&D Future Opportunities

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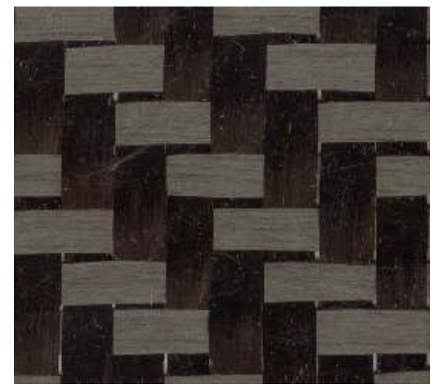
Who is Sigmatex?

- World Leader in Carbon Fibre Materials conversion
- UK Company
- Head Office in Runcorn
- Global presence
    - USA
    - Europe
    - China

What do we do?

Sigmatex convert Carbon Fibre into various Fabric Formats including:

- 2D Weaving
- 3D Weaving
- Multi-axial non crimp fabrics
- Uni-directional bespoke equipment



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What does Design mean at Sigmatex?

Design for optimal fibre performance – 2D

Design for function - 3D materials

Design for Lightweight Materials - Tape

Weave Design for aesthetics?

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Technical Textile Design

Performance –
- Maximum performance from fibrous materials built in to the textile.
- Understanding fibre properties for processing

Design –
- Understanding the end use of the textile.
- Aesthetics + performance or cost + performance or a combination

Processing Technology ? –
- Complexity
- End Use
- Post processing

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Enabling Processing Technologies

3D weaving

Tape Weaving

Multi-axis Weaving

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Design for 2D materials

Plain Weave

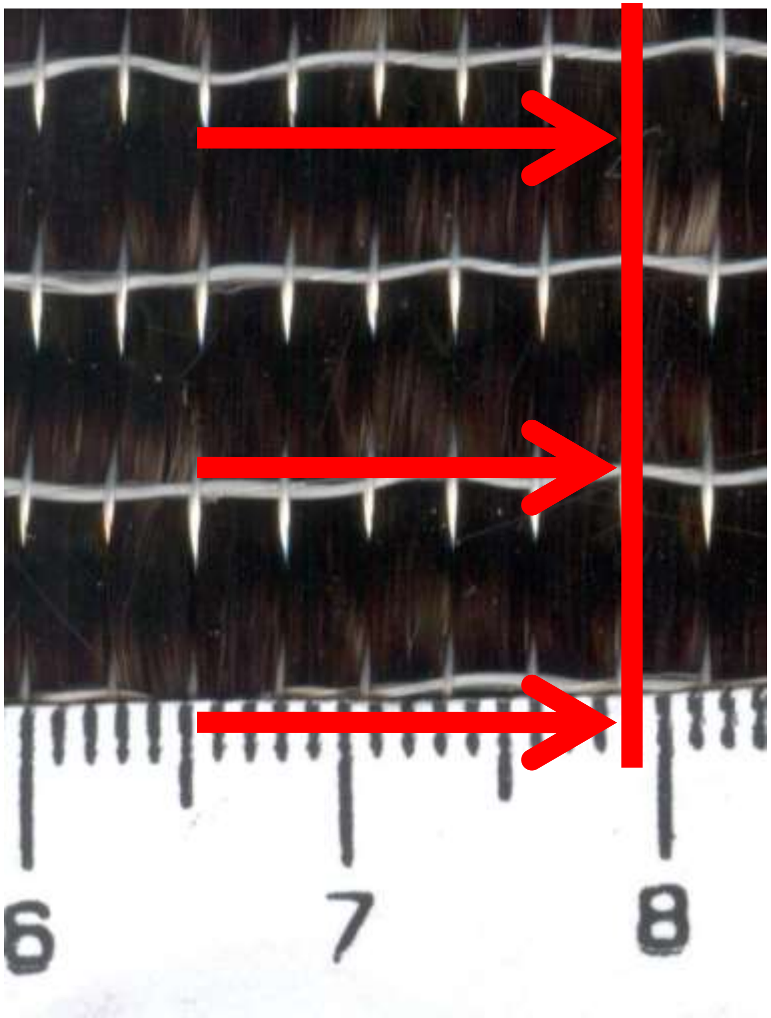
2x2 Twill

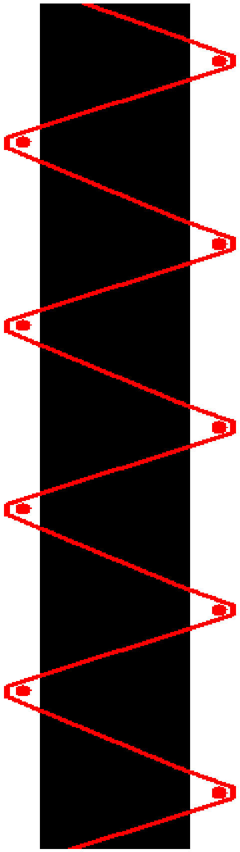
5 Harness Satin

The problem is Crimp

Crimp Reducing but not removed

Crimp reduction





Initial work was carried out using woven unidirectional fabrics, the dry fabric version of UD tape. As this is where the biggest issue with crimp existed.

UD is typically used where the greatest translation of potential properties is required

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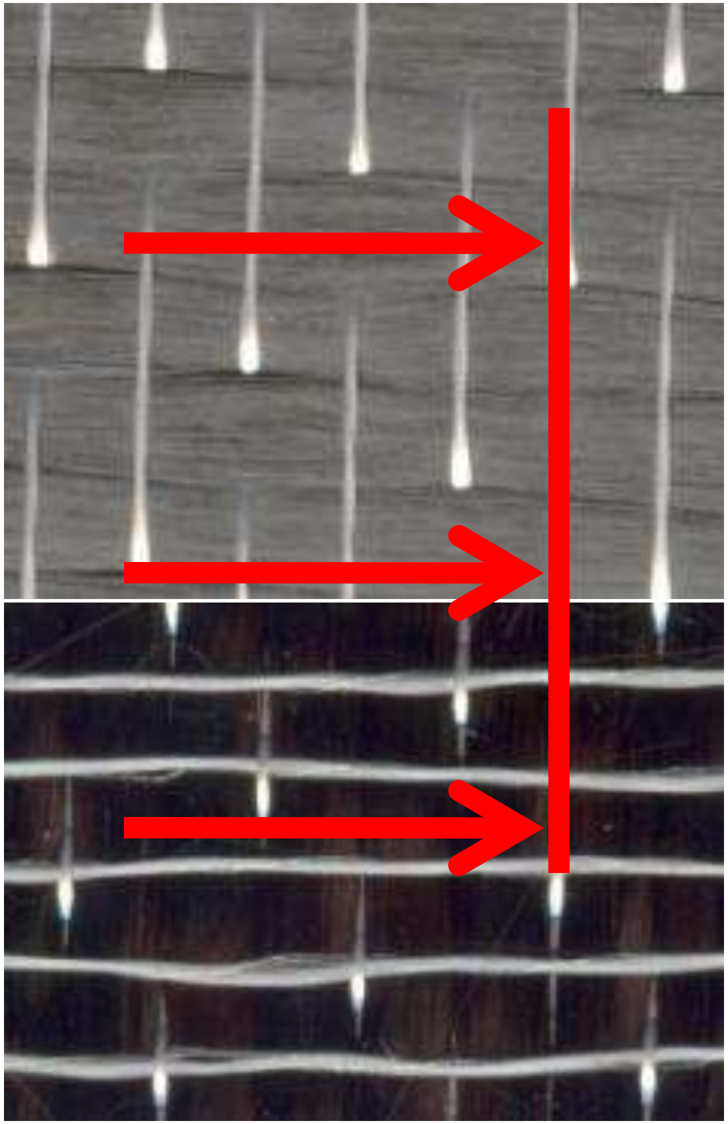
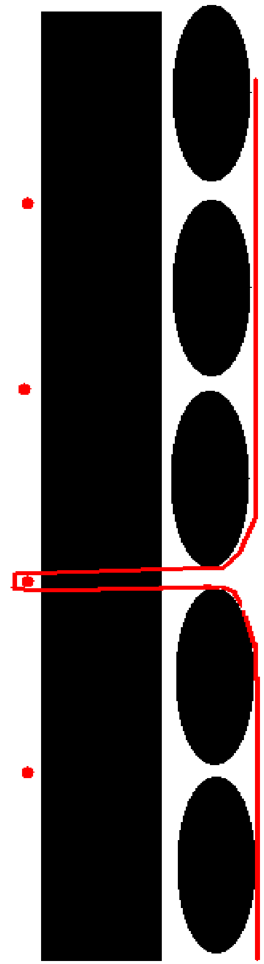


This has continued in the field of bi-axial fabrics



Whilst use of this Woven Non-Crimp style is still not common place, the UD version is now the version of choice amongst UD fabrics. The bi-axial version is currently the material choice for a primary structure in aerospace.

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Alternatively reduce crimp by spreading material

Plain Woven (DV5761250)

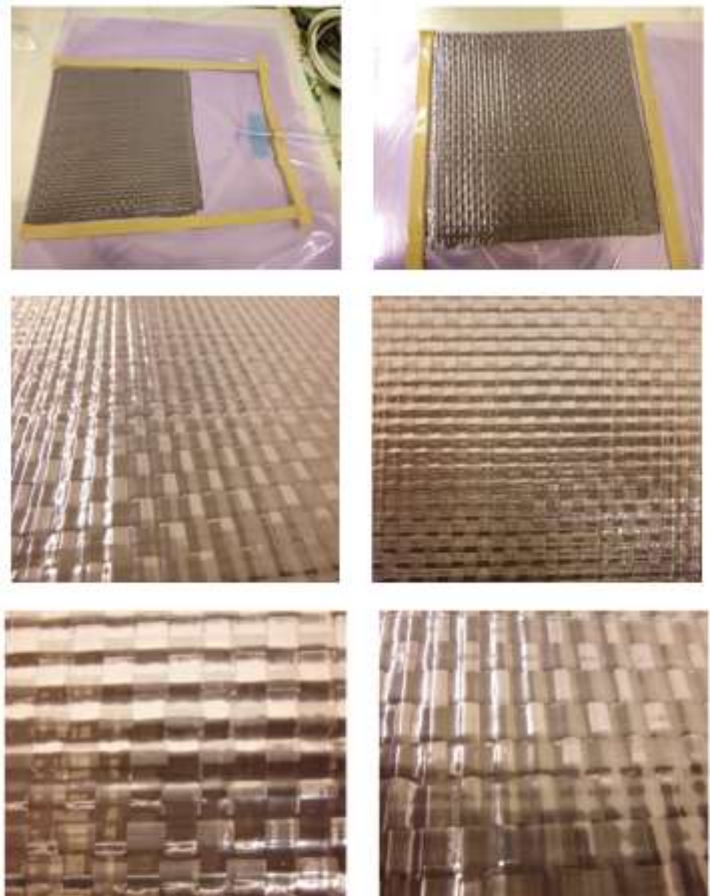
Specimen Number	Warp			Weft		
	Crimped Length (mm)	Un-crimped Length (mm)	Crimp %	Crimped Length (mm)	Un-crimped Length (mm)	Crimp %
1	1000	1005	0.5	1000	1006	0.6
2	1000	1004	0.4	1000	1006	0.6
3	1000	1004	0.4	1000	1005	0.5
4	1000	1005	0.5	1000	1007	0.7
5	1000	1006	0.6	1000	1006	0.6
	Average		**0.48 %**	**Average**		**0.6 %**

Tape Woven (DV6201400)

Specimen Number	Warp			Weft		
	Crimped Length (mm)	Un-crimped Length (mm)	Crimp %	Crimped Length (mm)	Un-crimped Length (mm)	Crimp %
1	1000	1001	0.1	1000	1002	0.2
2	1000	1002	0.2	1000	1001	0.1
3	1000	1001	0.1	1000	1003	0.3
4	1000	1001	0.1	1000	1002	0.2
5	1000	1002	0.2	1000	1001	0.1
	Average		**0.14 %**	**Average**		**0.18 %**

Surface Characteristics

Standard Woven Fabric



Sigma ST Fabric

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Design for 3D Materials

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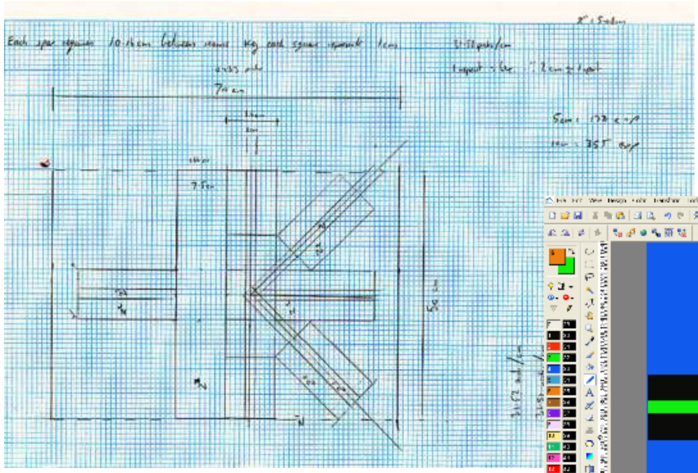
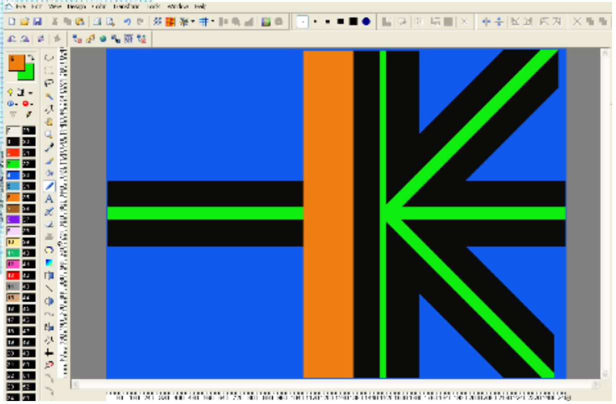
3D Design Process, Drawing to weave CAD to Product





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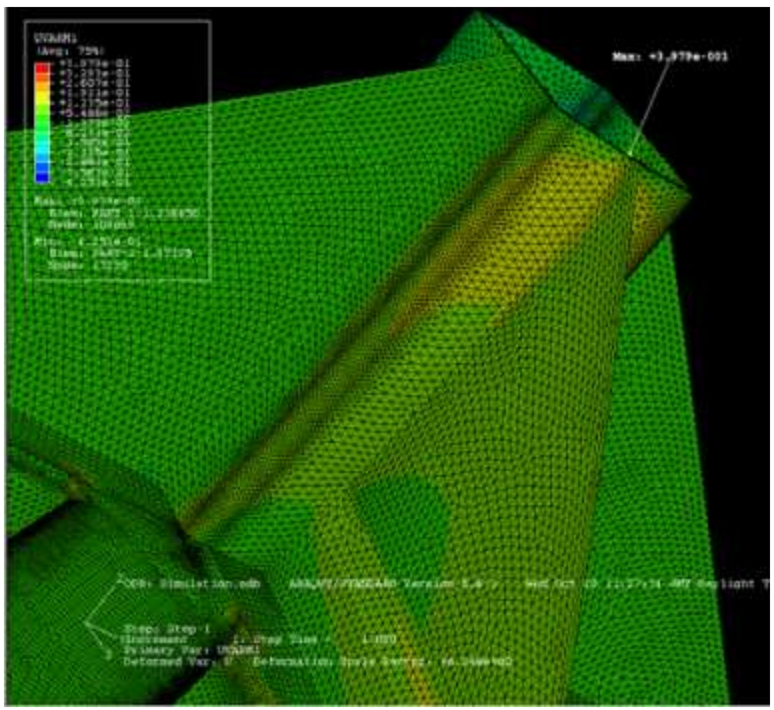
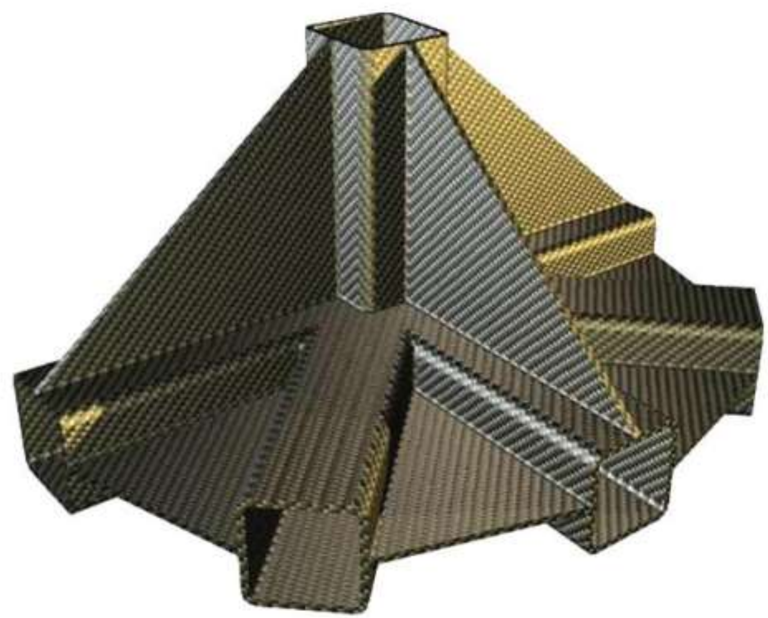
Failure Prediction

Finite Element Model Predictions versus Actual Results for Generic Truss

Off –axis Vertical load on 90 degree node





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OPW Nodal Structure

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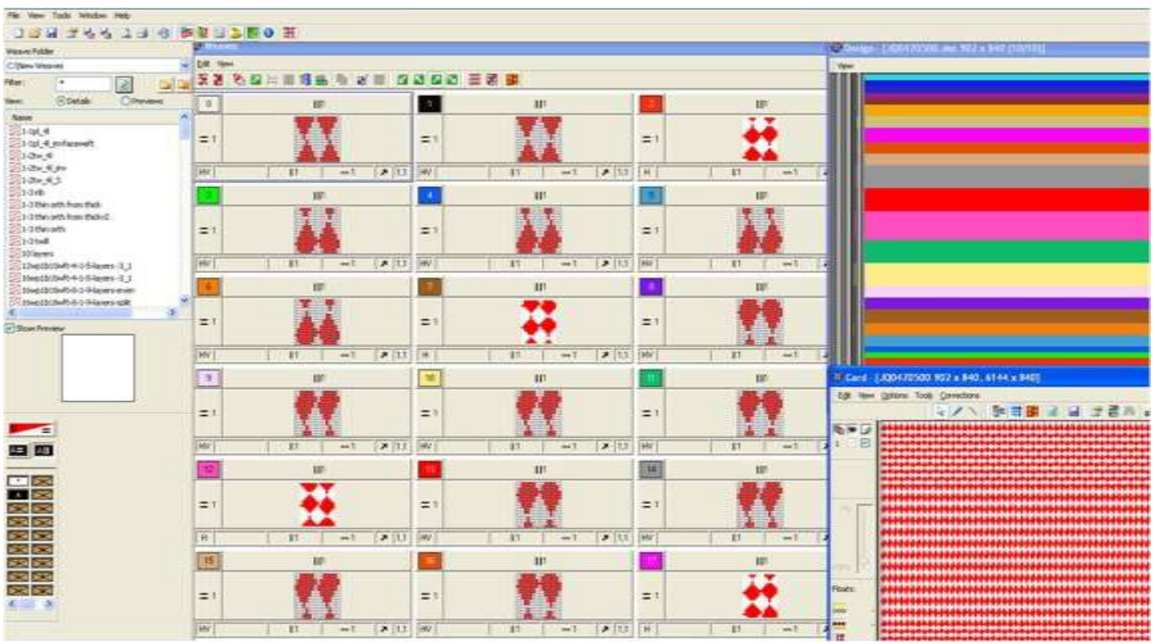
Design Process

Complete weave design capability, using in-house Design or customer CAD geometry to create woven structures to required dimensions using CAD design software.



- Customer Dimensions (CAD data)
- Fabric Definition (Sett – Construction)
- Define Protocol Definition
- Weave Creation
- Jacquard Parameter Definition
- Design File creation and manipulation
- Consolidate Design / Machine information
- Export Weave File to Jacquard
- **Woven Structure**

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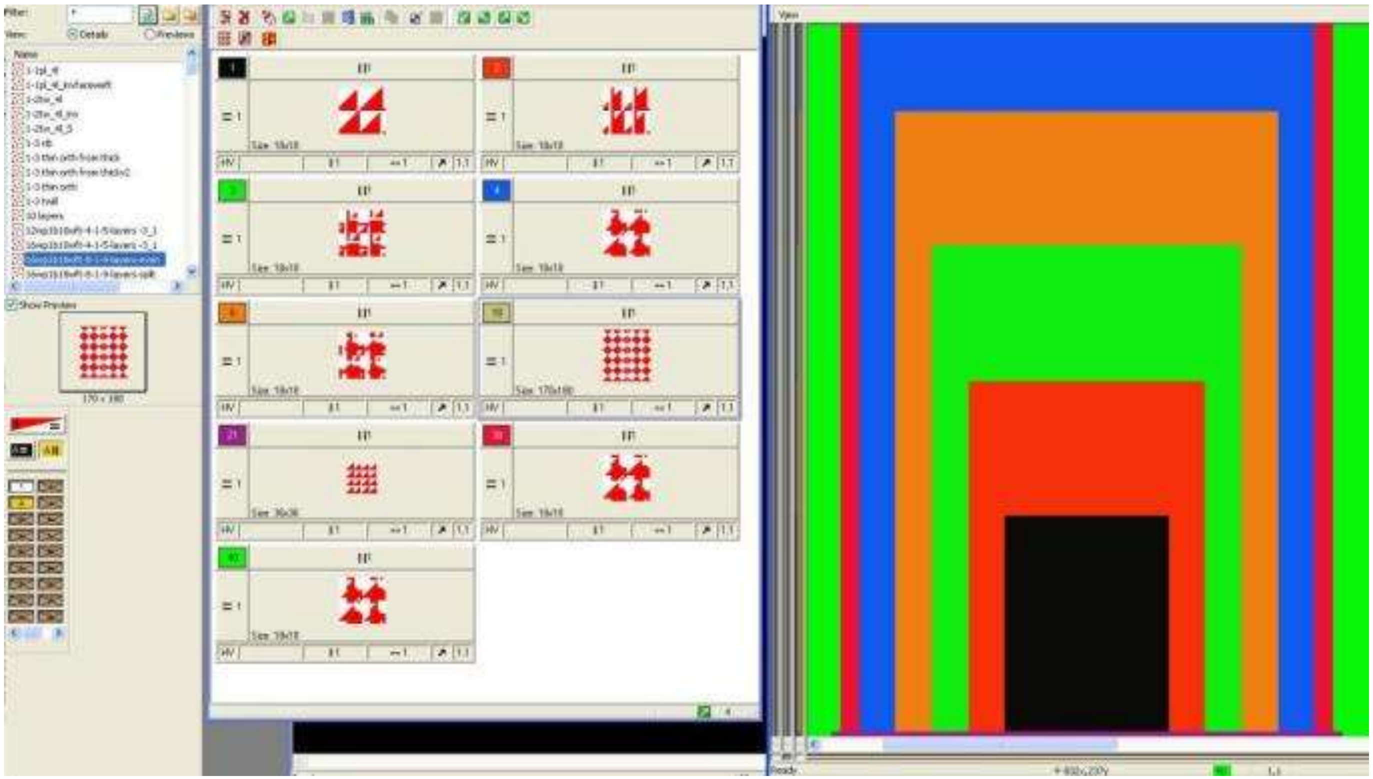

Each weave zone is allocated the corresponding weave

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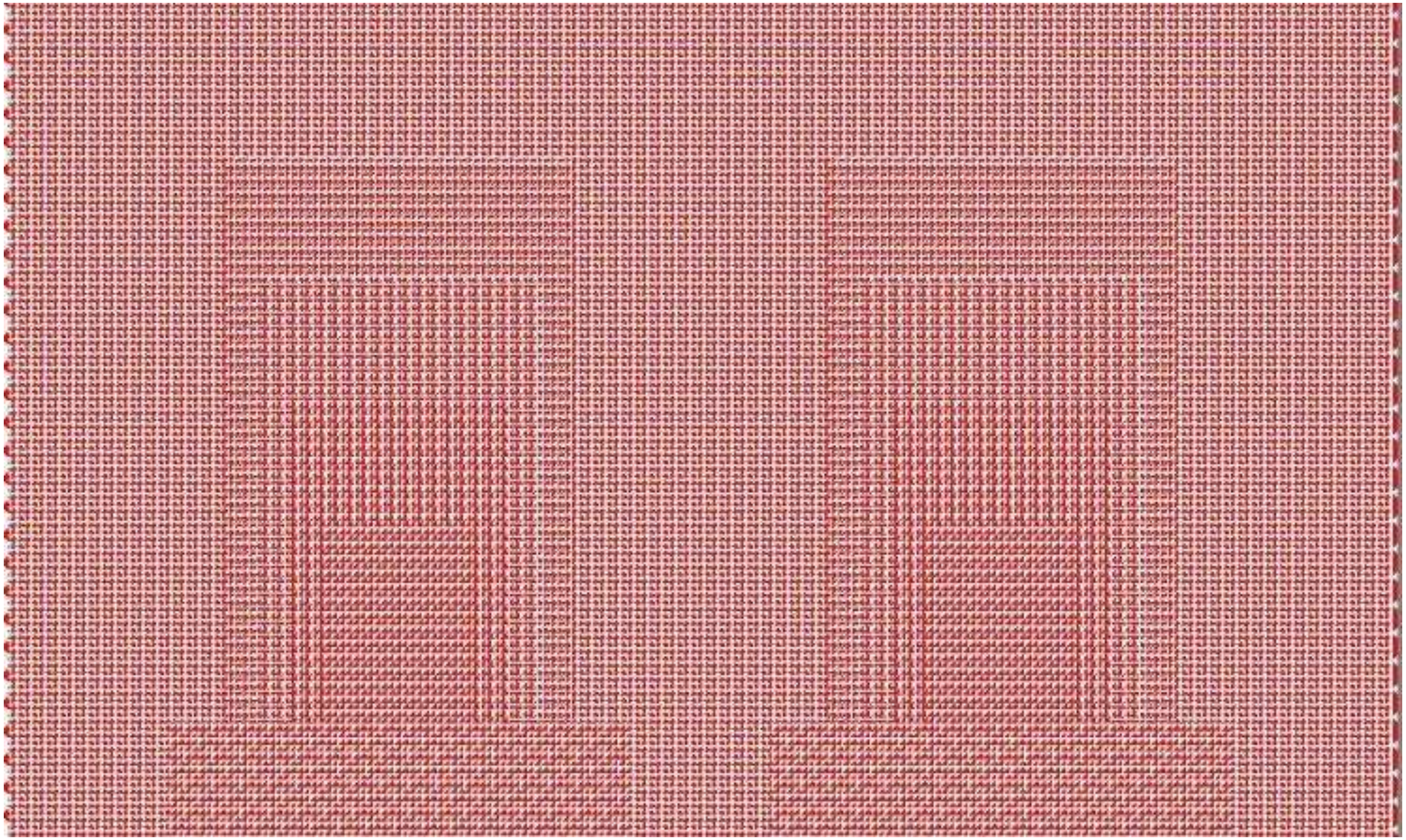

Output file is then created and transferred to
Weaving Loom & Jacquard via USB or Network

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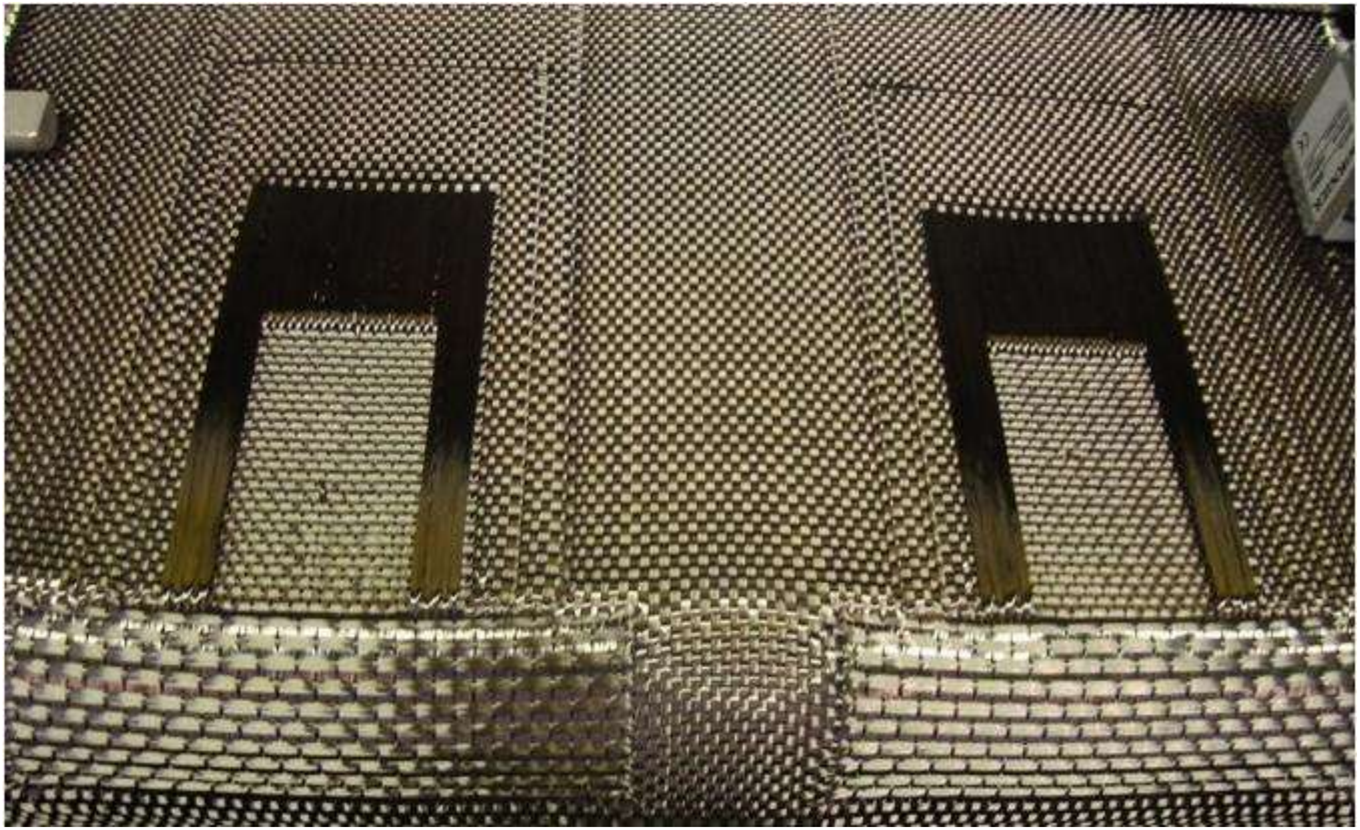


Design is the woven on loom

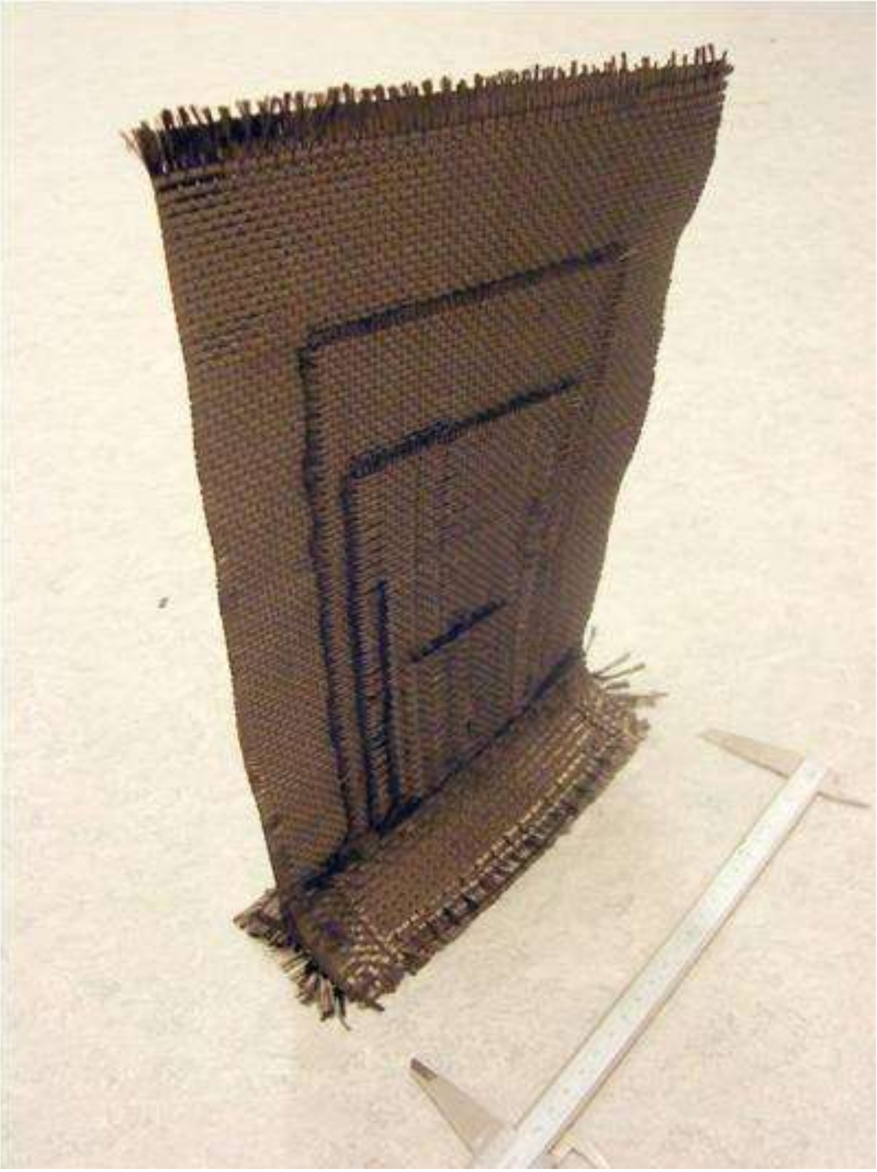
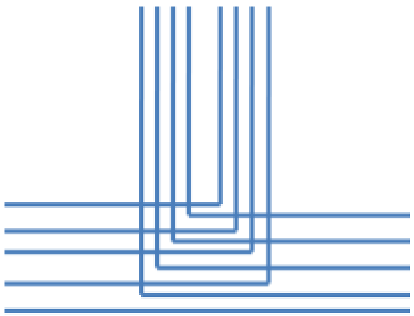


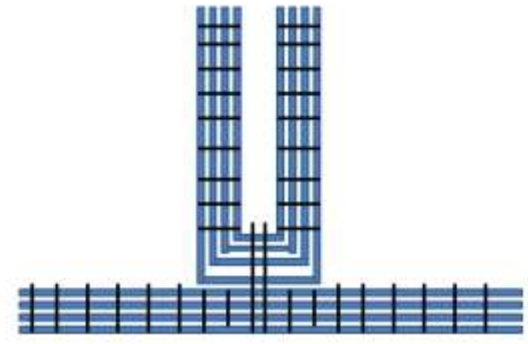
Image to show ply drop off and split root section

Pi Preform Design Comparison

Pi Preforms were designed and woven to provide high amount of fibre interlacing at base section and specific positioning of fibres in an Orthogonal design



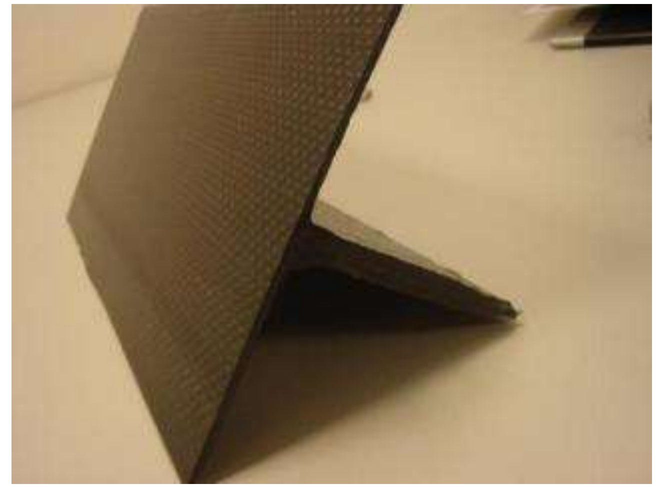
Bound Pi layer path

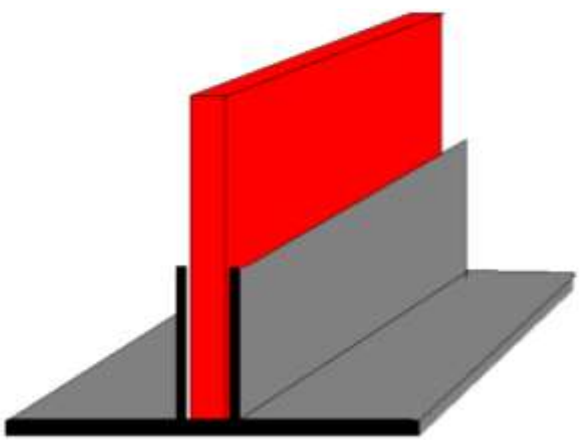


Orthogonal Pi layer path including Z binder

Infusion

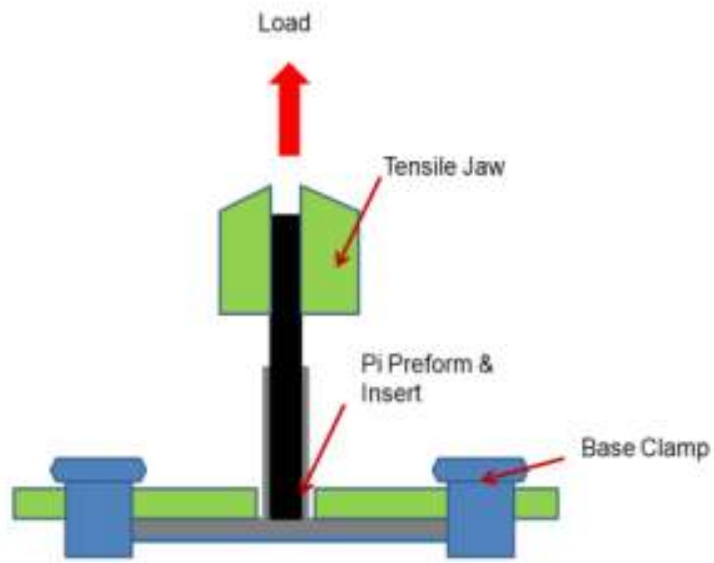
Pre infused

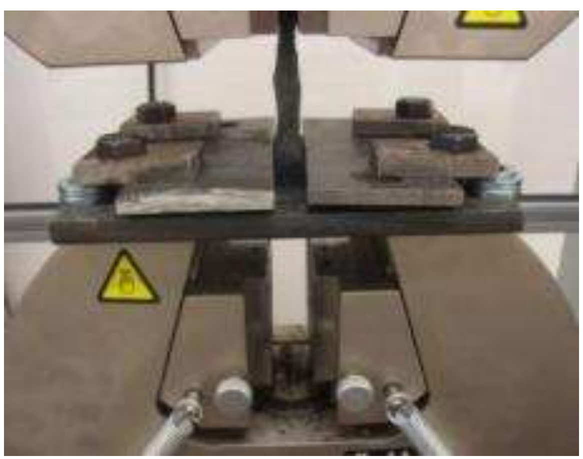




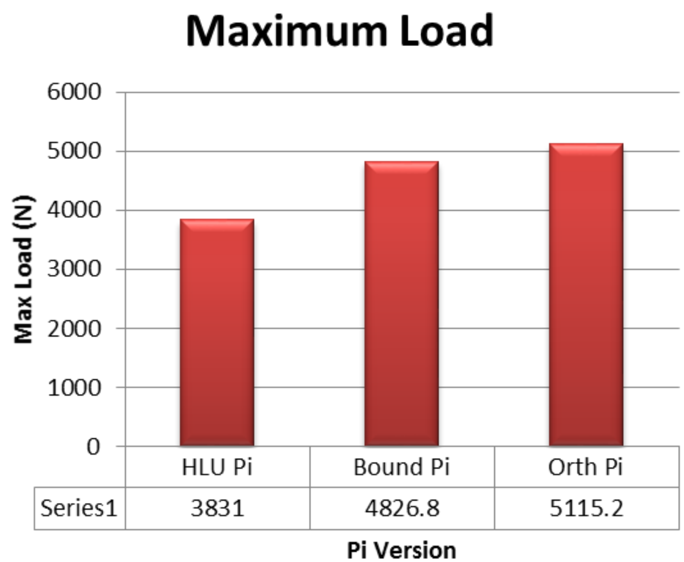
A Huntsman two part Epoxy resin system was used which allowed for a low temperature cure of 8 hours at 8o° C.
Prior to infusion the aluminum base-plate was pre-heated to 50° C.
The Pi sections were prepared on the base plate with a 3D woven flat structure inserted between the upright legs

Comparison 2D V 3D

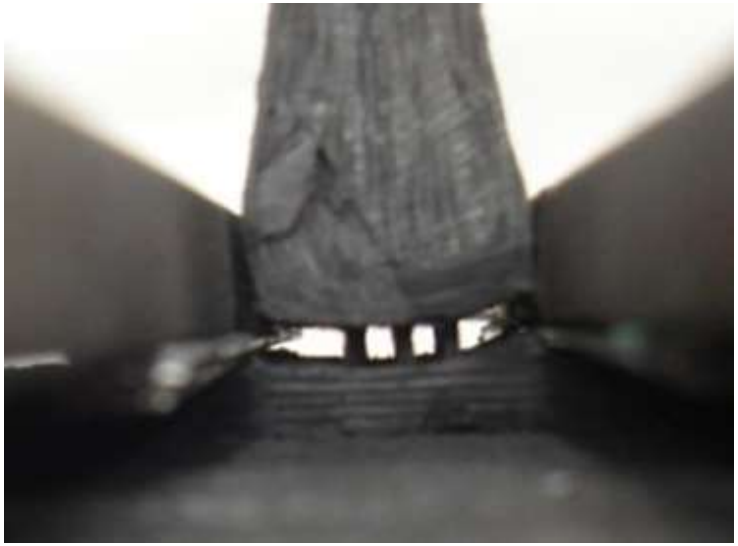


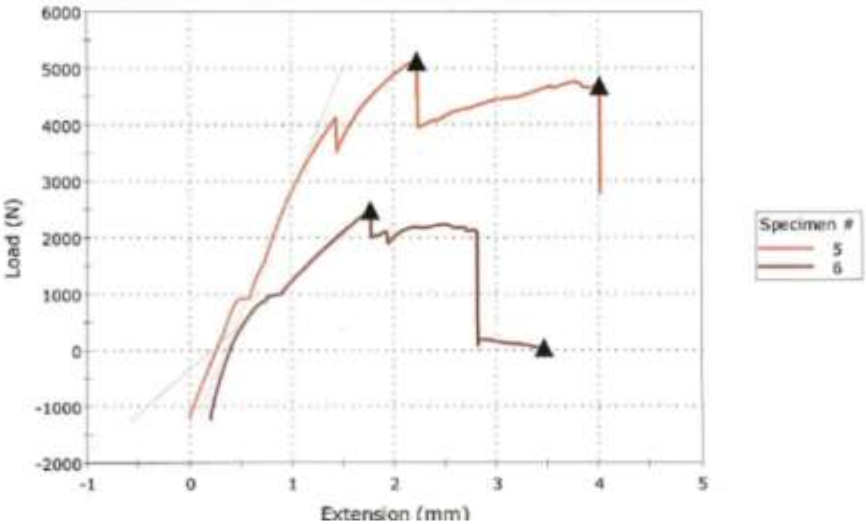


Test method has been setup to provide baseline data on Tensile Pull out of Pi designs



Alternative Pi preforms





- By using this method it is possible to use Higher strength very expensive fibres to improve performance as only small amount of fibre used in structure (3 threads per Pi). As opposed to all warp and weft in conventional structures.

Only 3 fibres designed in the correct location for tensile loading offered significant advantage

Put the fibre where it is needed

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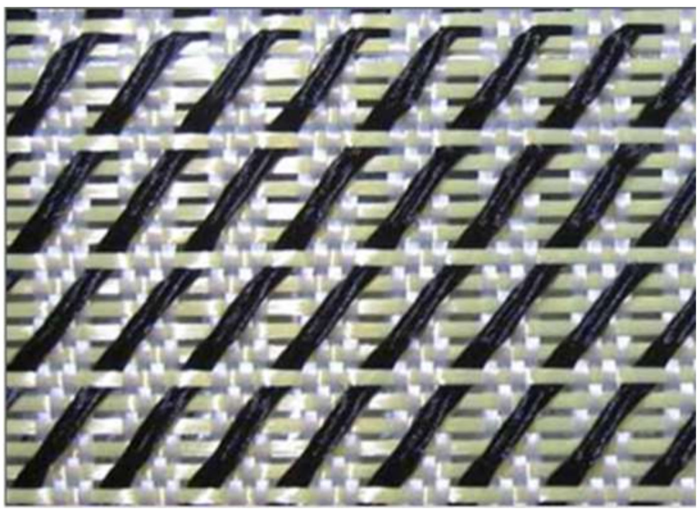
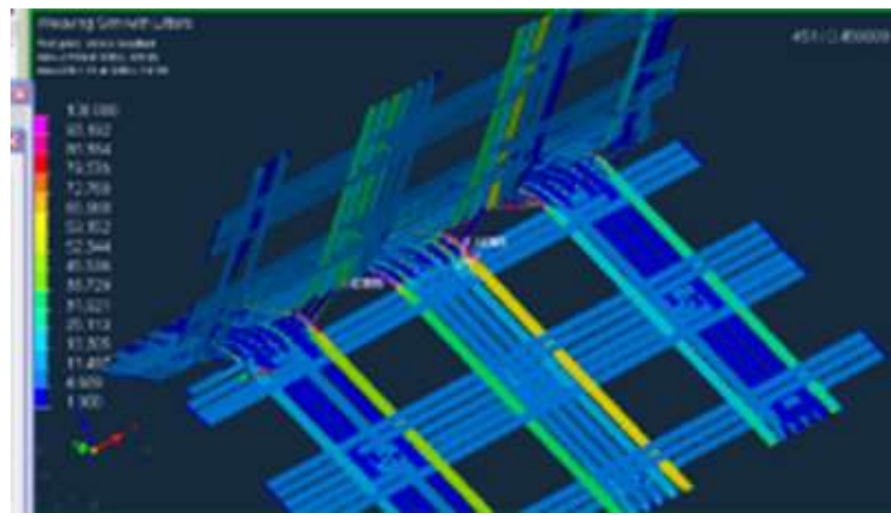
Design for LCA

R&D

Future Design Opportunities



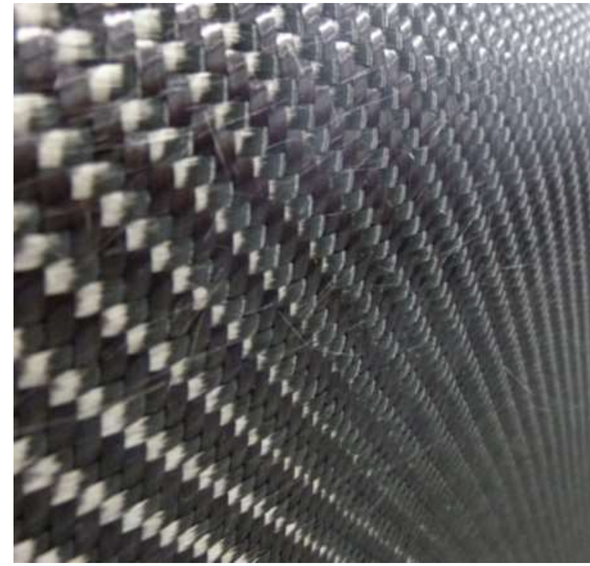


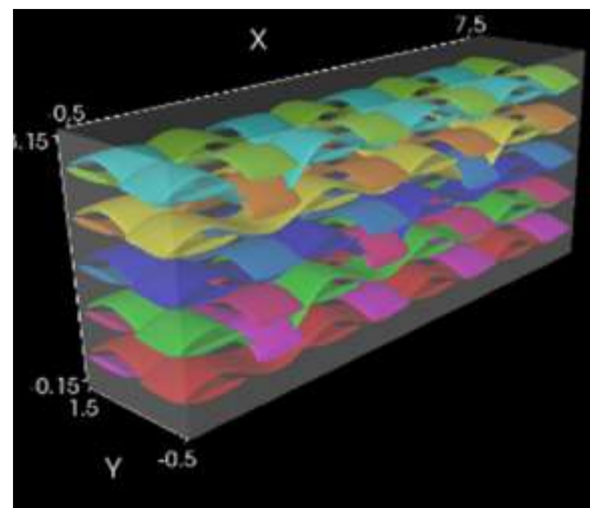
Summary

- The ability to use design to optimise materials performance is essential

- The future and success of materials will also be dependant on process repeatability and predicting materials performance

- The possibilities for Textile Design into Composite Applications are endless





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Thank You for your attention

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