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Bristol Composites Institute (ACCIS)

ADVANCED COMPOSITES COLLABORATION FOR INNOVATION & SCIENCE

Engineering and Physical Sciences Research Council

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EPSRC Centre for Doctoral Training in Advanced Composites for Innovation and Science

Advanced continuous tow shearing process

BCI Showcase

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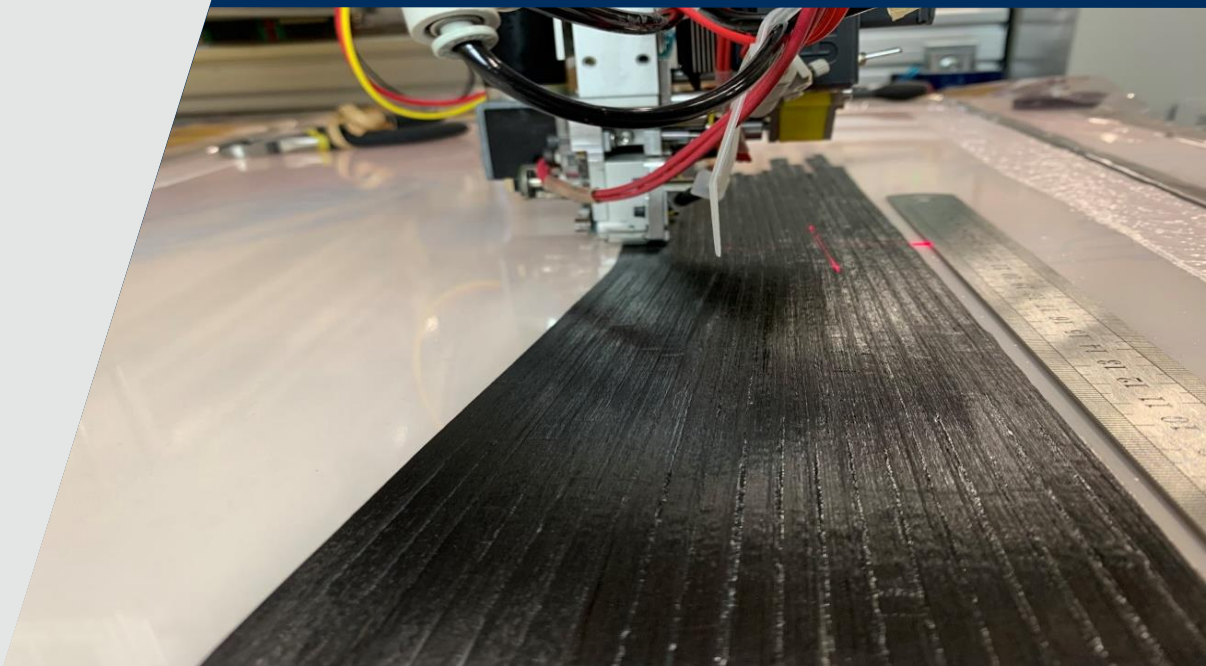
bristol.ac.uk/composites



Continuous tow shearing process

Continuous Tow Shearing (CTS) process allows defect free fibre steering for 1D angle variation composite lay-ups

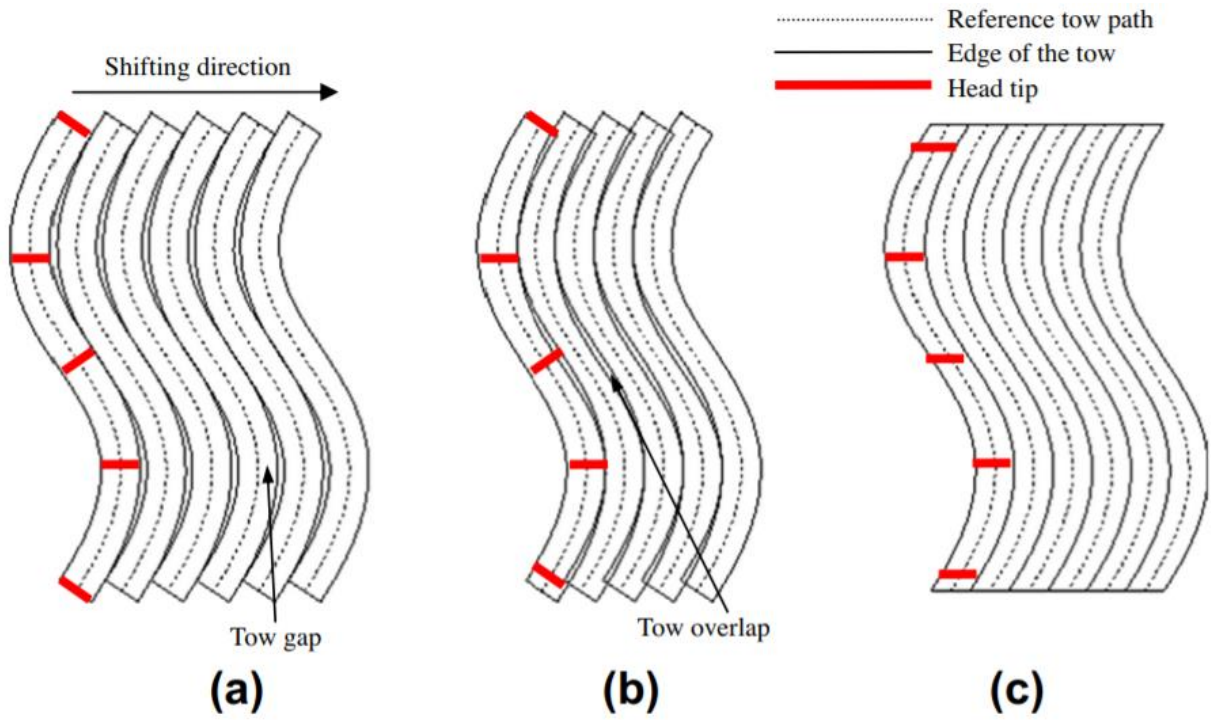
- Eliminates tow gaps or overlaps
- No coupling between the tape width and the minimum steering radius.

Challenges

- Laying up on a complex 3D surface is to date challenging, as triangular gaps with fibre discontinuities and resin rich areas are induced

Defect-free 3D fibre steering

- **Significantly expand the design space**
- **Achieve ultrahigh structural efficiency**



(a) Tow gaps induced by conventional AFP, (b) tow overlaps induced by conventional AFP, (c) CTS layup [1]

[1] B.C. Kim et al. / Composites: Part A 43 (2012) 1347–1356

Research aim and objectives

Aim:

Improving the current Continuous Tow Shearing (CTS) technology by utilising tow width control (TWiC)

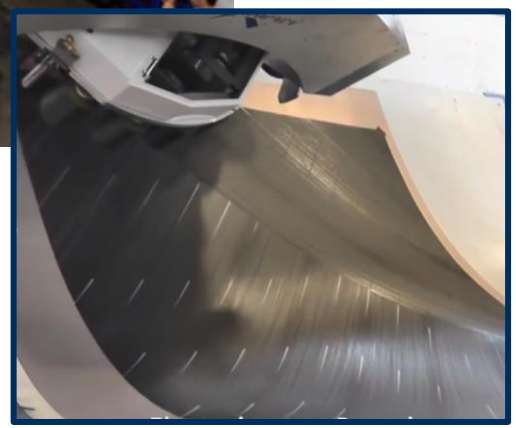
- Eliminating free tow edges and resin rich areas that result in high stress concentration without inducing tow drops or overlaps, and maintaining a constant fibre volume fraction

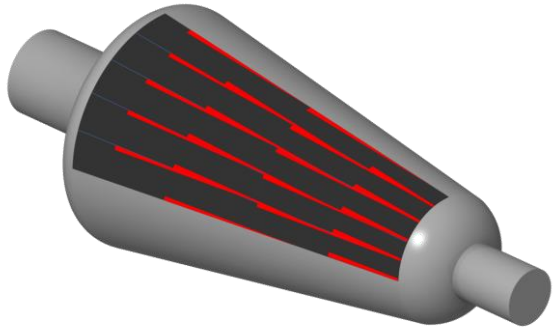
Objectives:

- Study the current CTS concept
- Find ideas to eliminate geometry induced defects
- Design and build a TWiC device head that can be easily mounted on current CNC machines or robots
- Produce 2-Dimensional and 3-Dimensional layups
- Evaluate and analyse the accuracy of the layup
- Improve the concept

Conventional layup defects

AFP process [2]





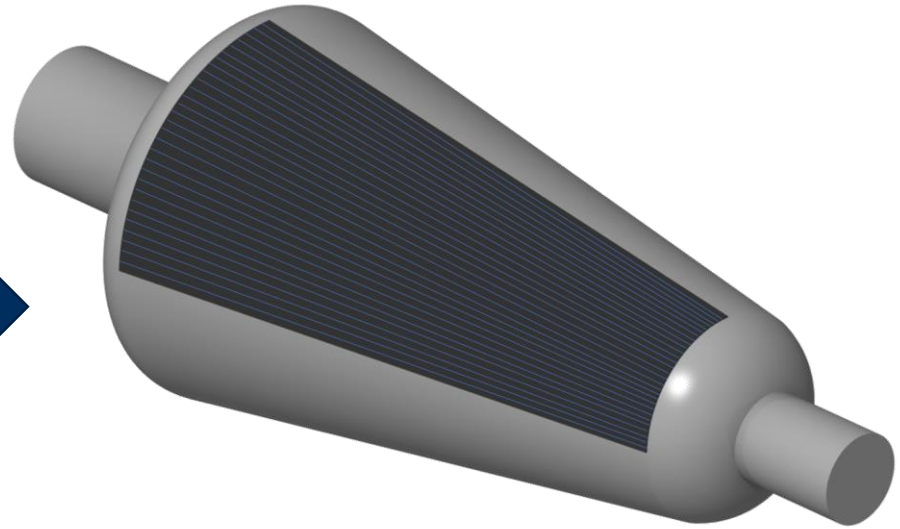
AFP layup with resin pockets

Geometry induced defects:
Resin rich areas and fibre discontinuities

High stress concentration

Areas of failure initiation

TWiC concept



'Defect-free' TWiC layup

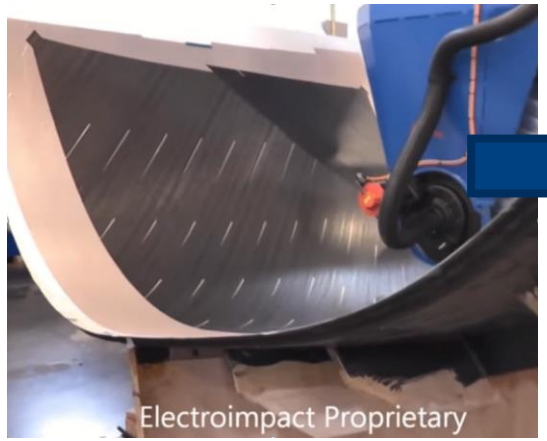
[2] https://www.youtube.com/watch?v=xK4gMDduHgA

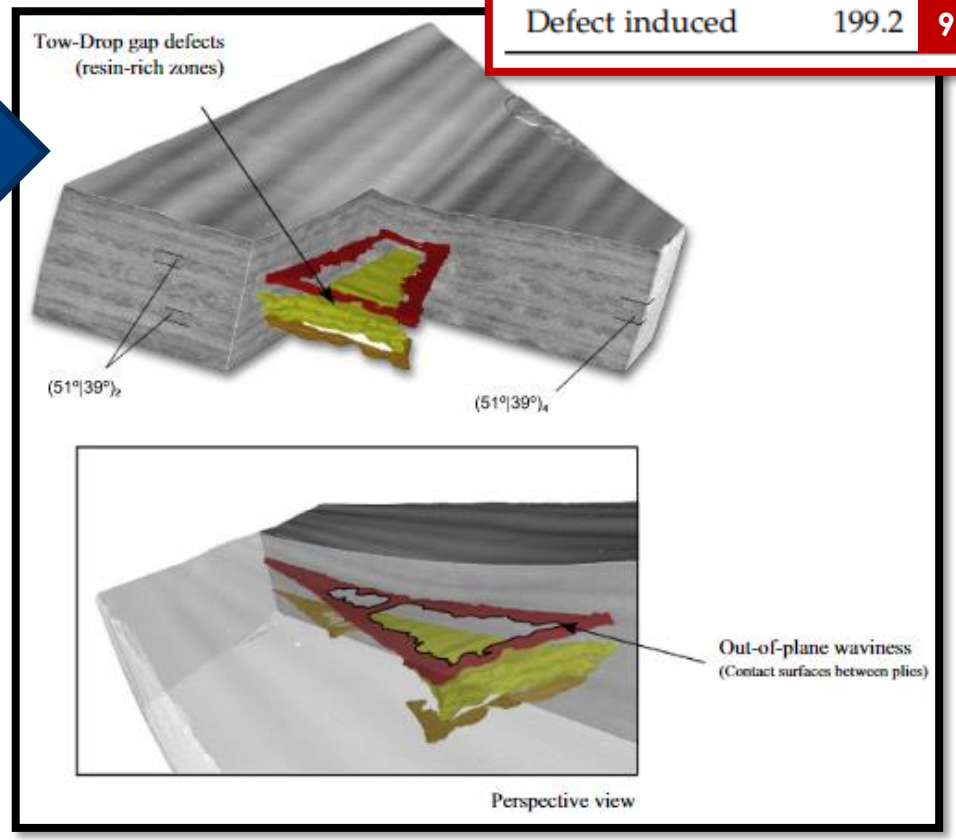
Effect of defects

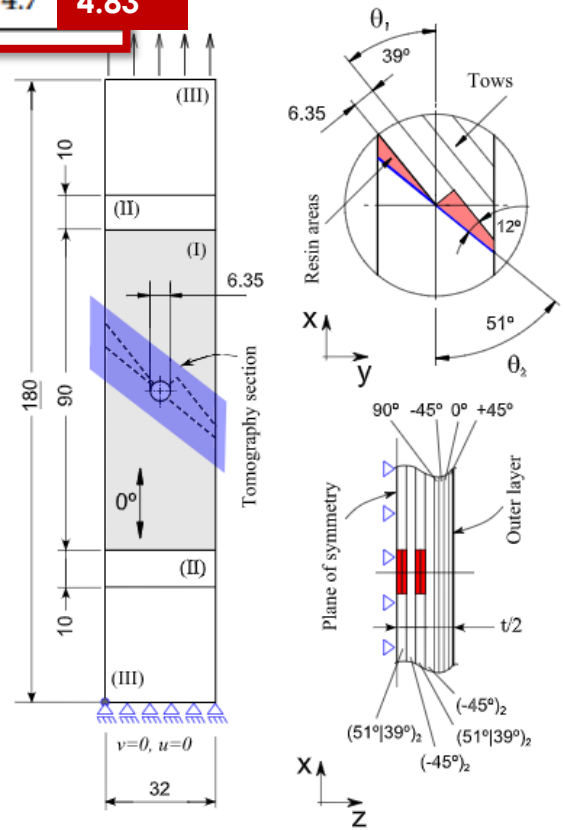
Specimen configurations	Analytical result (MPa)		Experimental result (MPa)	
Un-notched test:				
Baseline	357.5	12.59	389.2	22.12
Defect induced	312.5		303.1	
Open hole test:				
Baseline	219.2	9.12	225.6	4.83
Defect induced	199.2		214.7	

Table 2: Comparison of tensile test results between defect free specimens, and un-notched and notched specimens containing resin rich areas. [3]

Strength reduction in %







[3] Test specimens with induced tow drops, resulting in triangular shaped resin rich areas for un-notched and notched tensile tests by Falco et al. .

X-ray computed tomography of specimens. [3]

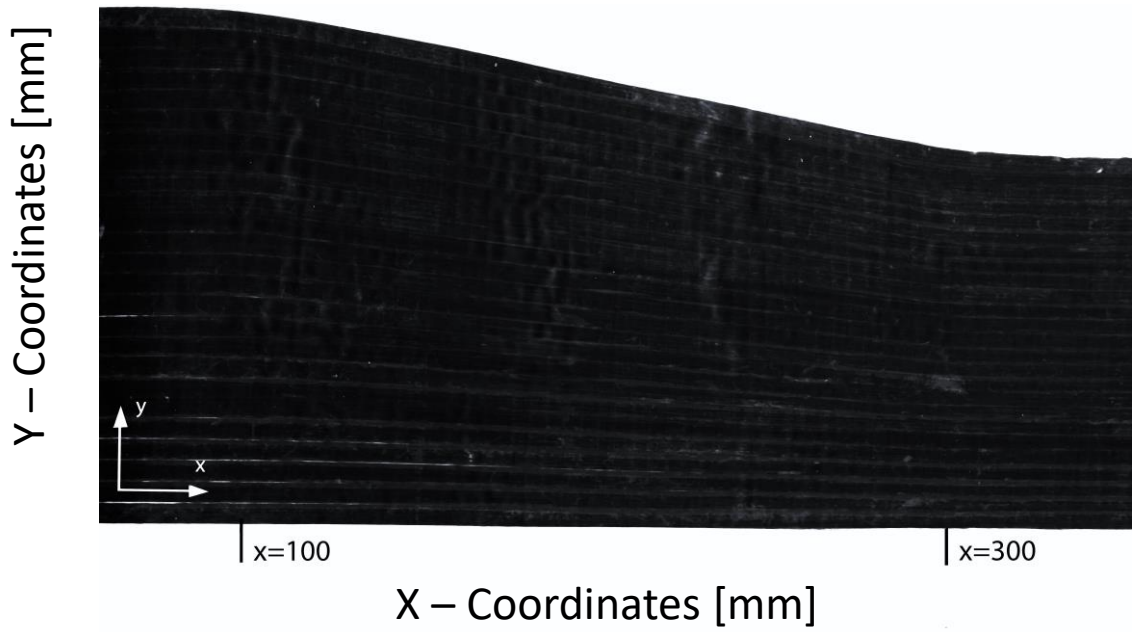
Specimen geometry and boundary conditions. All dimensions in mm. [3]

Conclusion

CTS utilising TWiC device is able to

- Change the tow width by approximately 30% (to be improved)
- Produce complex shaped 3-dimensional structures without tow gaps and overlaps
- Eliminate fibre discontinuities and resin rich areas (hot spots for damage initiation)
- Produce less defects than material deposition processes used to date

CTS layup utilising TWiC device



Defect-free 3D fibre steering

- **Significantly expand the design space**
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Thank you

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