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

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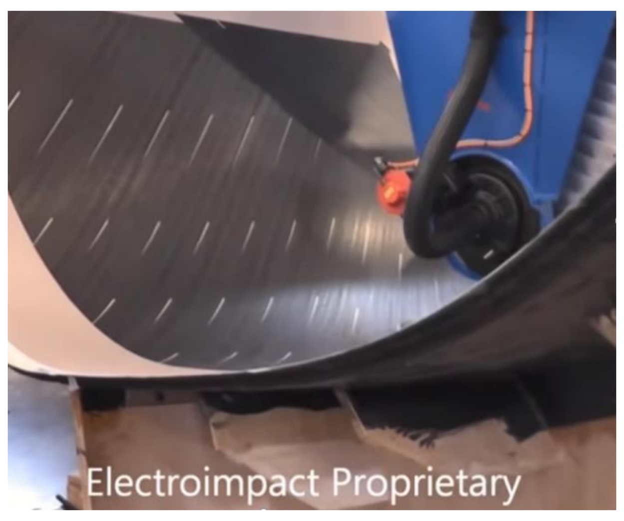
Advanced Continuous Tow Shearing utilising Tow Width Control

Michelle Rautmann*[1], Edwin Rosario Gabriel, Dmitry Ivanov and Byung Chul (Eric) Kim*[2]

AFP layup limitations



AFP induced triangular shaped gaps on 3-dimensional surface. [1]

Geometry induced defects:
Resin rich areas and fibre discontinuities

↓

High stress concentration

↓

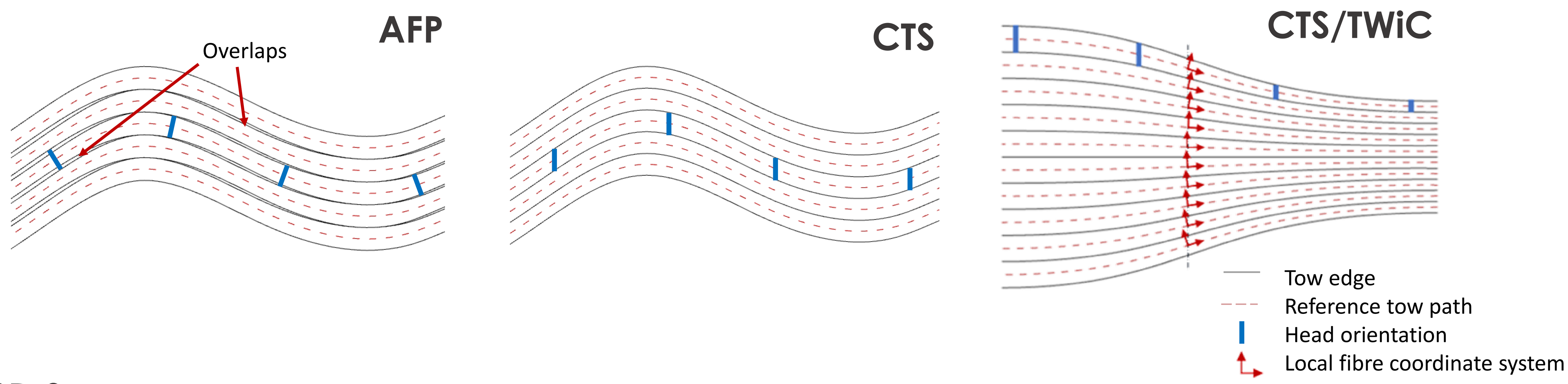
Areas of failure initiation

- 22.1% strength reduction for 0% gap-covered test specimens
- 10.8% strength reduction for 100% gap-covered test specimens (overlaps)
- 8.6% strength reduction using staggering method of gaps

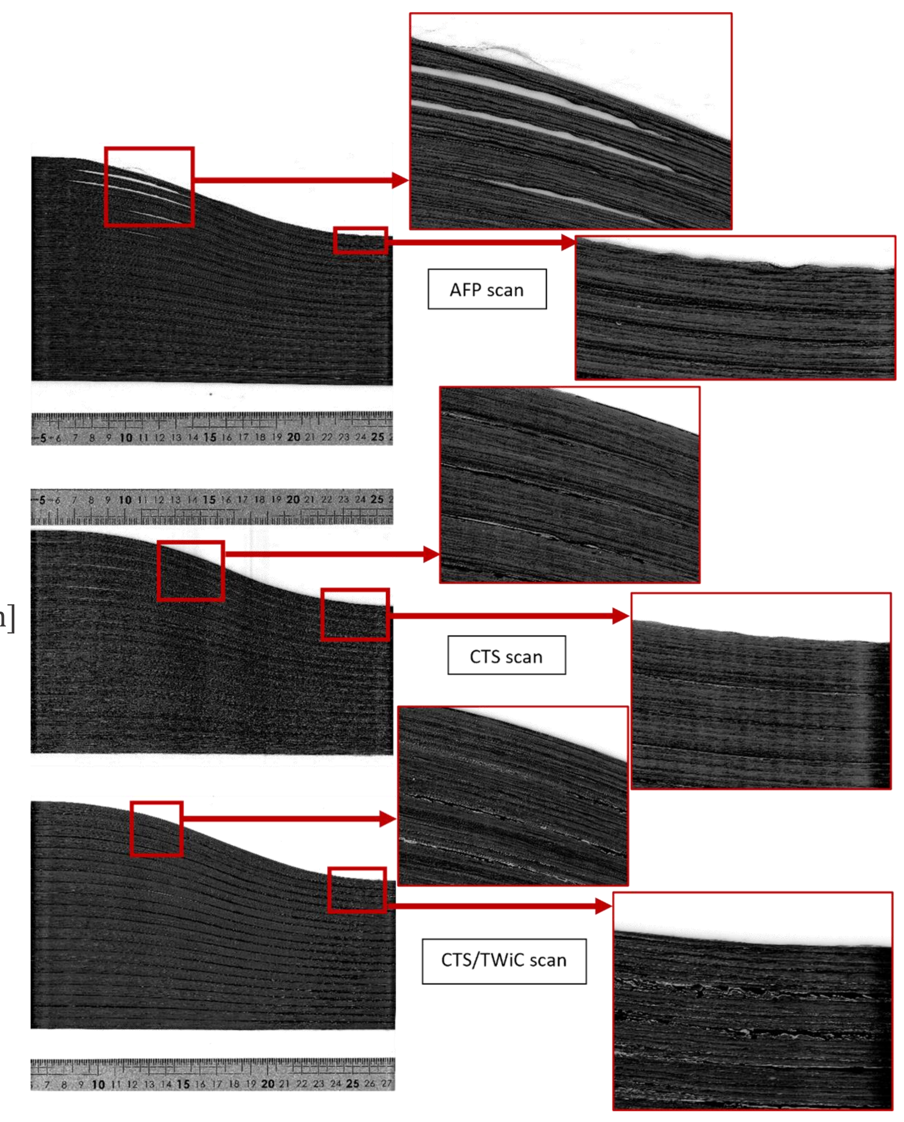
[2]

While the **C**ontinuous **T**ow **S**hearing **(CTS)** process has been successful in eliminating defects in 1D angle variation layups by employing in-plane shear deformation, 3D composite layups pose a significant challenge due to triangular gaps with fibre discontinuities and resin-rich areas, leading to high stress concentration and areas of failure initiation.

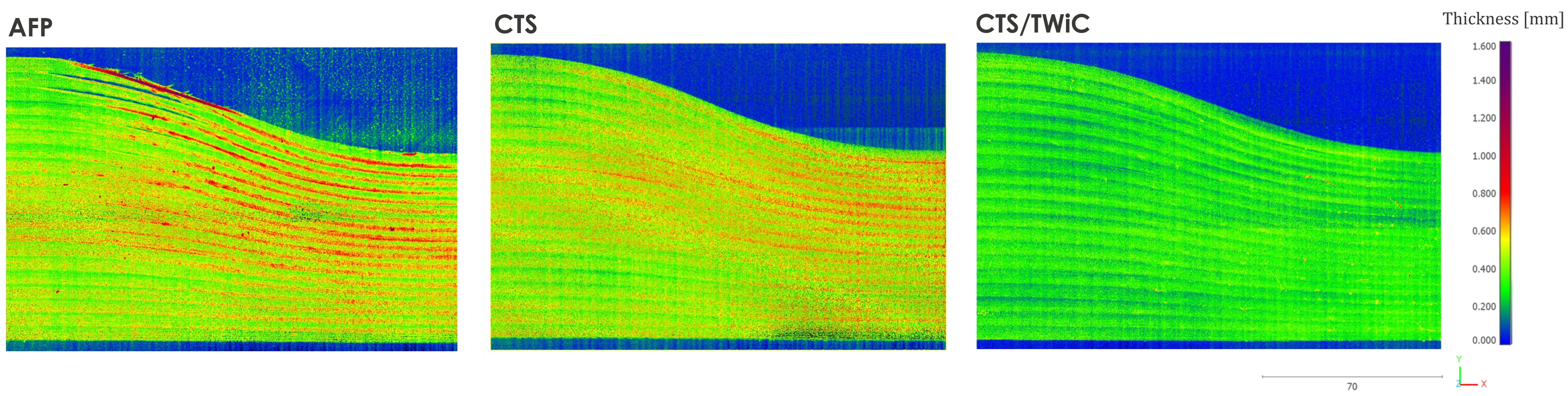
A novel concept of a **T**ow **Wi**dth **C**ontrol **(TWiC)** mechanism is proposed, offering an innovative solution by enabling on-the-fly width adjustment of the tow. This mechanism eliminates tow drops and resin pocket defects while maintaining a constant fibre volume fraction, ensuring production of defect-free 3D composite layups. The implementation of the TWiC device within the CTS process unlocks the potential for achieving **ultra-high structural efficiency** in composite production.

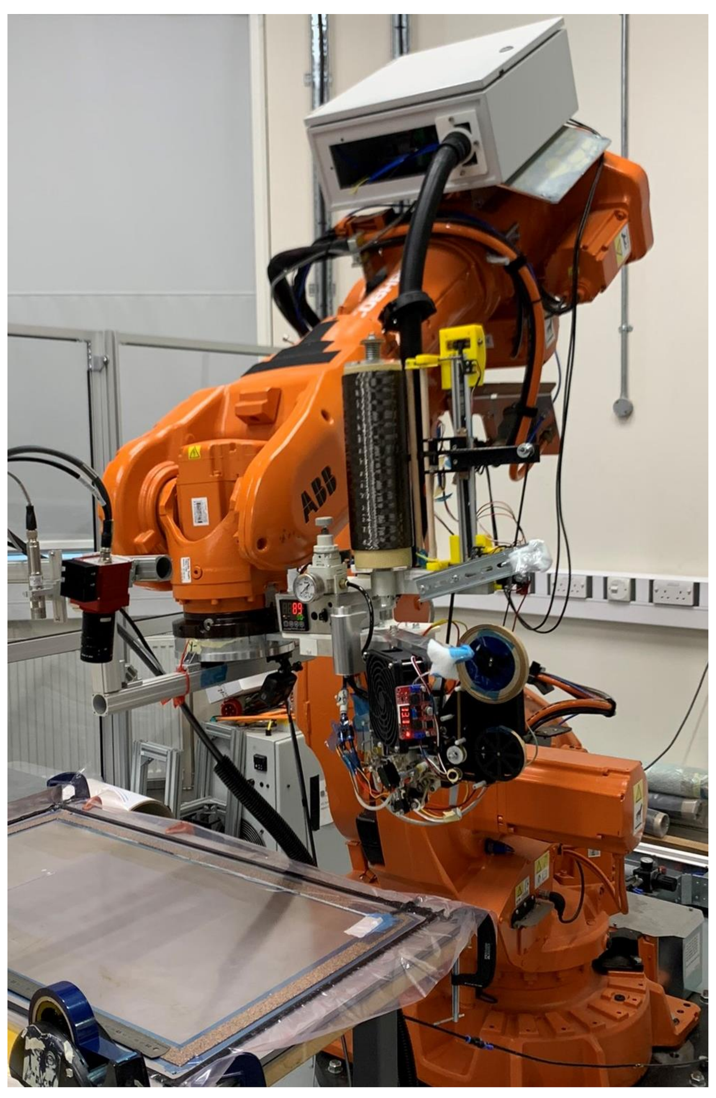


2D Scans



3D Scans



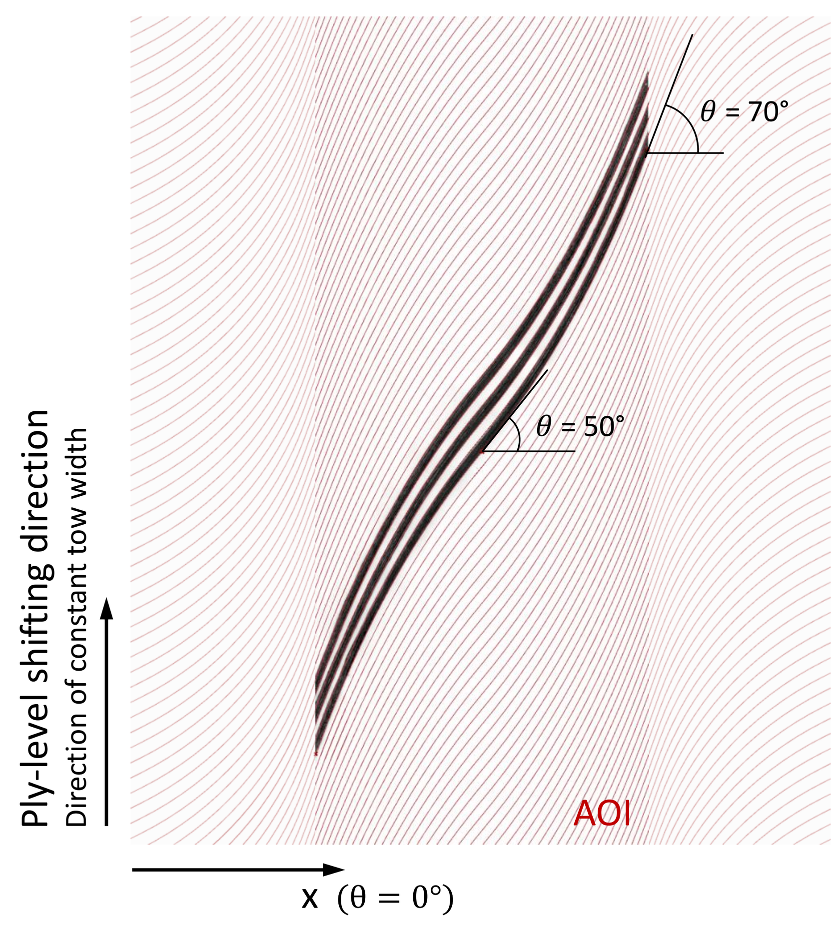


Robot with mounted CTS/TWiC head.

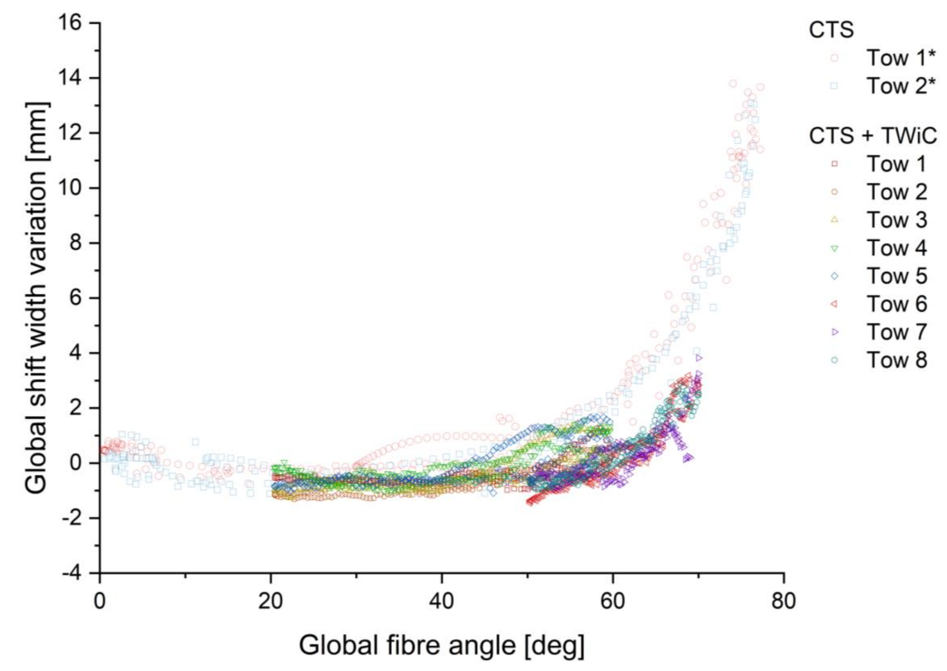
Advantages

- Potential for achieving very high global fibre angles
- Production of complex shaped 3-Dimensional structures without tow gaps and overlaps
- No fibre discontinuities and resin rich areas (hot spots for damage initiation)
- Constant fibre volume fraction

High global fibre angle layups



2D scan of high global fibre angle CTS+TWiC layup with constant width in ply-level shifting direction with target boundaries overlay.



Comparison of global shift width variation between CTS*[3] and CTS+TWiC produced tows.

*[1] Email: Michelle.Rautmann@bristol.ac.uk
*[2] Email: b.c.eric.kim@bristol.ac.uk

bristol.ac.uk/composites

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

[2] O. Falcó, J.A. Mayugo, C.S. Lopes, N. Gascons, J. Costa, Variable-stiffness composite panels: Defect tolerance under in-plane tensile loading, Composites Part A, 63, 2014, pp. 21-31 (doi: 10.1016/j.compositesa.2014.03.022)

[3] B. C. Kim, P. M. Weaver, and K. Potter, "Manufacturing characteristics of the continuous tow shearing method for manufacturing of variable angle tow composites," Compos. Part A Appl. Sci. Manuf., vol. 61, pp. 141–151, Jun. 2014

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