University of BRISTOL

Bristol Composites Institute

# Creation of ‘Over-moulded’ PEEK samples for Interface Bond Strength Predictions


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BCI research symposium

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EPSRC Centre for Doctoral Training in Composites Science, Engineering and Manufacturing

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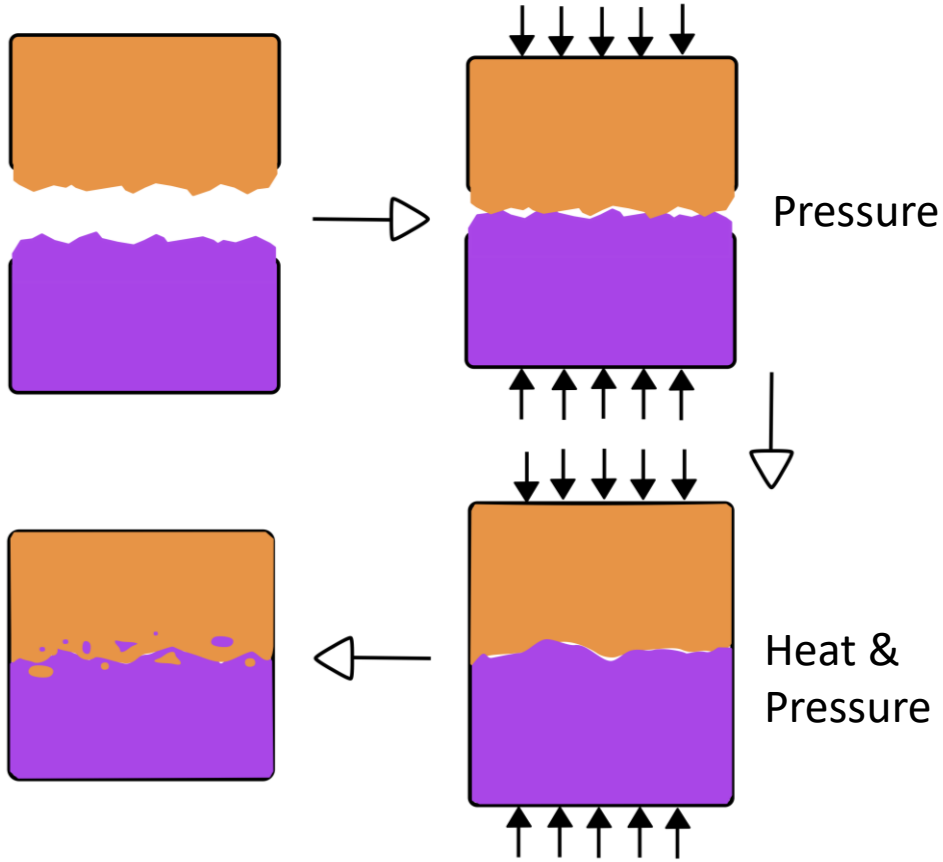
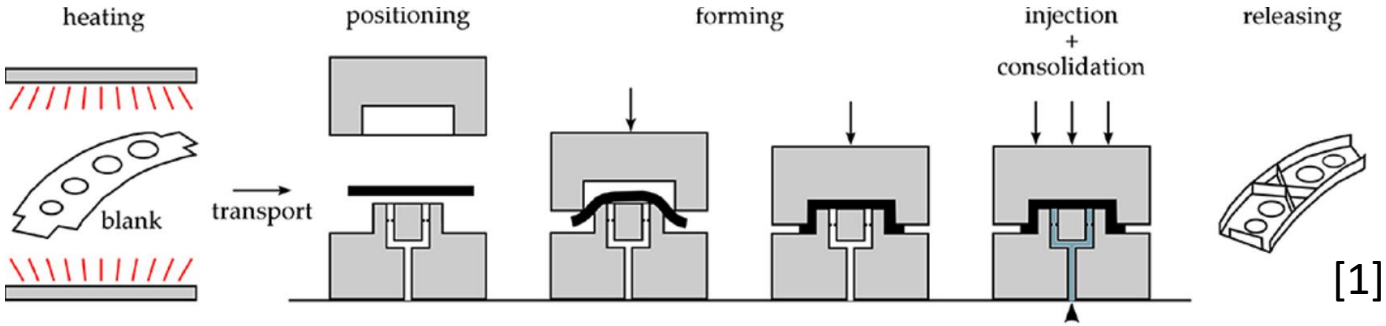
# Outline

- Thermoplastics & why
- Crystallisation kinetics of PEEK
- Creation of Kinetics model
  - Testing model with complex cooling tests
- Interface strength
  - Optimisation of sample design
- Future work

# Thermoplastics

- Use in new manufacturing techniques (e.g. additive manufacturing and over-moulding)
- Regenerated interfaces of high interest for thermoplastic composites
- Crystallisation is an important phase transition for thermoplastic processing

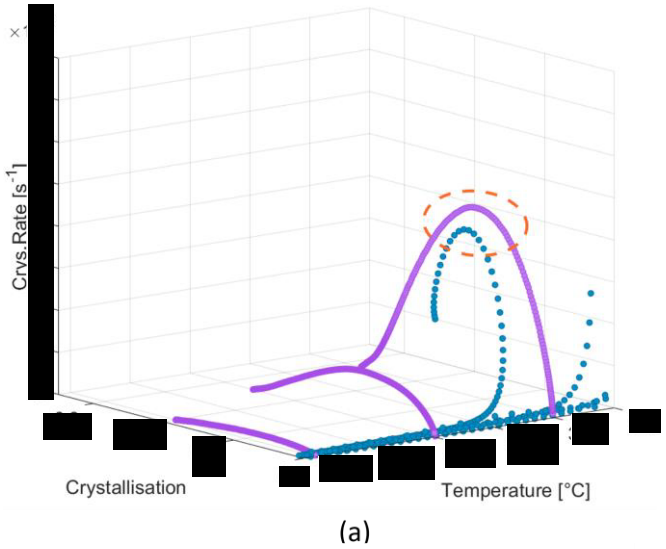


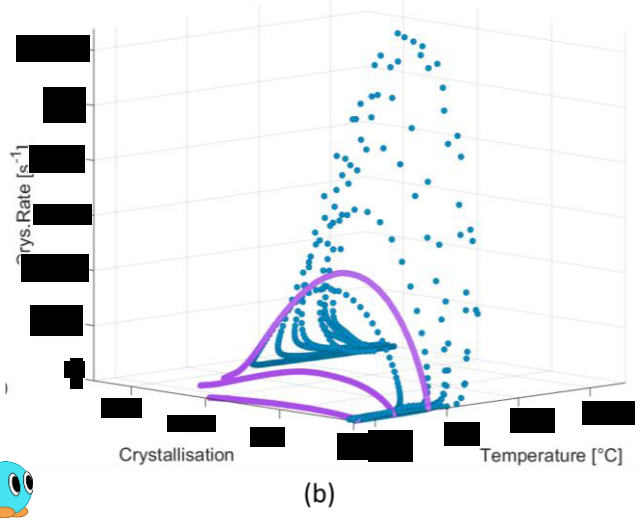




[1]

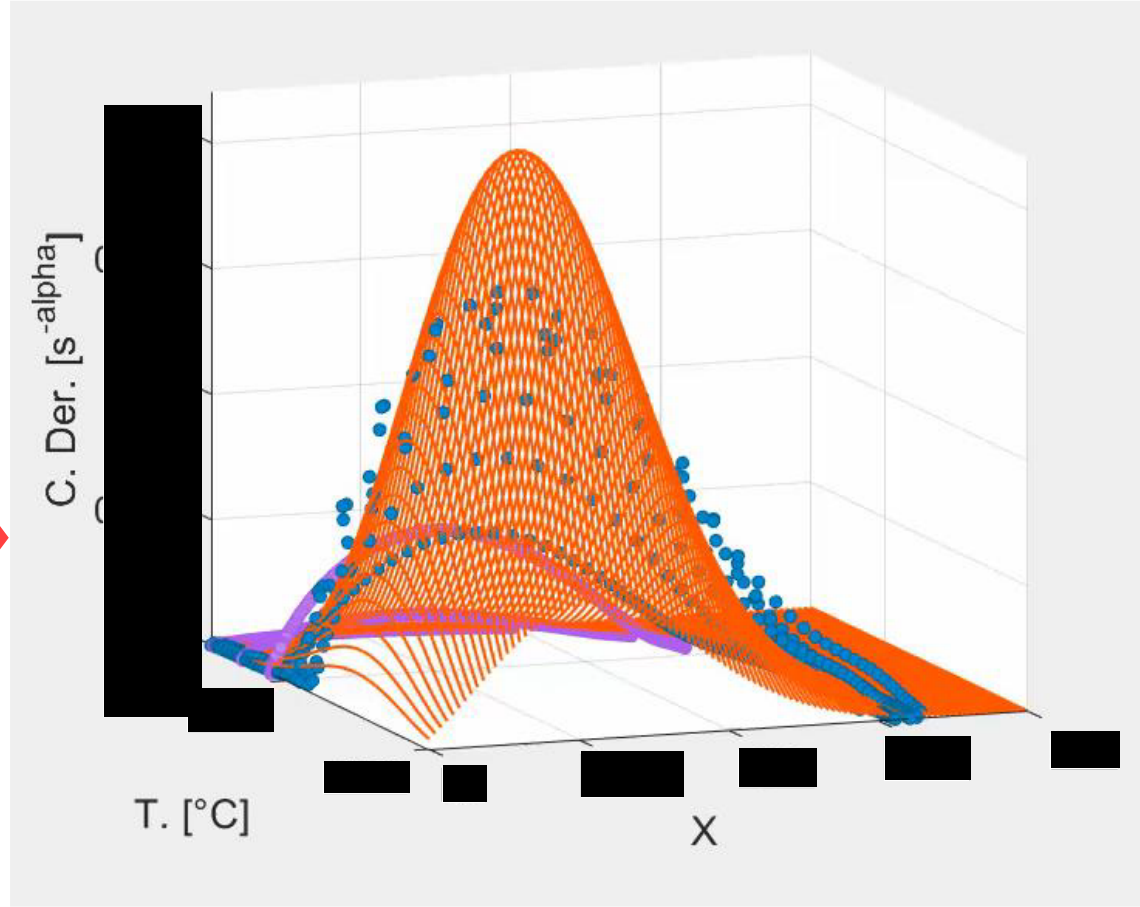
[1] R. Akkerman, M. Bouwman, and S. Wijskamp, 'Analysis of the Thermoplastic Composite Overmolding Process: Interface Strength', *Front. Mater.*, vol. 7, p. 13, 2020, doi: 10.3389/fmats.2020.00027.

# Thermoplastic Crystallisation Kinetics



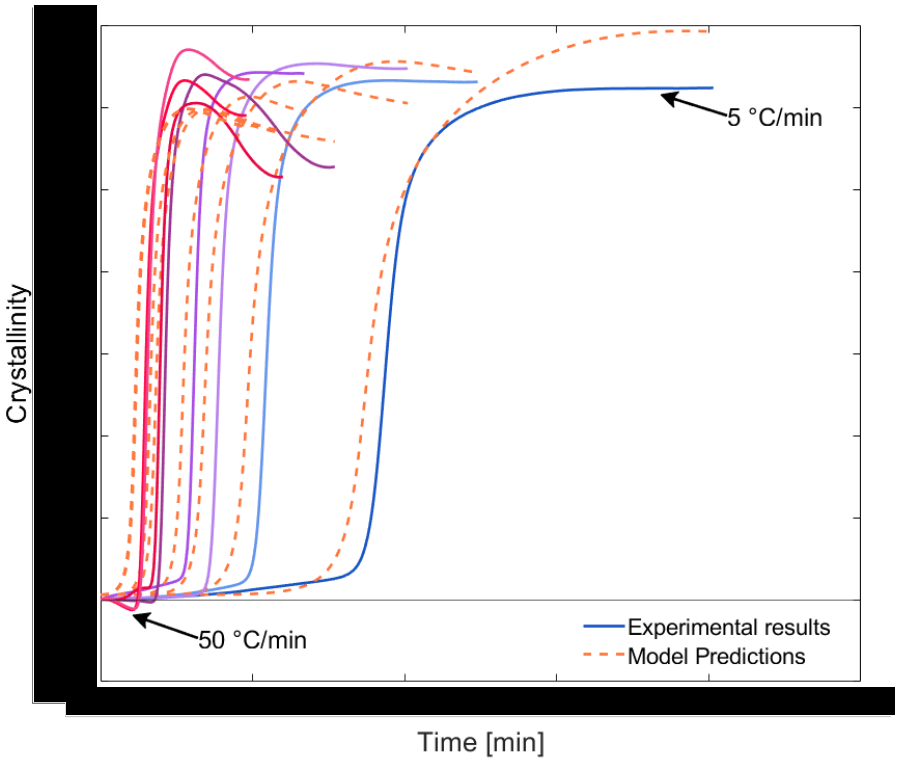




Fractional Differential Equations

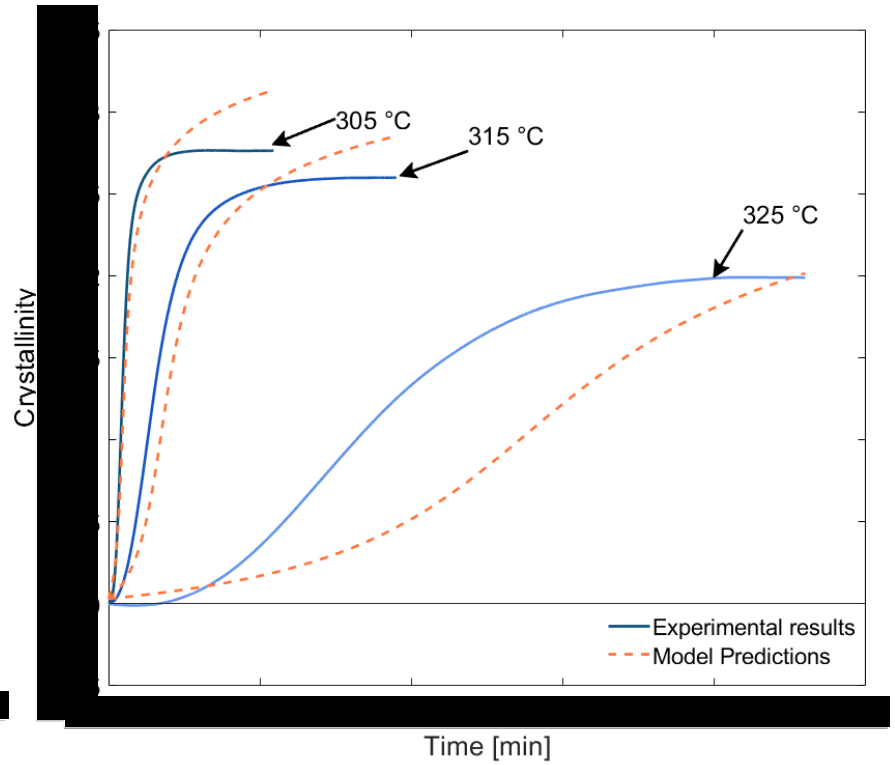



$$D^m X = k * (W_1(T) * W_2(X) * (1 - \mathrm{sech}(2T)))$$

# Fractional model results



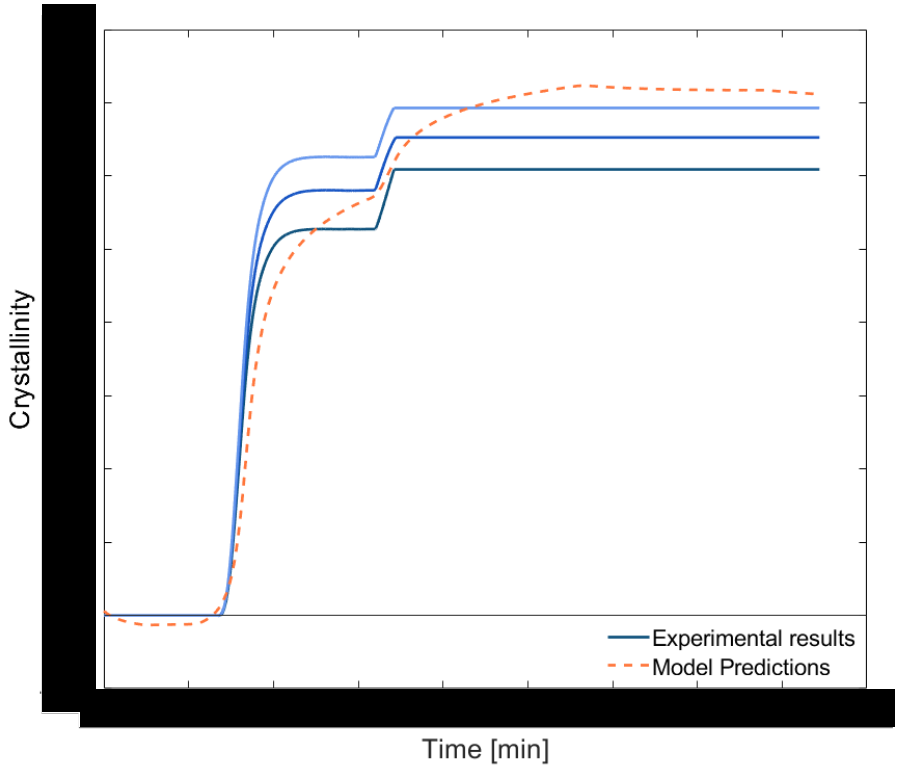

- Dynamic tests




- Isothermal tests

- Final crystallinity predictions within 5% error margin
- Limitations :
  - Sensitive to initial conditions
  - Thermal lag at higher temperatures
- Potential tool that can be adapted for other thermoplastics

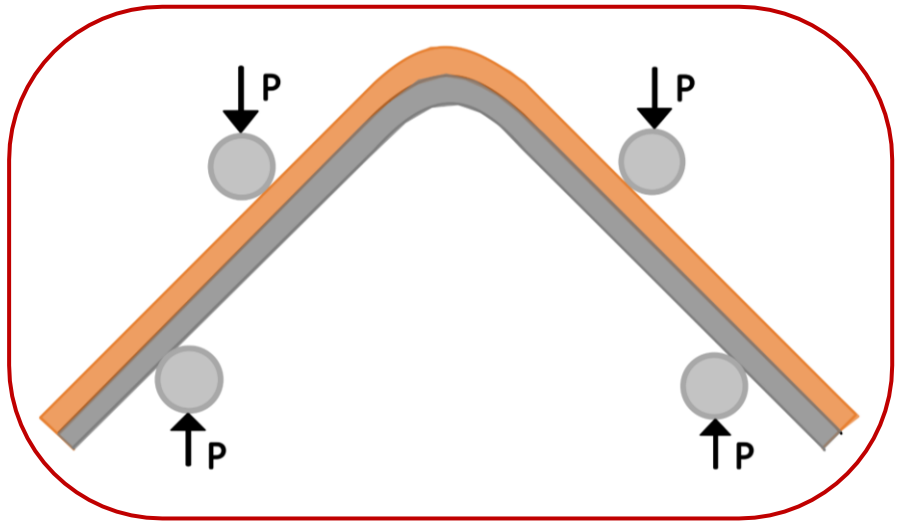
# Fractional model results




- Ramp Dwell Cool tests

- Final crystallinity predictions within 5% error margin
- Limitations :
  - Sensitive to initial conditions
  - Thermal lag at higher temperatures
- Potential tool that can be adapted for other thermoplastics

# Interface Strength - FEA



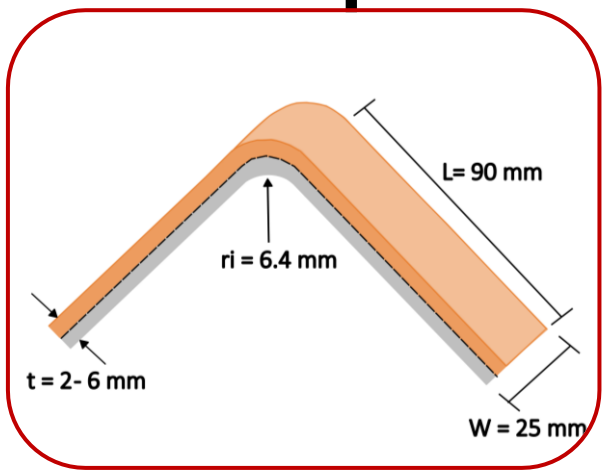

- No clearly established tests to examine ‘over-moulded’ interface
- Adaption of L-Shape curved beam test
- Optimisation of test design via Finite Element Analysis

- 4 possible failure modes can occur:
  - Brittle PEEK, Fibre failure, Composite delamination and Interface delamination
- Failure stresses will be normalised against the relevant strength values

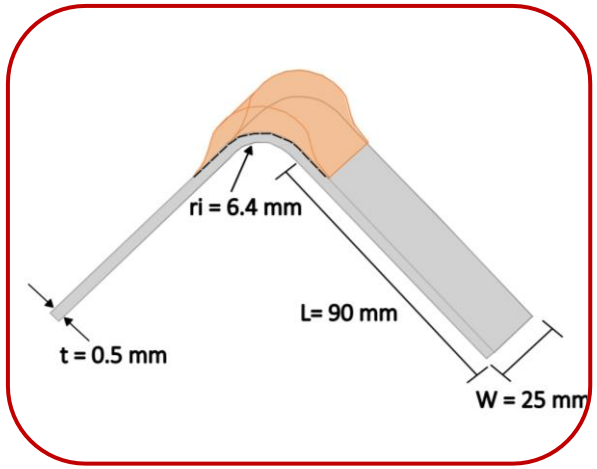
| Strength values | [MPa] |
|---|---|
| Unidirectional Strength of PEEK/CF | [redacted] |
| Transverse Strength of PEEK/CF | [redacted] |
| Critical Hydrostatic Tension of PEEK | [redacted] |
| Interface Strength of PEEK/CF | [redacted] |

[2] N. Yi, Y. Chen, J. Shen, R. Davies, and O. Ghita, ‘Correlation between interfacial bond strength and degree of healing in overprinting PAEK on CF/PAEK composites’, *Compos. Part Appl. Sci. Manuf.*, vol. 183, p. 108217, Aug. 2024, doi: 10.1016/j.compositesa.2024.108217

# L-Shape Configurations

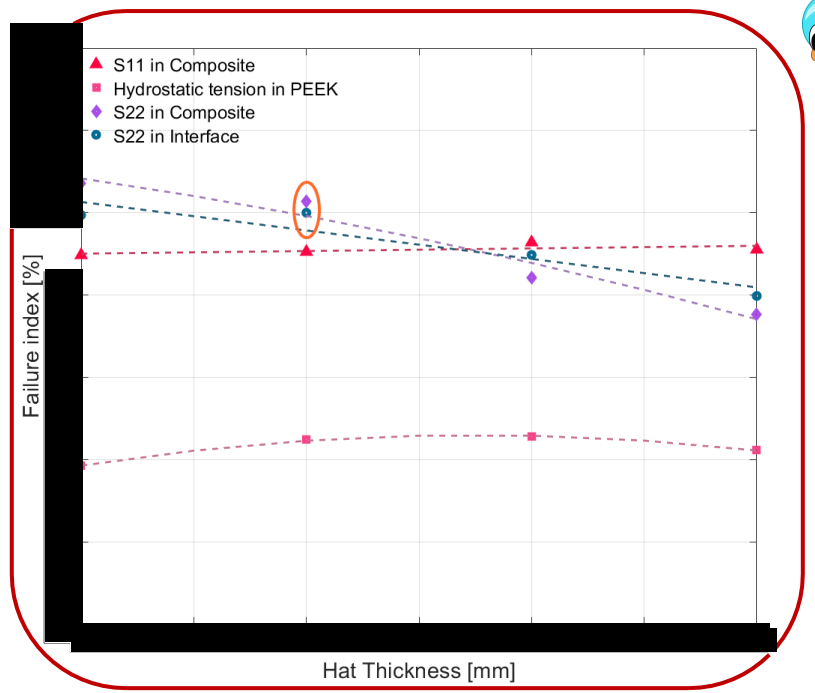



Bi-material

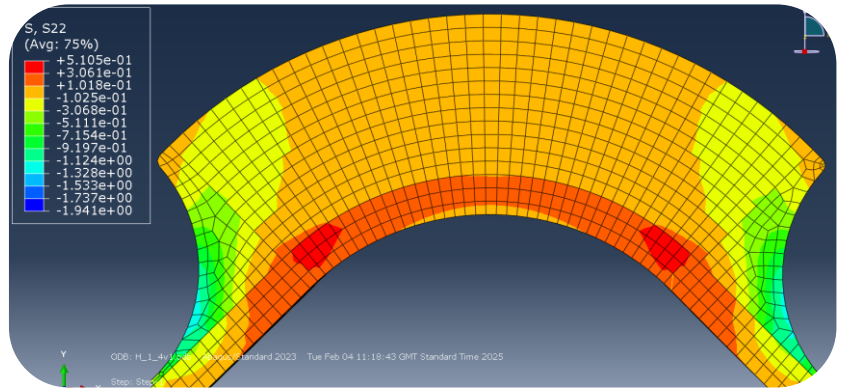



'Hat'

FEA iterative process



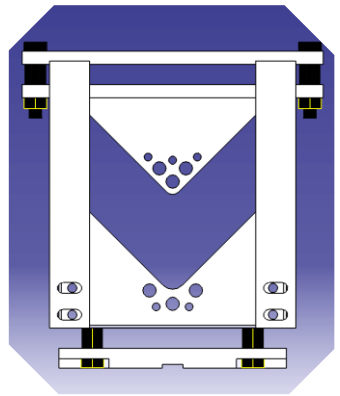

Compilation of the failure indices vs the PEEK 'hat' thickness using a UD thickness of 1 mm.

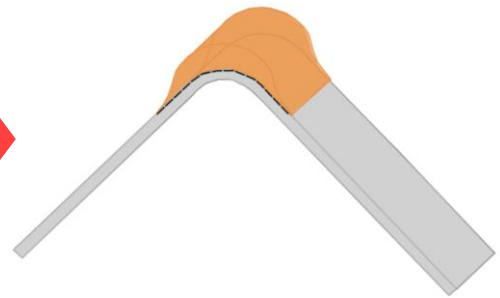


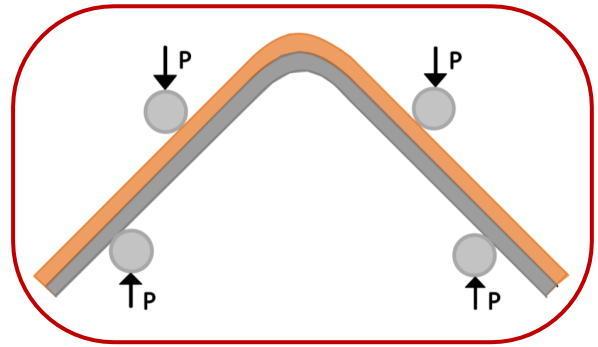
# Future work

- Manufacturing ‘Hat’ L-shape samples
- Testing their interface strength through a 4-point bend test

FDE Kinetics model → Crystallinity of interface







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# Thank you!

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