Extracting matrix creep parameters for modelling the consolidation of MCF composites

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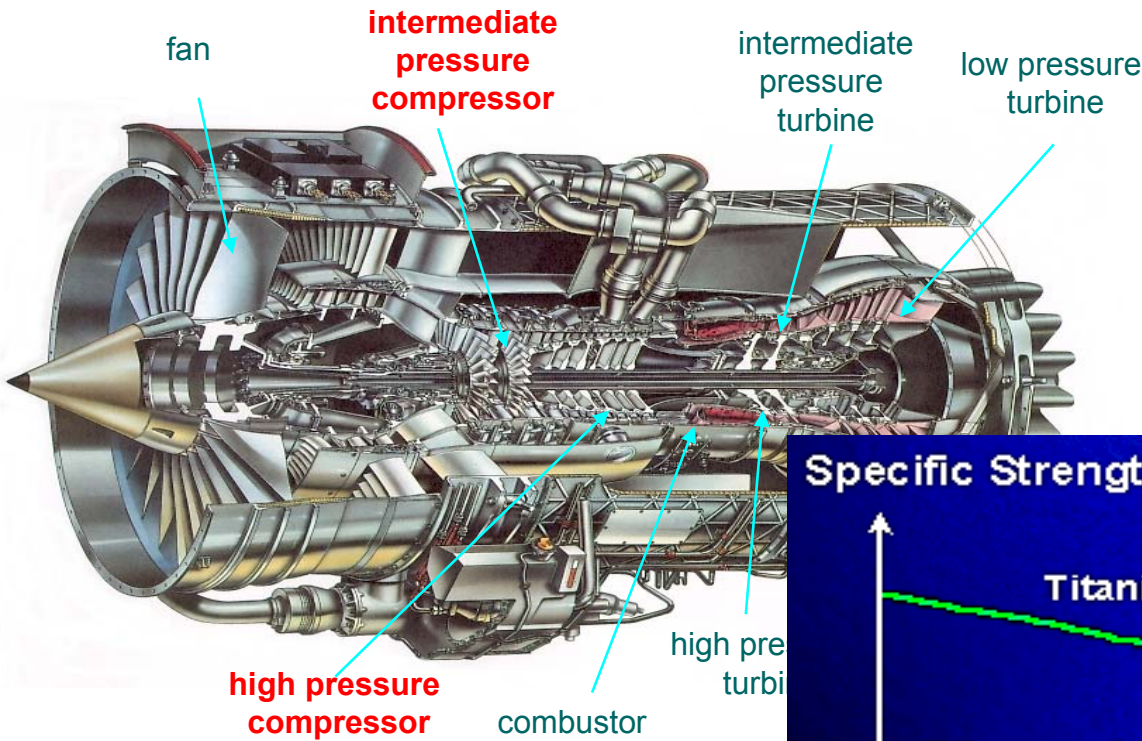
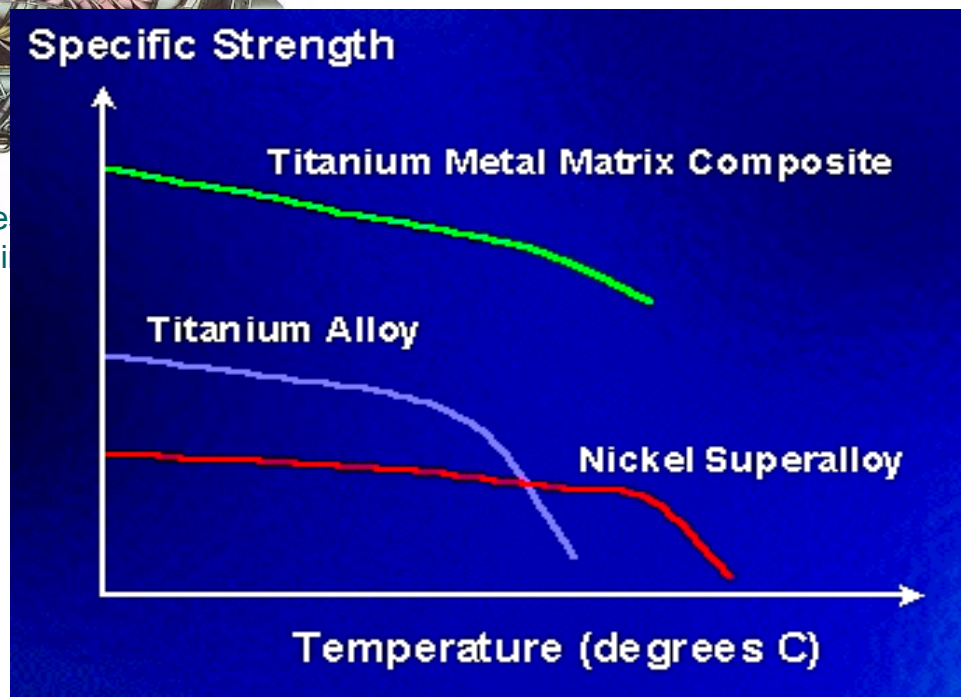
OUTLINE

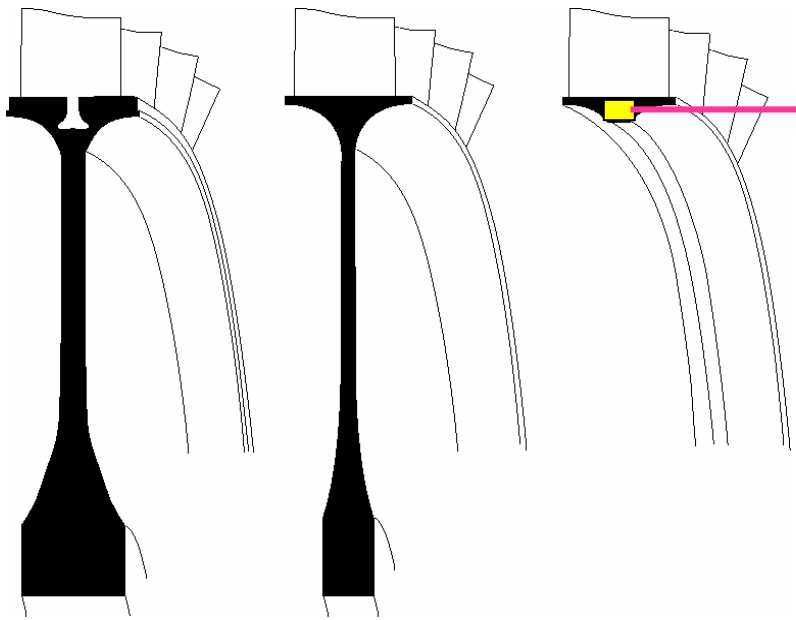
- **Background**
  - ***Matrix-coated fibres (MCFs)*** *approach*
- **FE modelling the *MCF* consolidation**
  - ***Matrix coating property***
  - ***Fibres arrangement***
- **Consolidating Ti-MMC with regular fibre arrangements**
- **Summary**

Aeroengine Materials





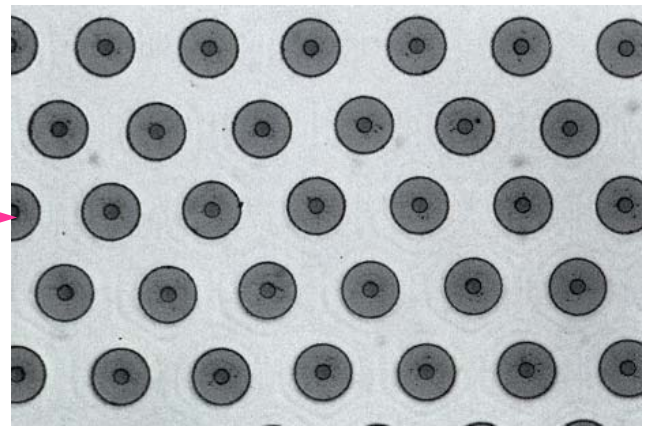
Application of Ti-MMCs



Current disk and blade arrangement

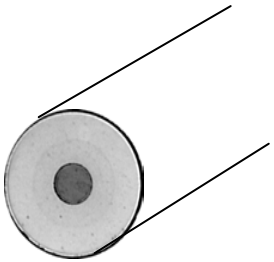
Bladed disk: BLISK. 50% weight saving

Bladed ring: BLING. 70% weight saving, but ring must be reinforced

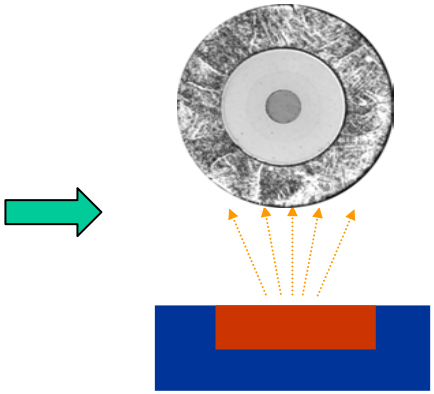


A demonstrator Ti MMC BLING ~20cm in diameter.

Ti-MMCs Manufacture -- *MCF method*

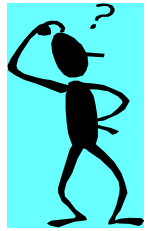


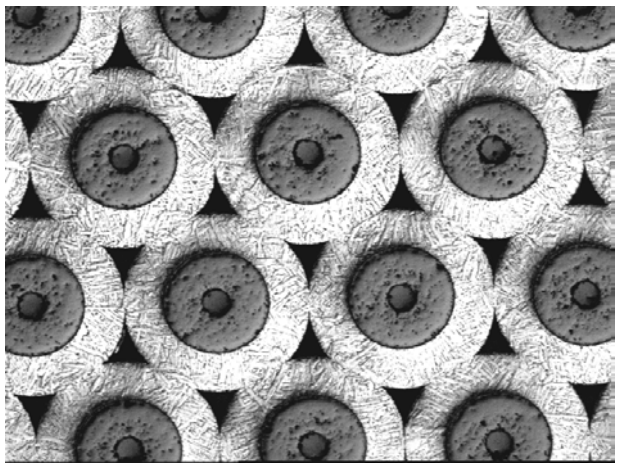
SiC fibre



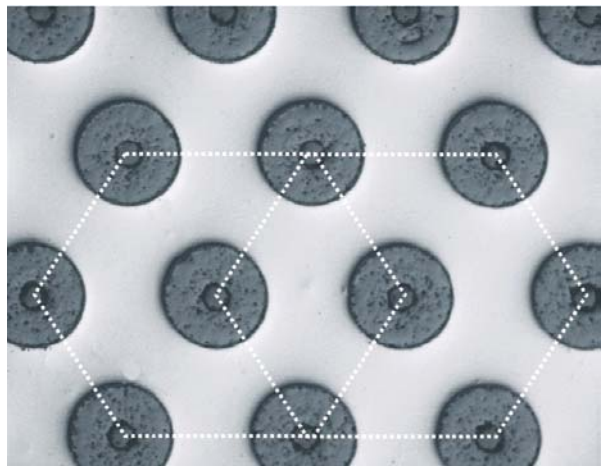
vapour coated with matrix alloy

Matrix coated fibre (MCF)





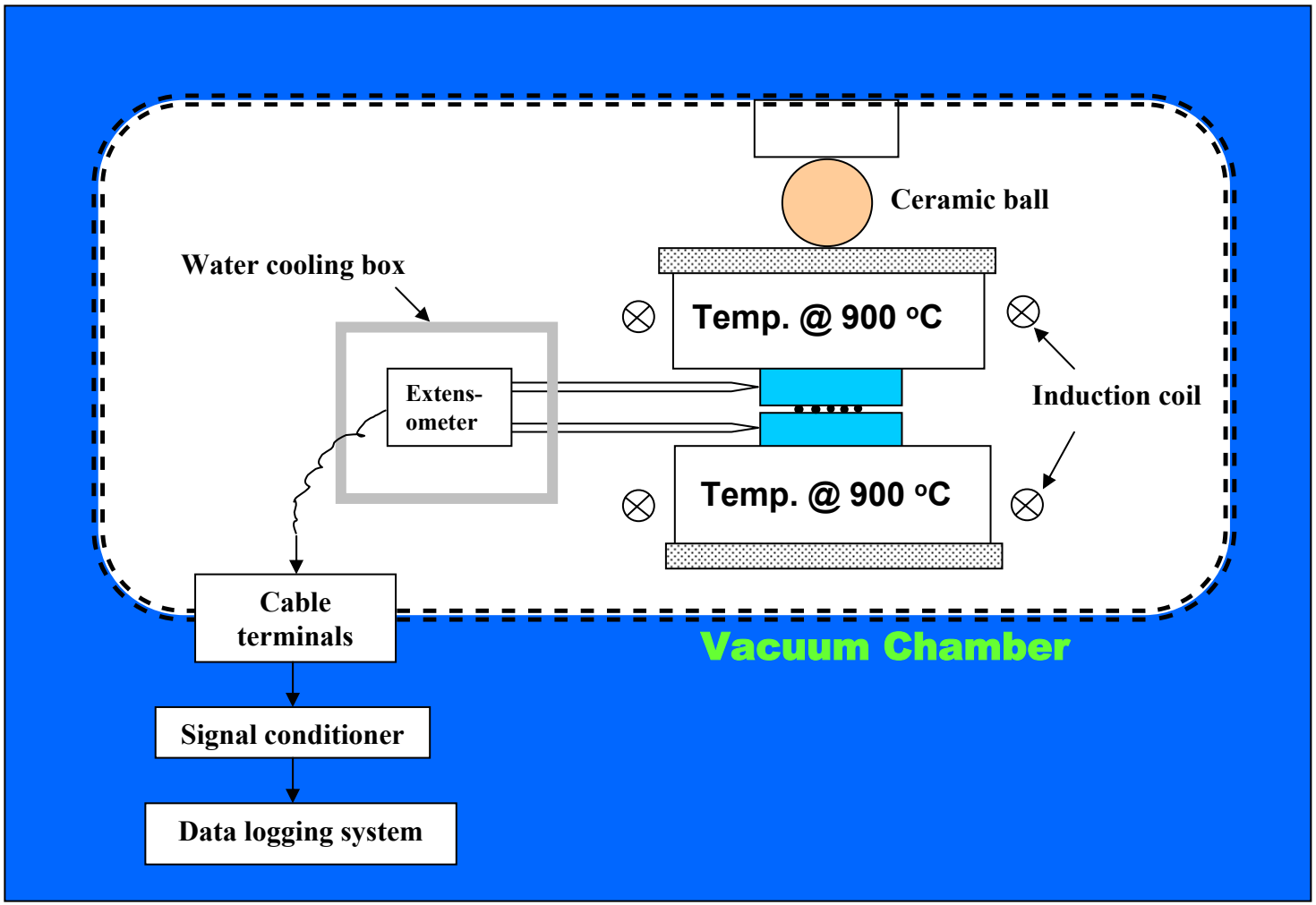
HIPing / VHPing



Finished composite

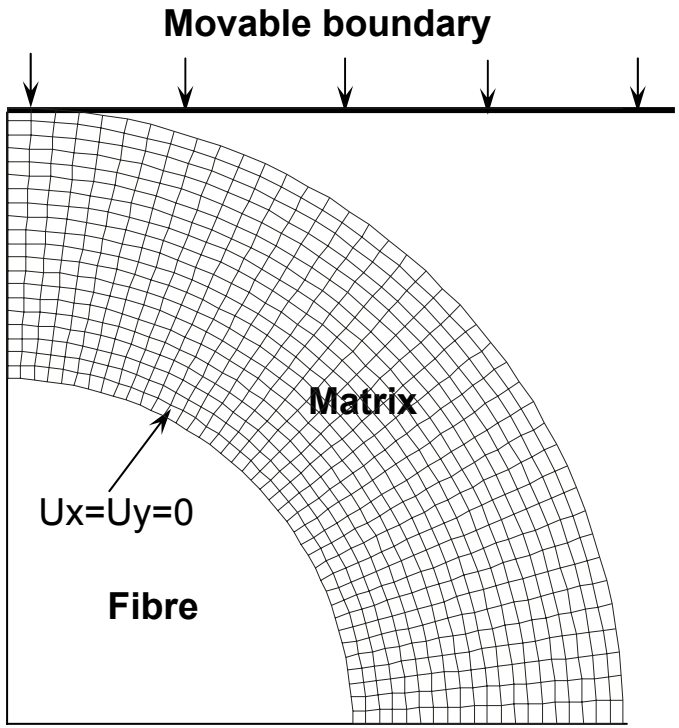
Compression Testing on Single MCF

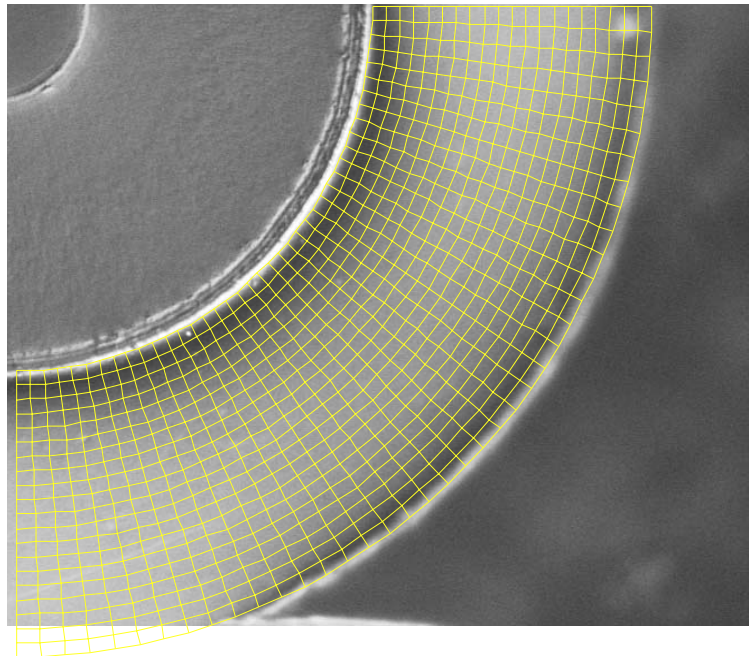
Matrix property



FE Model for Compression Testing

Matrix property



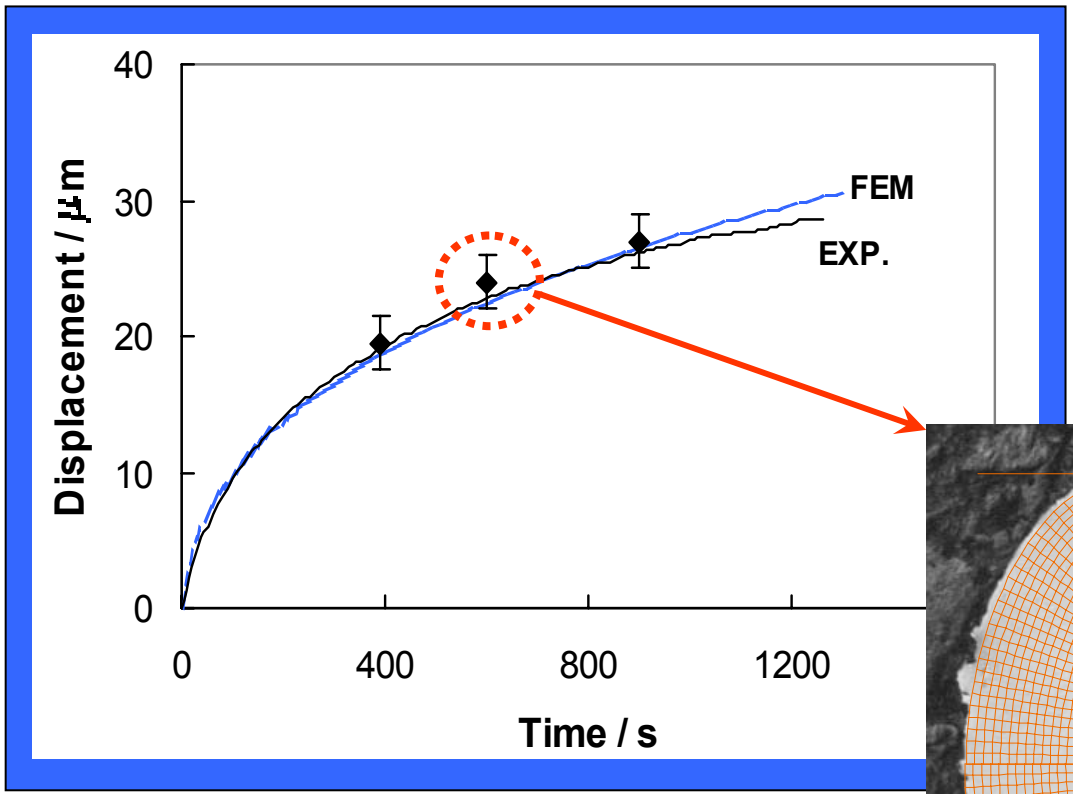


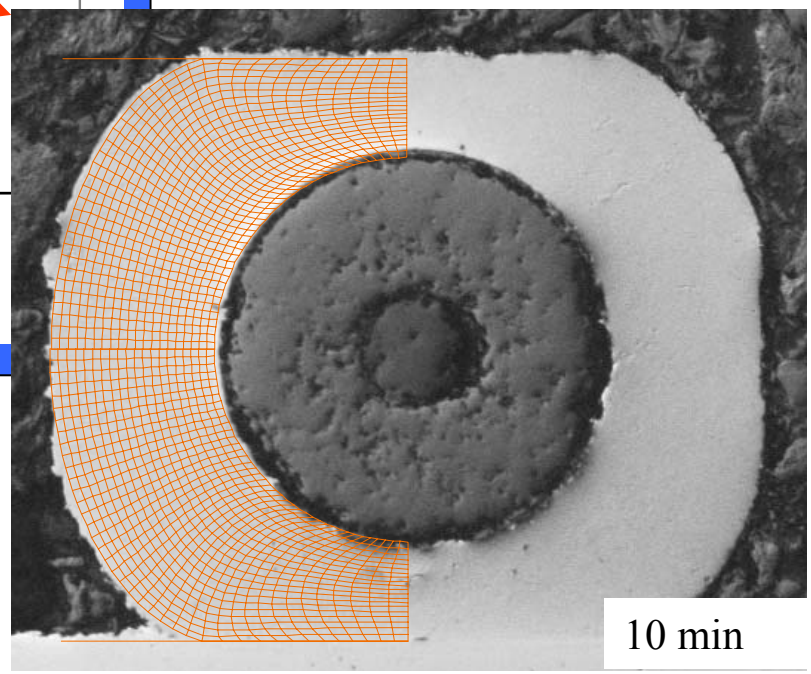
A & n in power-law creep (PLC):

$$\dot{e} = A\sigma^{n}$$

Best-fitting & Geometry Comparison

Matrix property



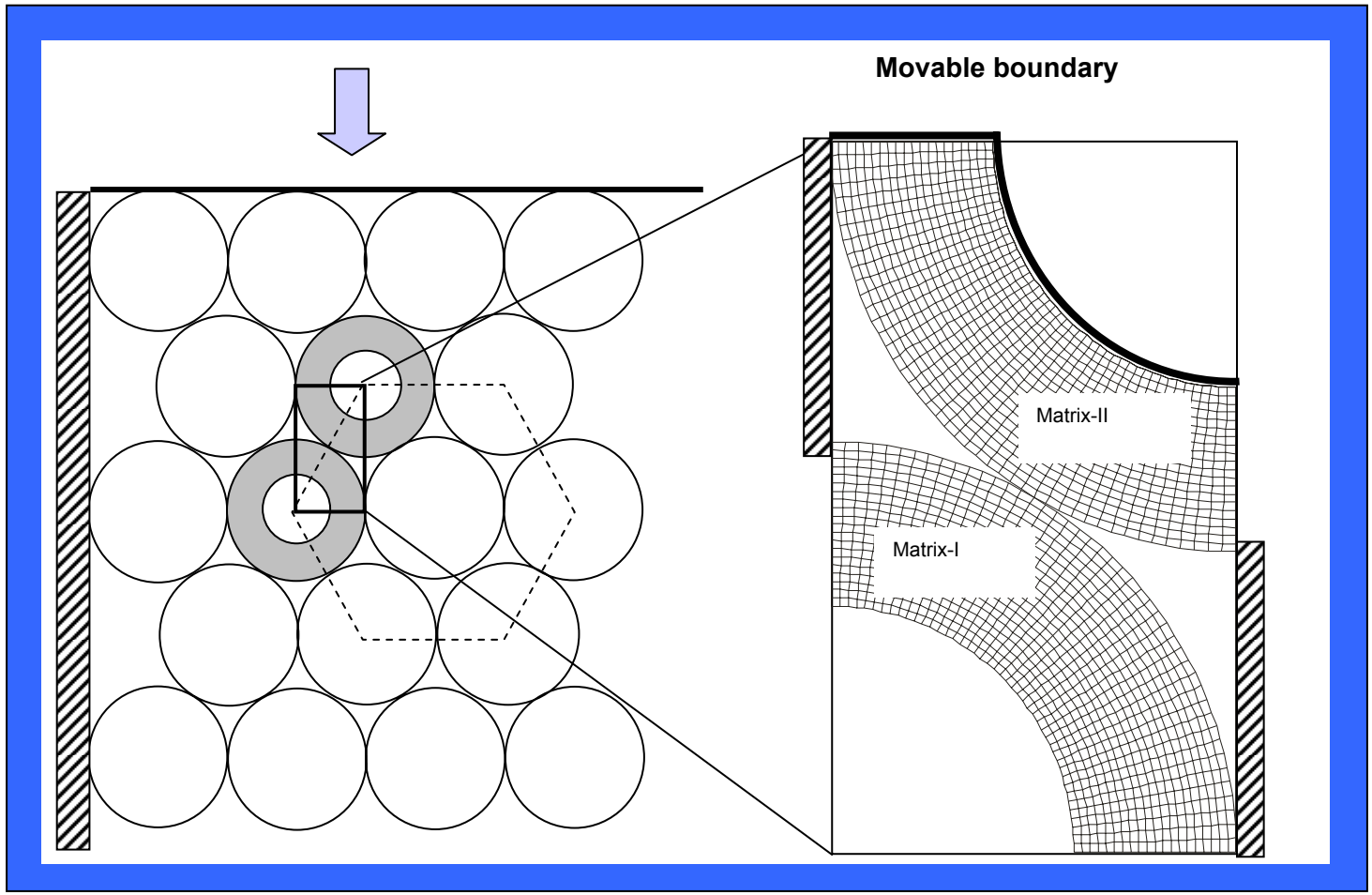


Optimum A & n

Consolidation Process Simulation

--*Hexagonal array*

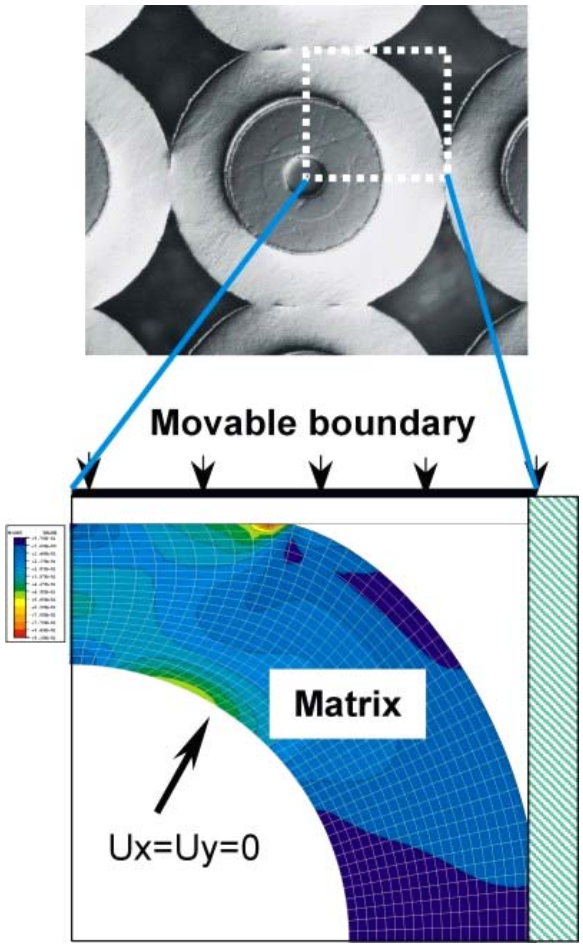
FE modelling

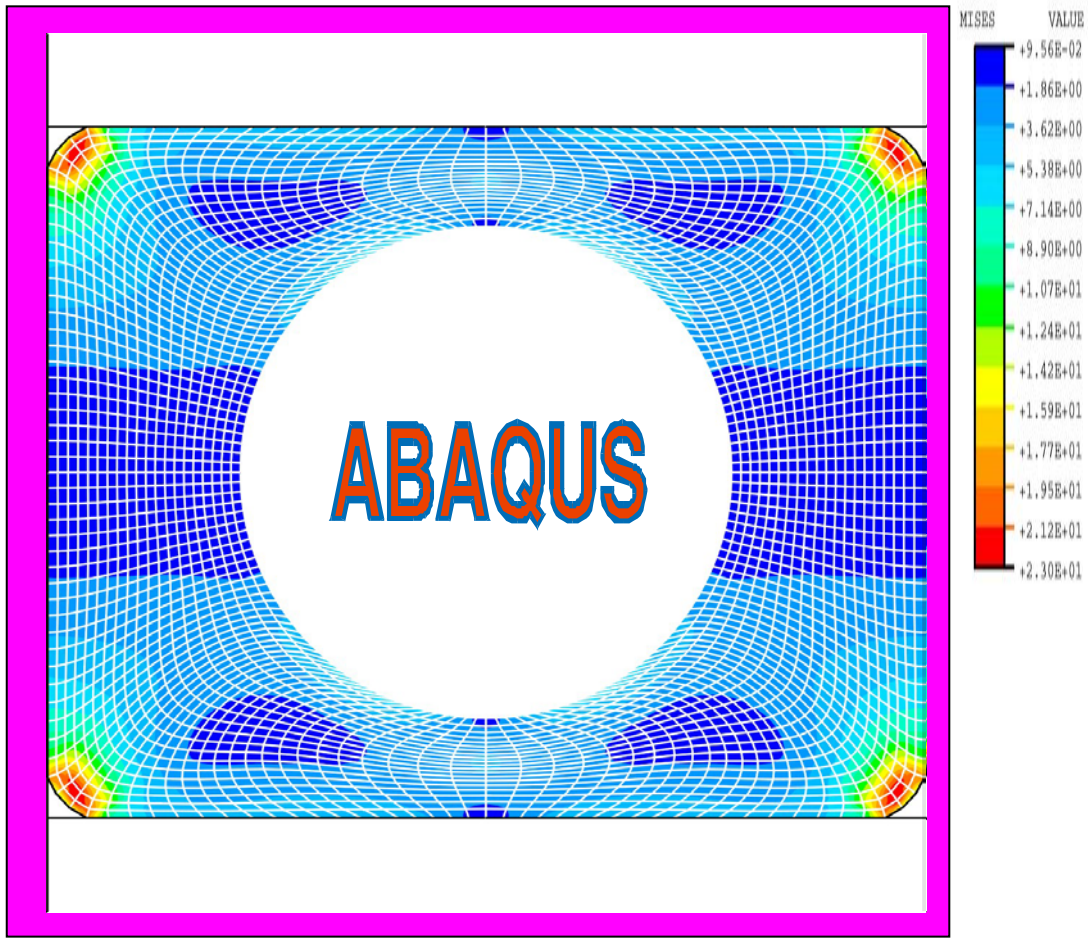


Consolidation Process Simulation

--*Square array*

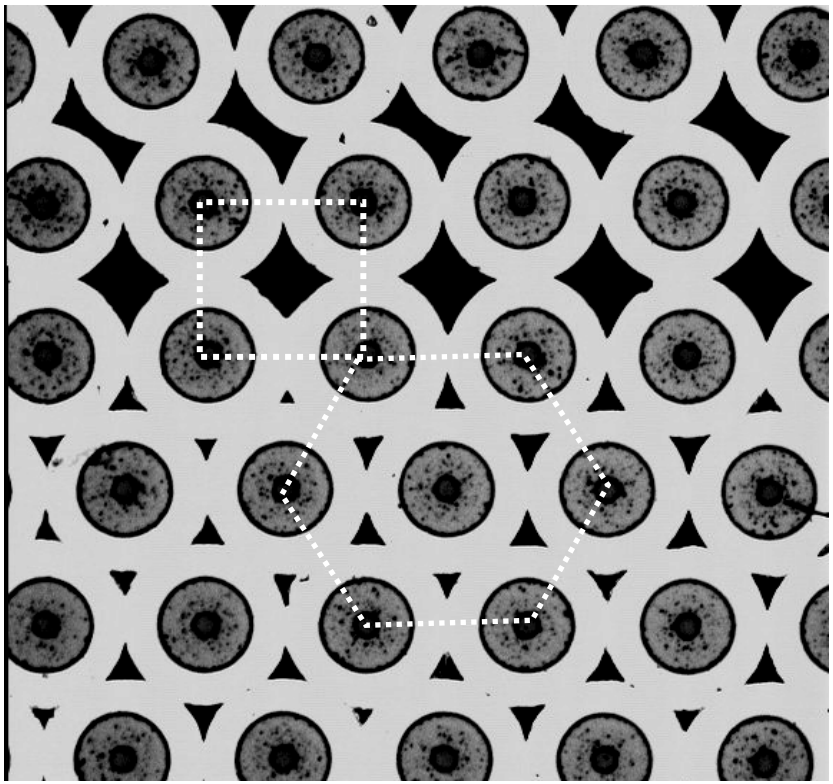
FE modelling

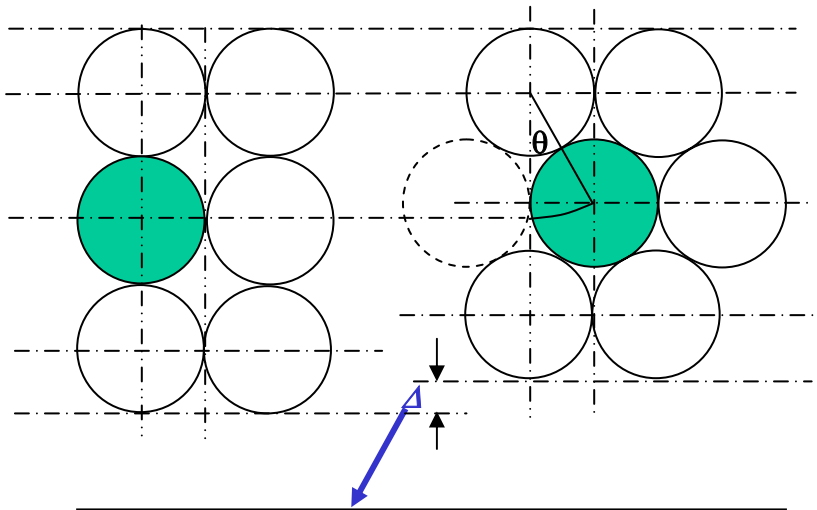




Effect of Fibre Re-arrangement

Fibre Array





Vertical displacement:

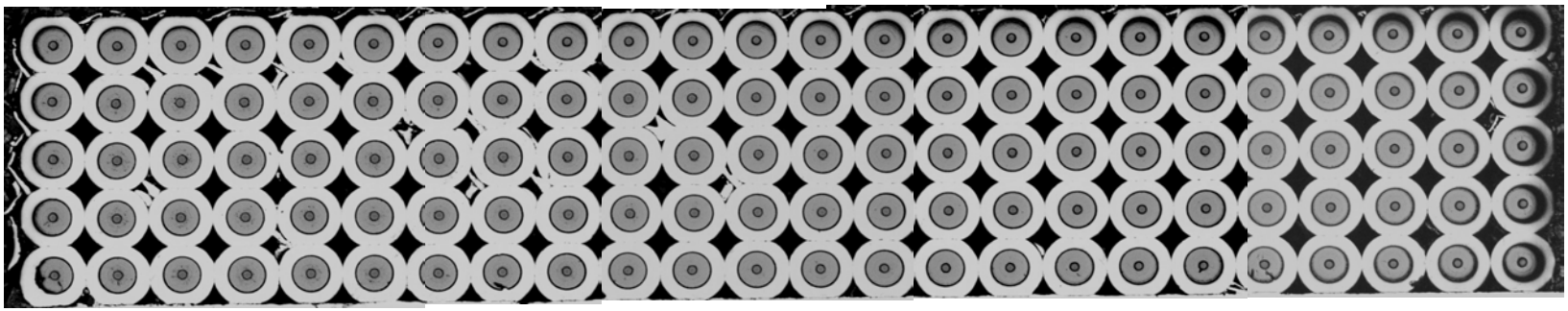
$$\Delta = D\,(N-1)\,(1-\cos\theta)$$

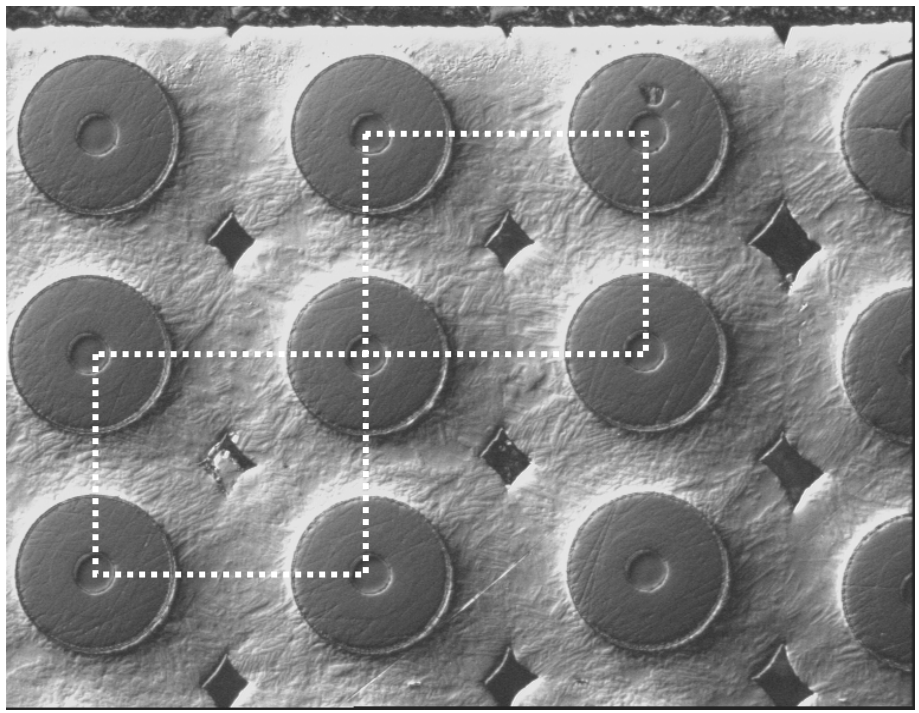
N-- number of layers,
D-- fiber diameter.

Control of fibre arrangement in experiments

SQUARE Fibre Arrangement

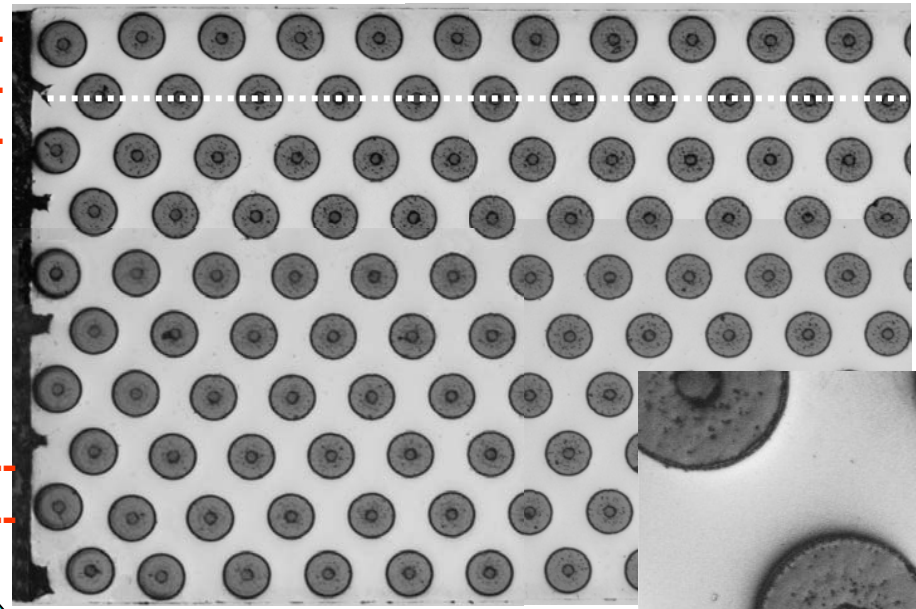
Fibre Array



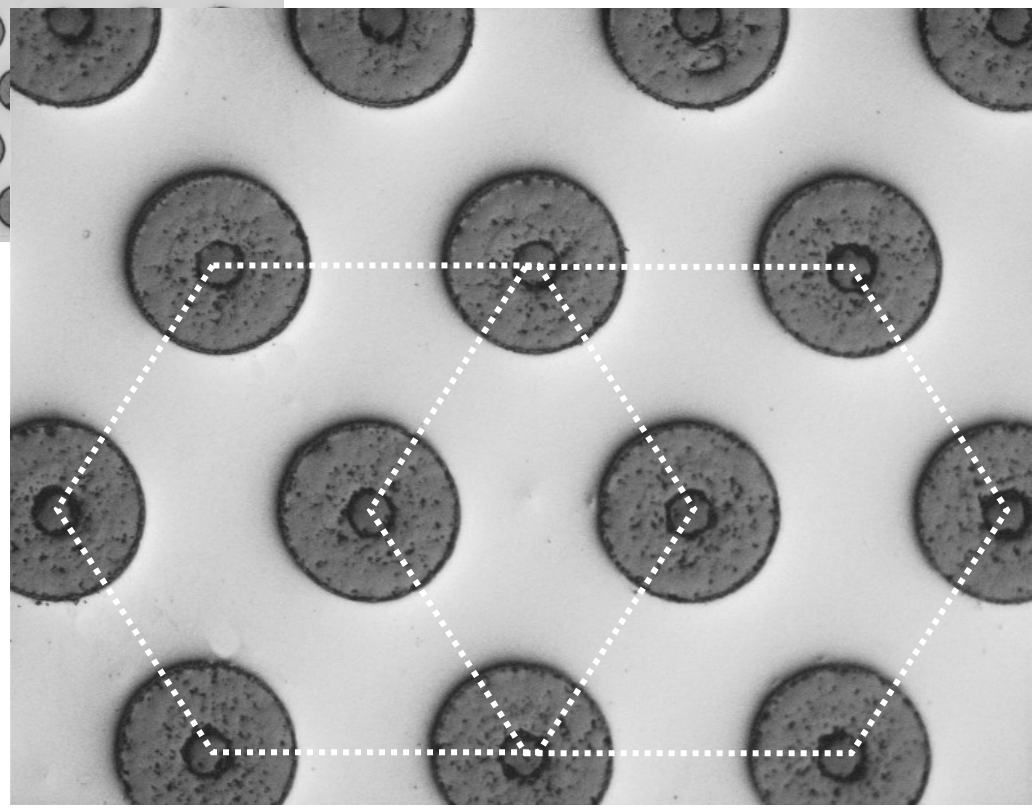


HEXAGONAL Fibre Arrangement

Fibre Array

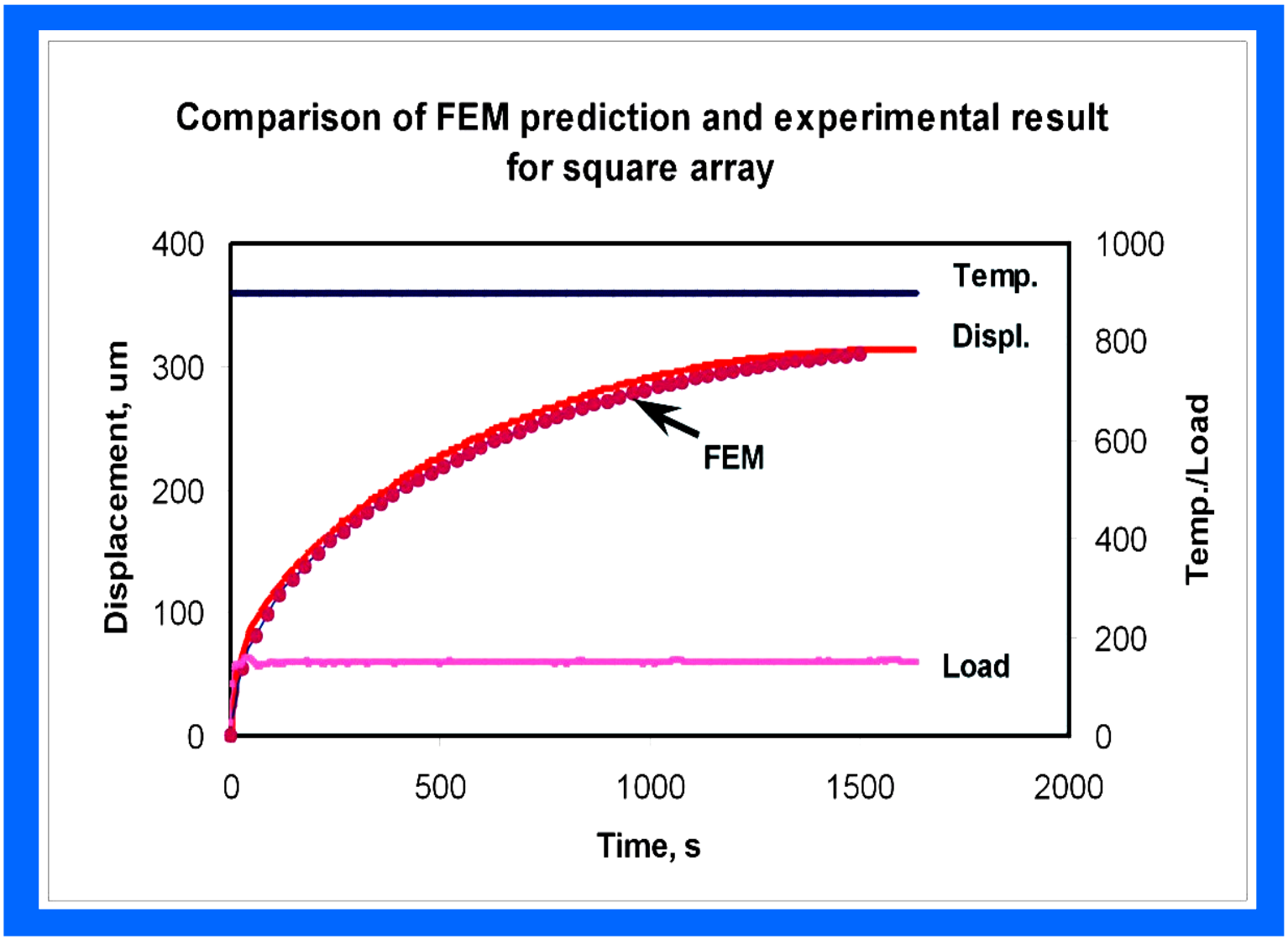


Number of fibres in each layer



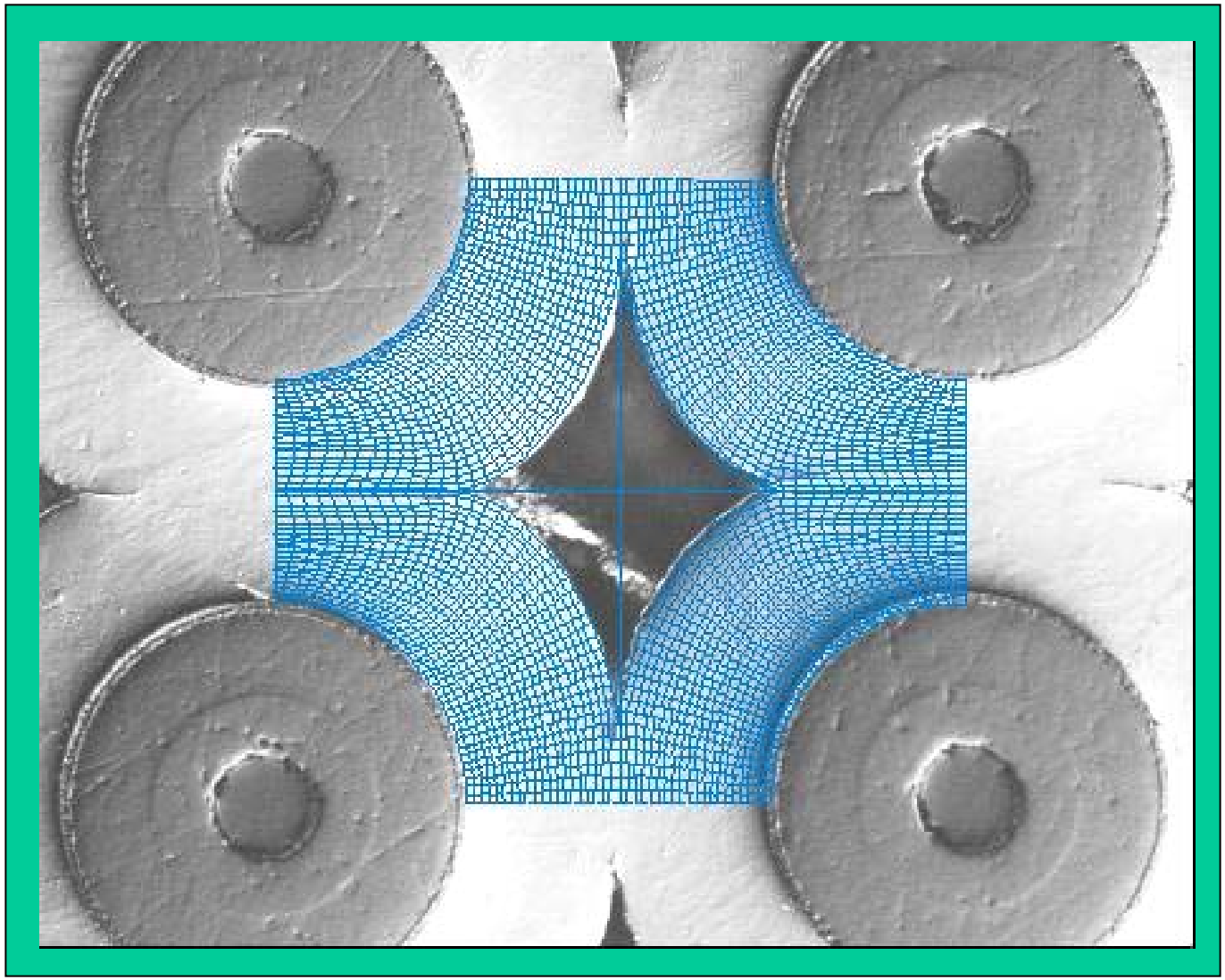
Densification Behaviour (Exp. vs FEM)

Fibre Array



Densification Behaviour (Exp. vs FEM)

Fibre Array



Densification Behaviour (Exp. vs FEM)

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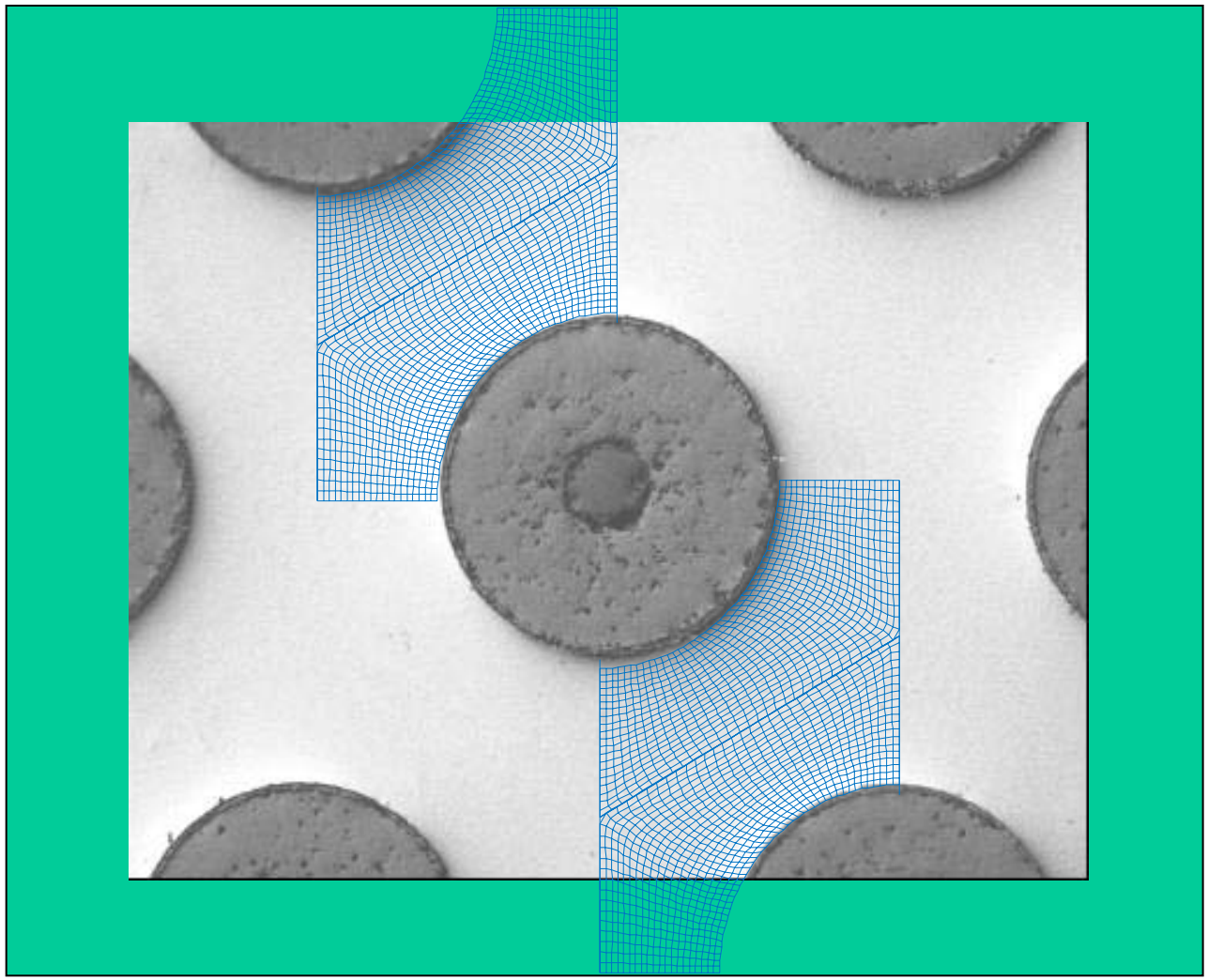
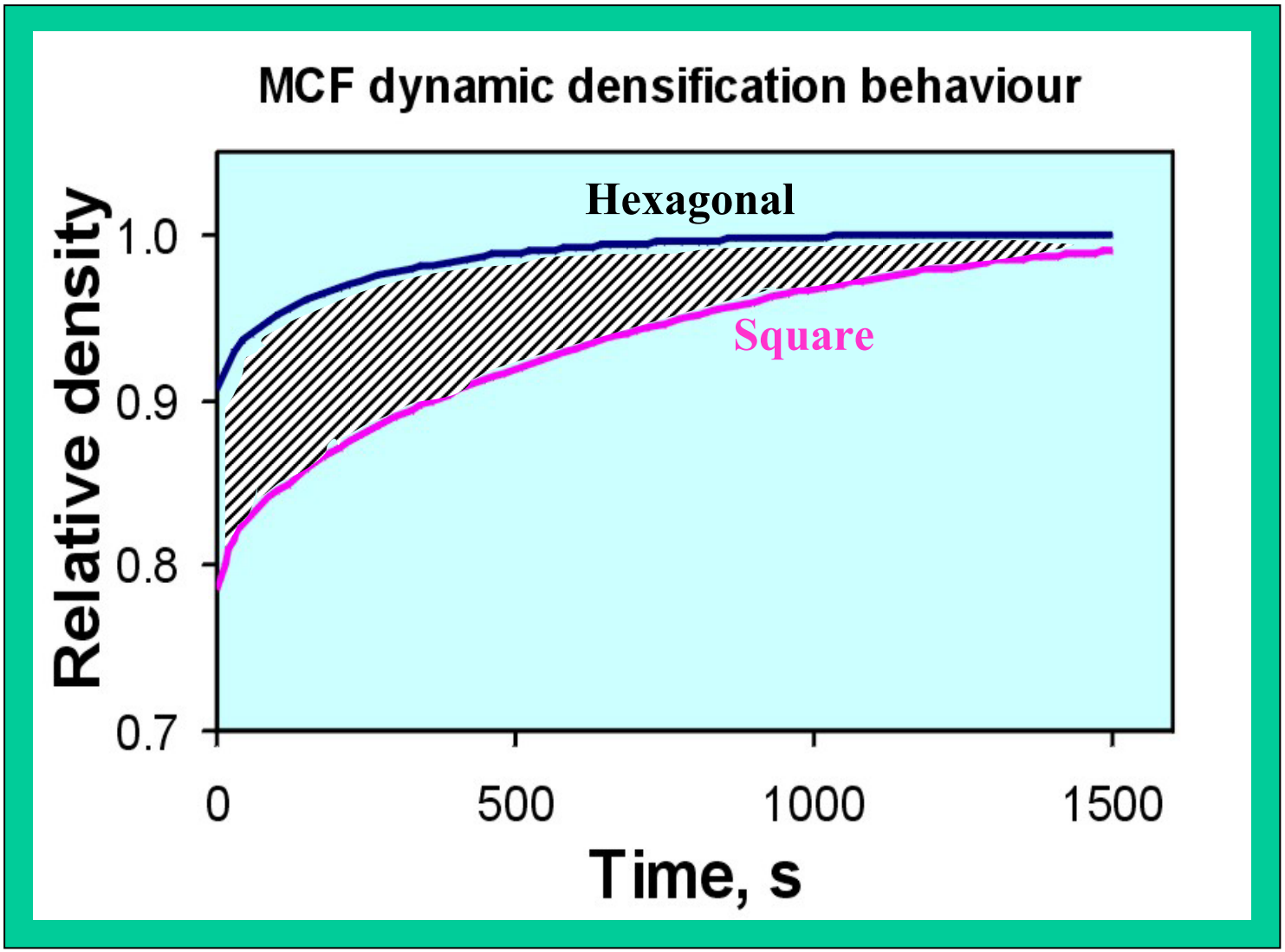


MCF Dynamic Densification Behaviour



Summary

- Matrix coating properties were extracted by *coupled experimental and FEM studies on single MCF.*
- FE models have been developed to simulate the MCF consolidation processes.
- Fibre arrangement has been carefully controlled to provide meaningful comparison with FEM predictions.
- **Novel test methods and predictive modelling are helping Rolls-Royce to develop manufacturing processes for aero-engine components.**