TESTS TO MEASURE THE MATERIAL PROPERTIES RELEVANT TO THE MODELLING OF PROCESS INDUCED DEFORMATIONS IN COMPOSITE PARTS

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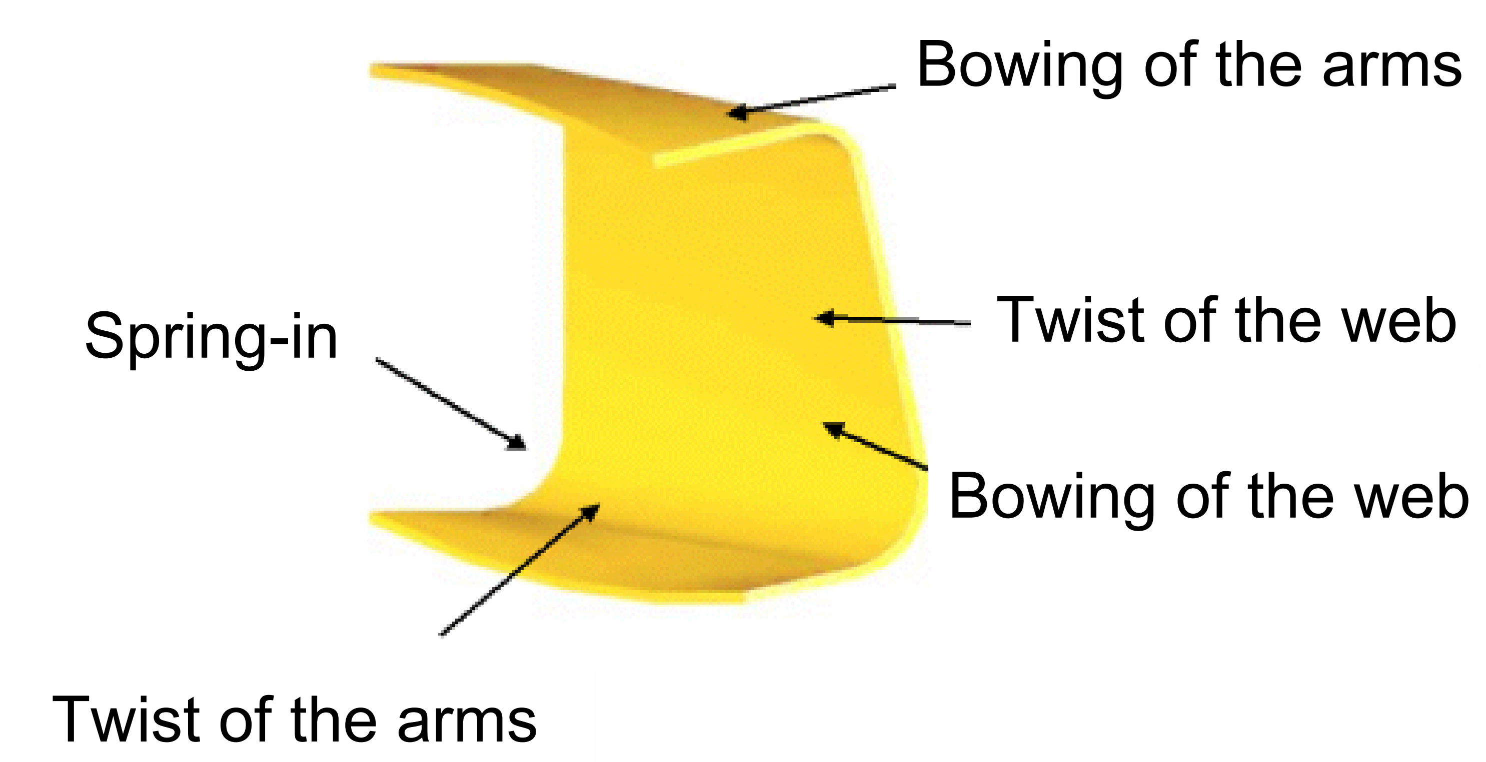
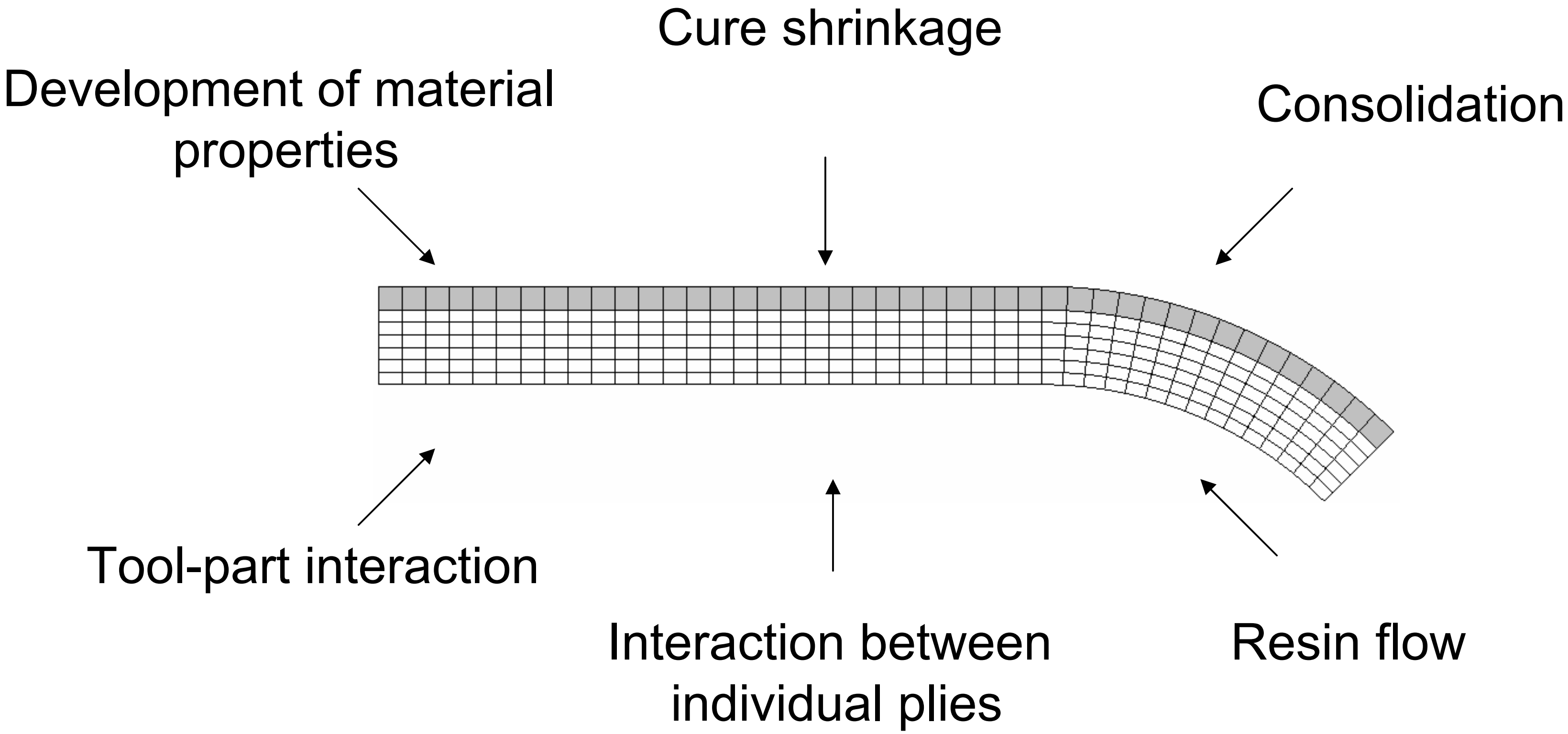
Outline:

- Introduction to process induced distortions
- The Development of the Degree of Cure
- Frictional Stresses Between the Tool and the Composite
- The Development of Cure Shrinkage During the Cure
- Conclusions

Stresses that arise during the cure can cause significant distortion of polymer matrix composite structures



A successful model of process induced distortion requires good understanding of material behaviour throughout the cure cycle



The Development of the Degree of Cure and the Glass Transition Temperature

Material:

The prepreg used in this study is a unidirectional carbon/epoxy, produced by Hexcel Composites designated as **AS4/8552**

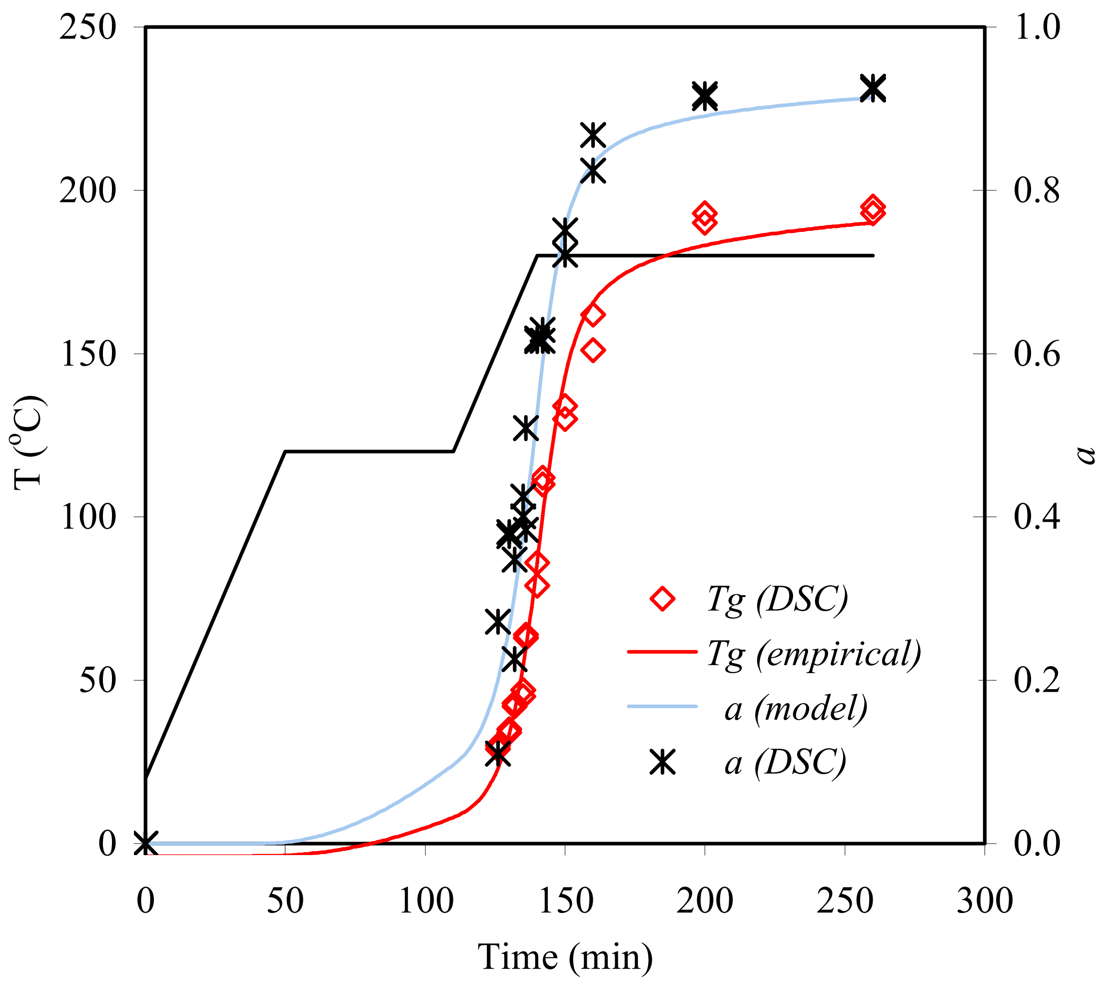
The nominal thickness of the prepreg was given as 0.250 mm

The development of the degree of cure, α, was modelled using the cure kinetics model proposed by Cole

$$\frac{d\alpha}{dt} = \frac{K\alpha^{m}(1-\alpha)^{n}}{1+e^{C[(\alpha-\alpha_C)]}}$$

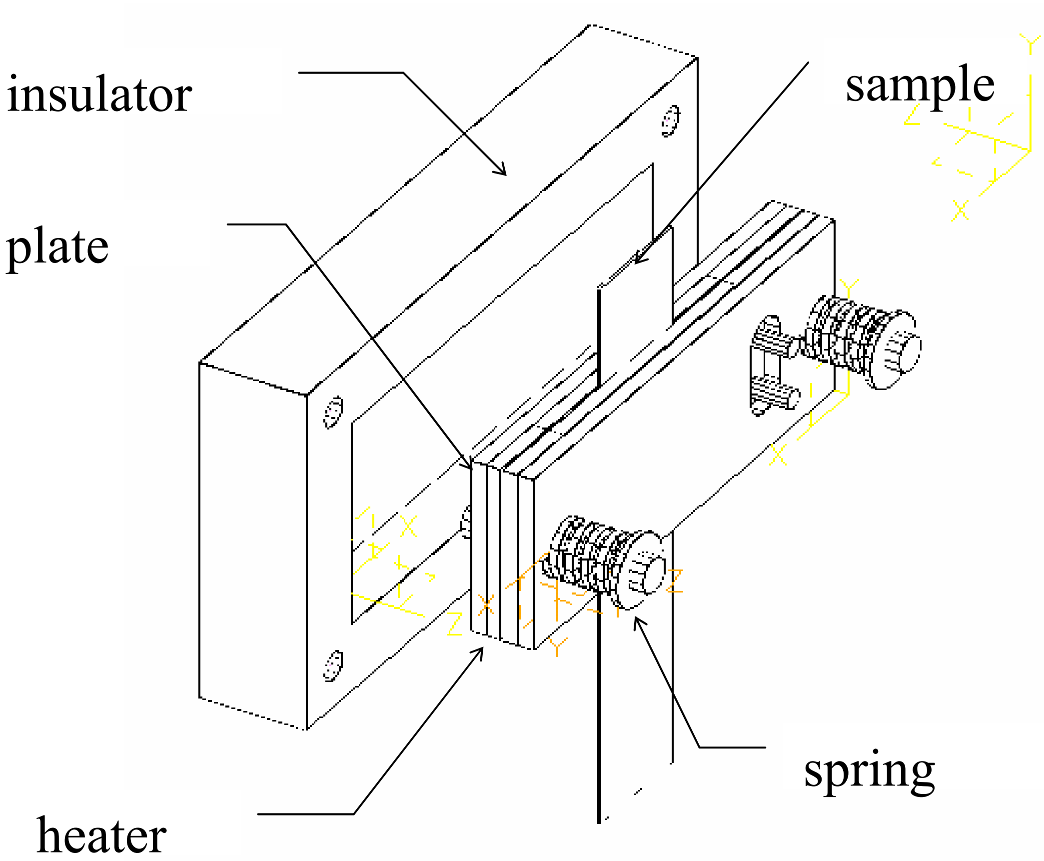
The constants of the model were calculated by QinetiQ using dynamic DSC tests performed in a TA Instruments DSC 2920.

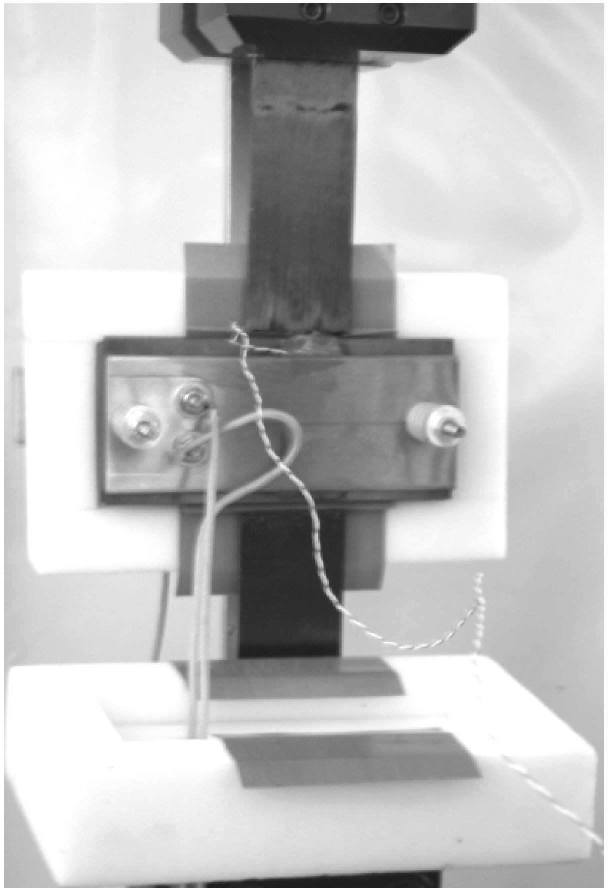
Cure kinetics model predictions for degree of cure plotted versus time throughout the cure cycle



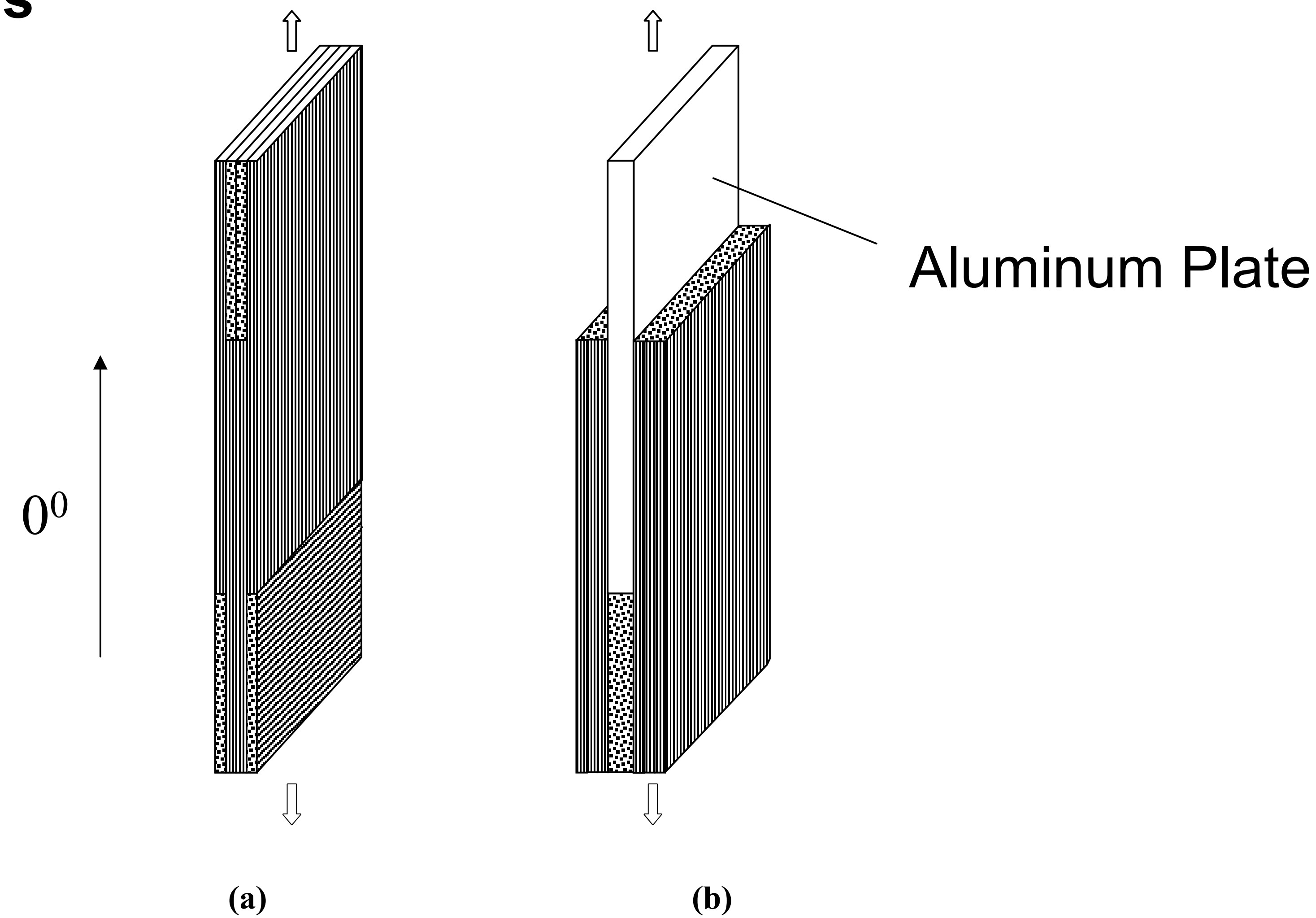
Gel point and the Frictional Stresses Between the Tool and the Composite

Ply Pull-Out Testing Setup

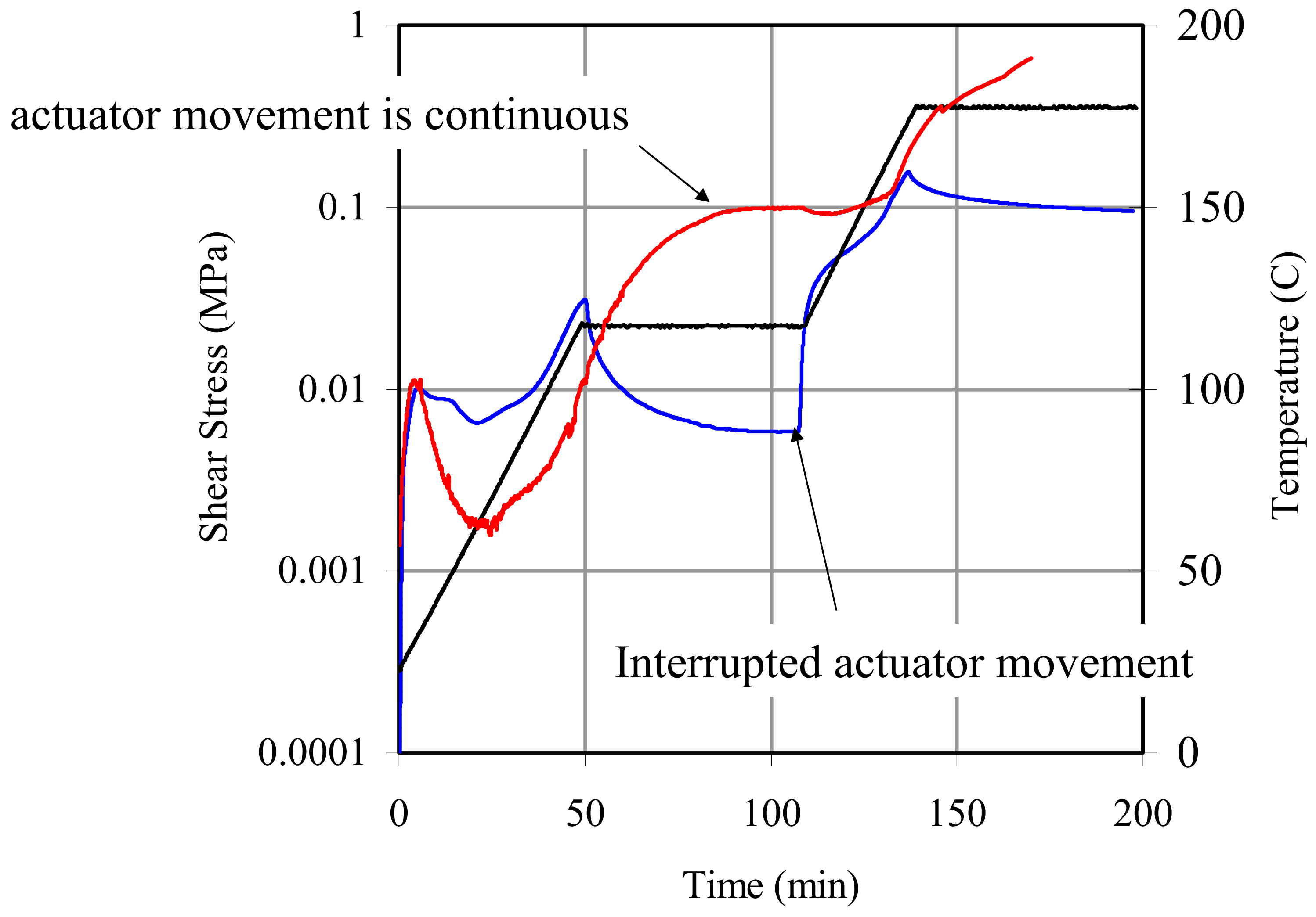




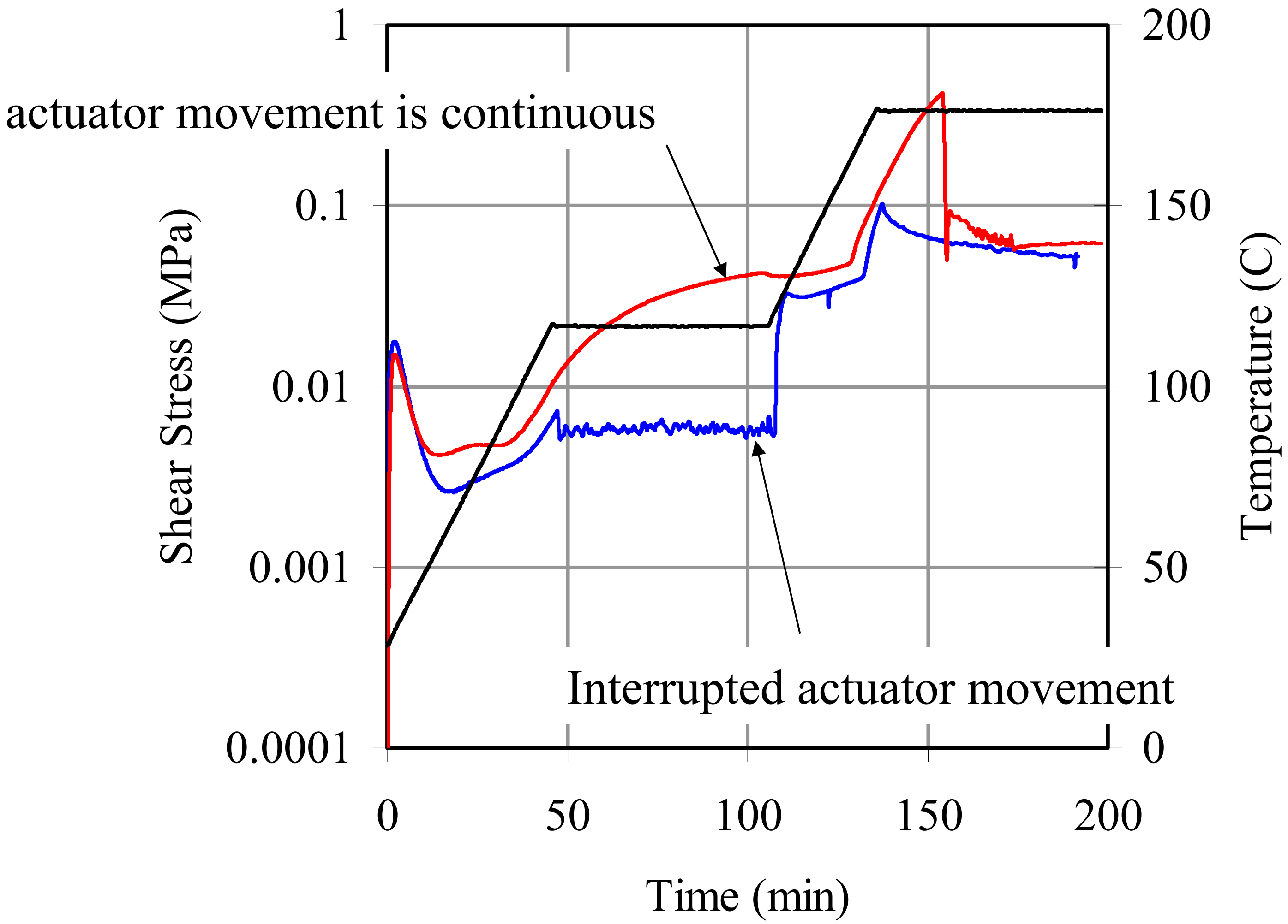
Specimens



Inter-ply shear stresses during the MRCC

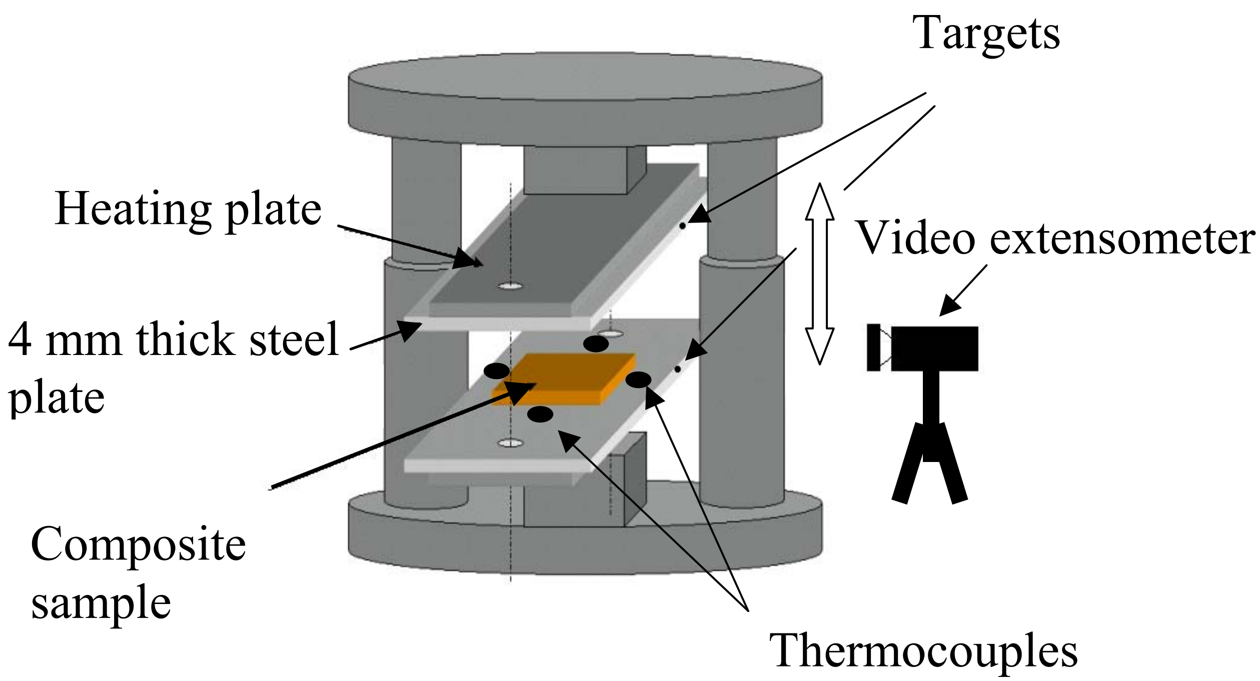


Tool interaction shear stresses during the MRCC



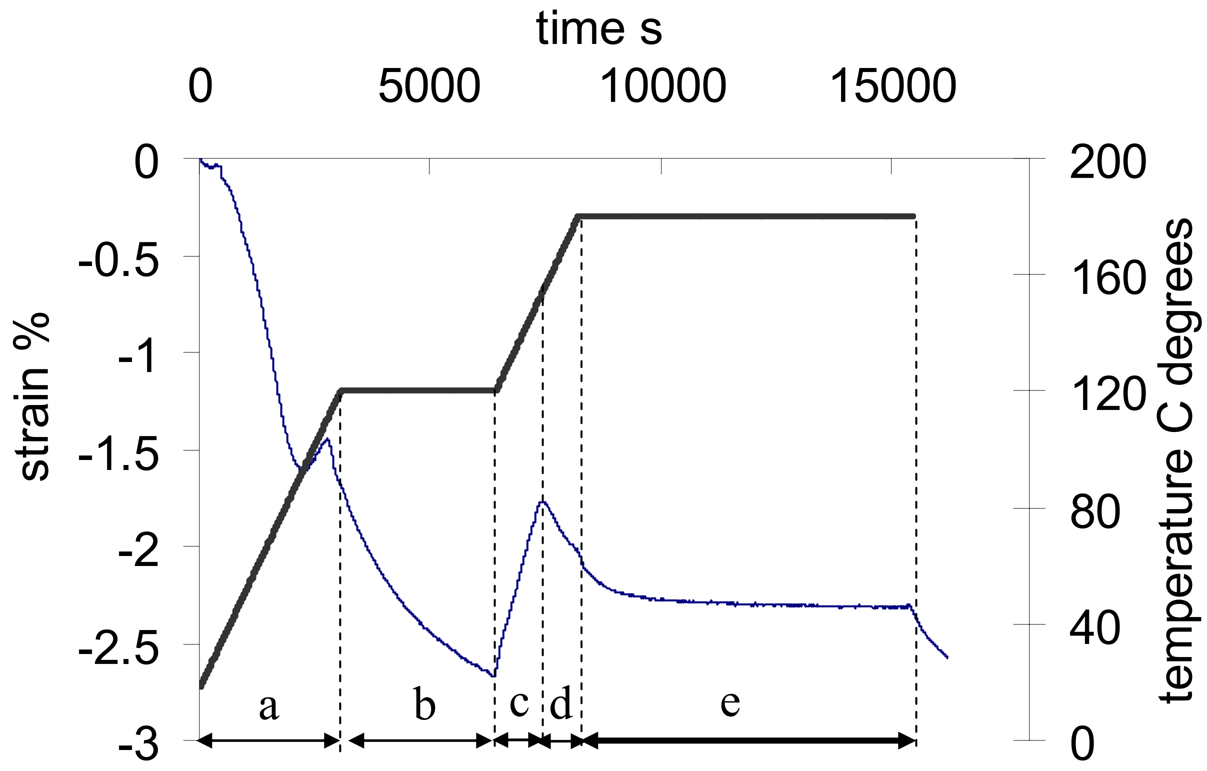
The Development of Cure Shrinkage During the MRCC

Experimental set-up used for cure shrinkage measurements

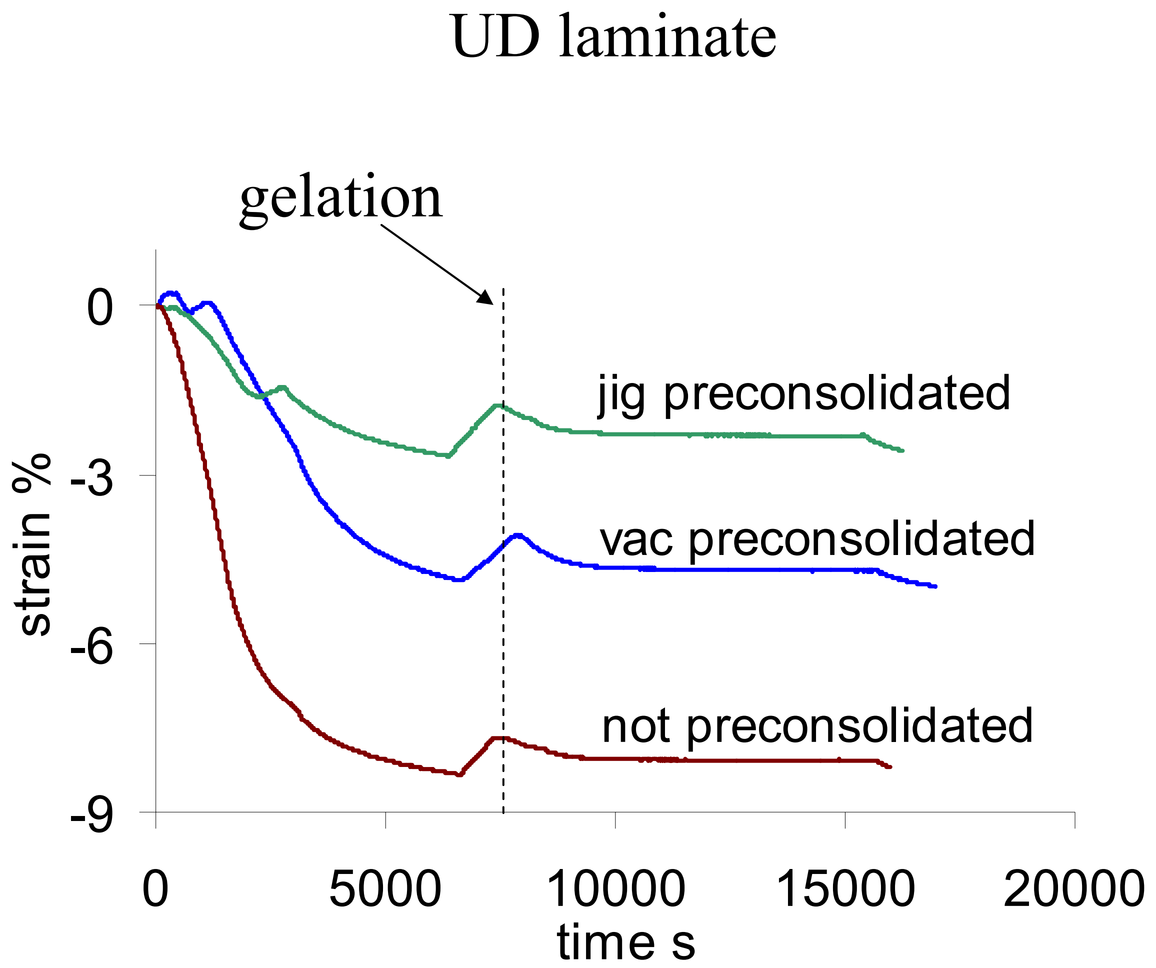


Through-thickness strain induced by consolidation and cure shrinkage

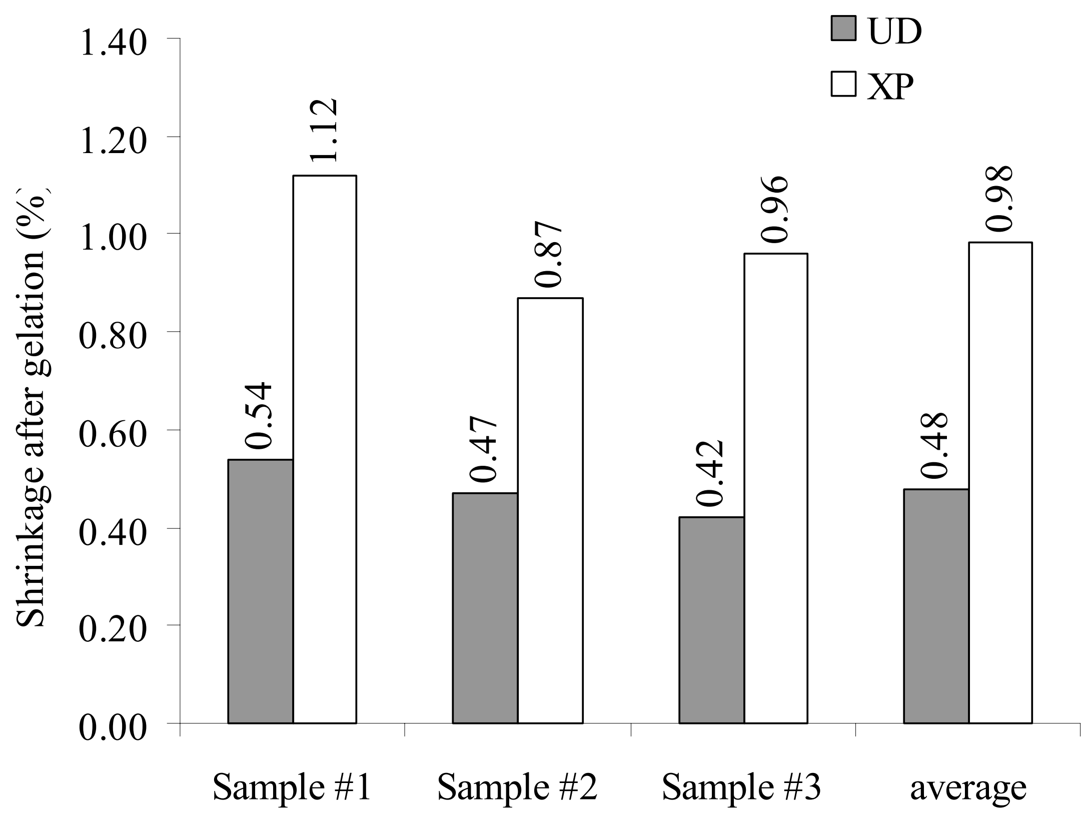
UD laminate



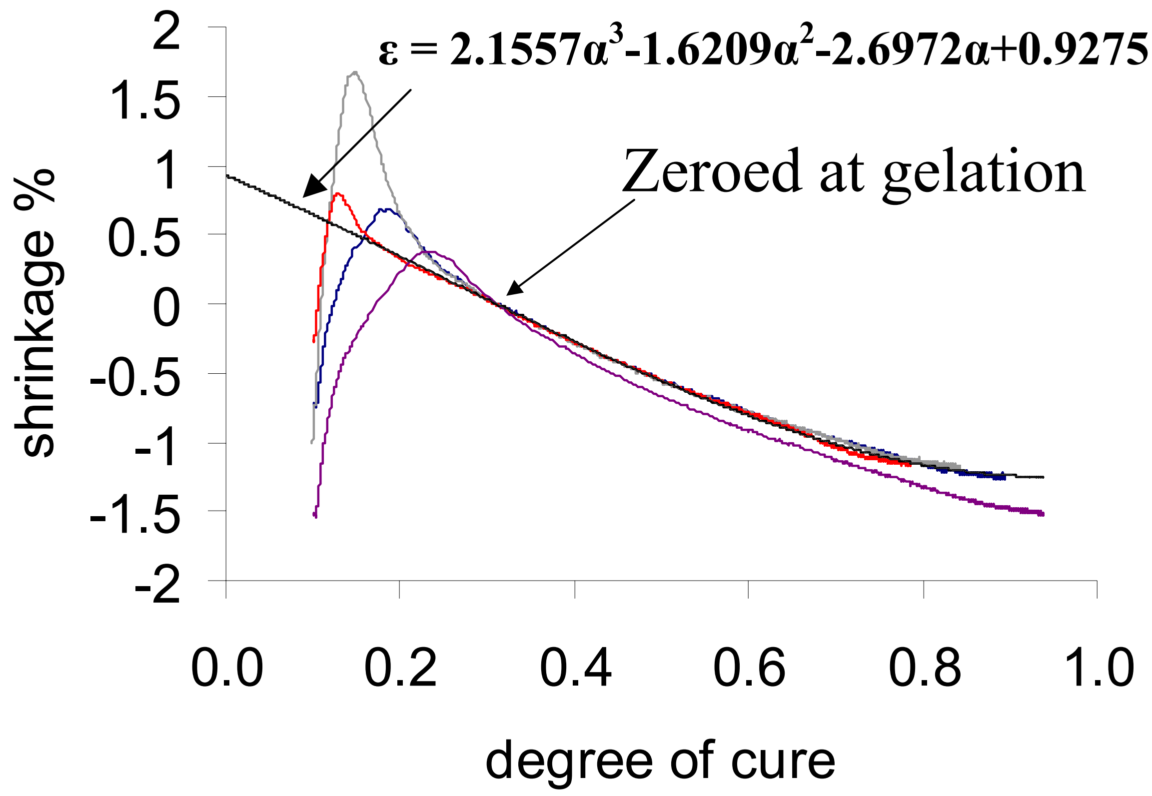
The effect of preconsolidation on the through-thickness strain



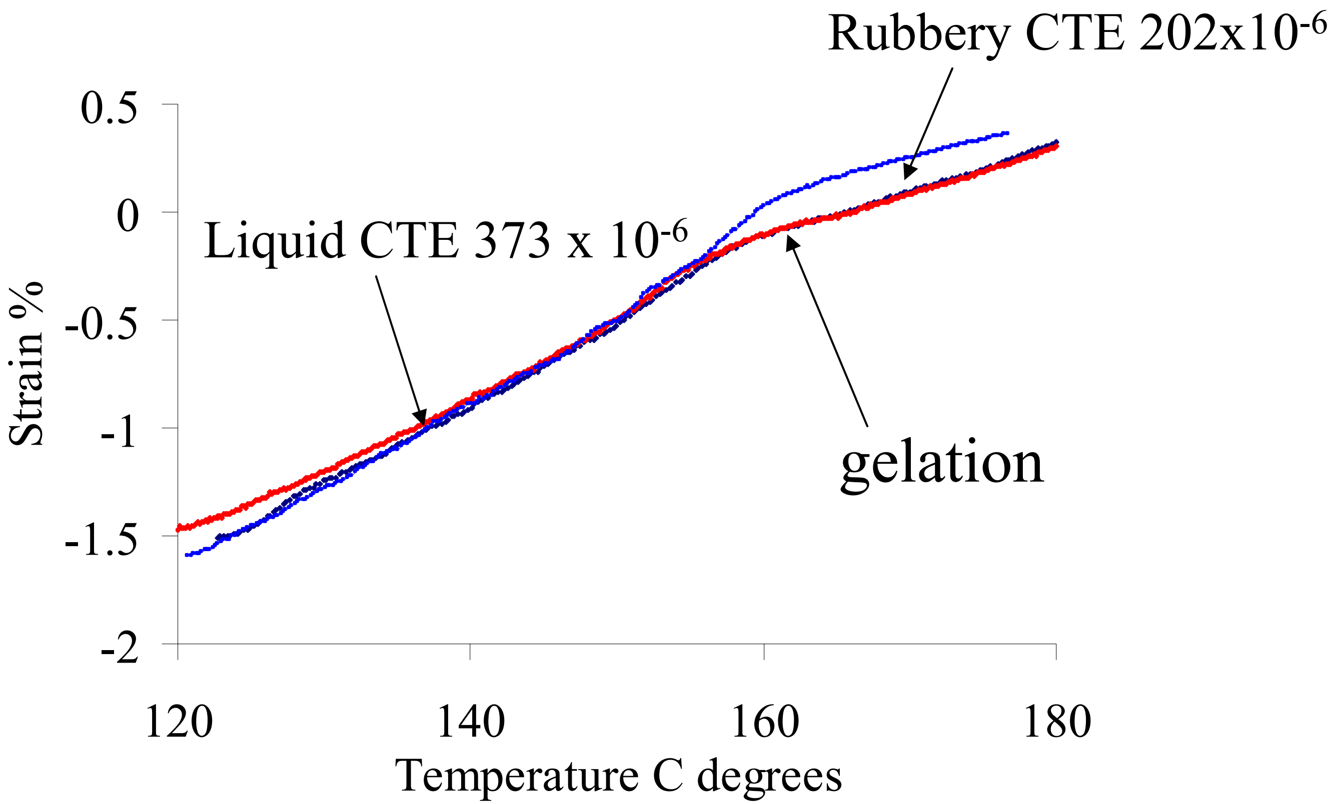
Through-the-thickness cure shrinkage strains after gelation for unidirectional and crossply composites



Relation between cure shrinkage and the degree of cure



Thermal expansion strains



Conclusions:

The development of cure during the manufacturing cure cycles was investigated using the model proposed by Cole

The model takes into account a shift from kinetics to diffusion control

An excellent agreement was achieved between the model predictions and the experimental measurements of degree of cure and glass transition temperature

Conclusions:

The maximum shear stress during the cure cycle is rate and lay-up dependent

The interfacial shear stress varies within the range of 0.01-0.1Mpa in tool/prepreg interfaces and 0.02-0.25 MPa in prepreg/prepreg interfaces up to the point of vitrification

It was found that when the resin approaches 30 % degree of cure the magnitude of force required to shear plies increases, which was taken as the beginning of gelation

Conclusions:

A novel approach has been developed to measure through thickness consolidation strains of epoxy laminates during the whole cure cycle.

The technique captures the thermal expansion during the heating stages, the laminate consolidation throughout the cure process, and also the cure shrinkage

The new method proved to be reliable and sensitive therefore it could be applied to a wide range of materials.

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