UNDERSTANDING THE EFFECT OF CYCLIC COMPRESSIVE LOADING ON THE THICKNESS BEHAVIOUR OF UNCURED PREPREGS

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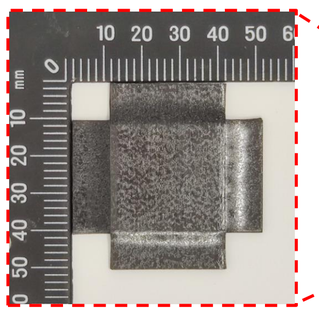
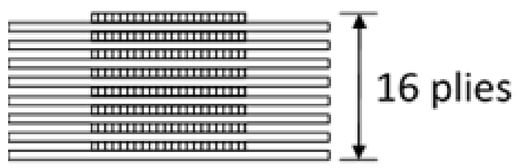
During AFP processing, the deposited material undergoes cyclic mechanical loading and unloading induced by sequential passes of the compaction roller. The behaviour of the material under cyclic compaction becomes much more complex for material systems where hysteresis and permanent strain are an issue. Previous studies have also documented a springback effect in dry fibres, and it is expected that the springback effect in other material systems will differ and result in further complexities.

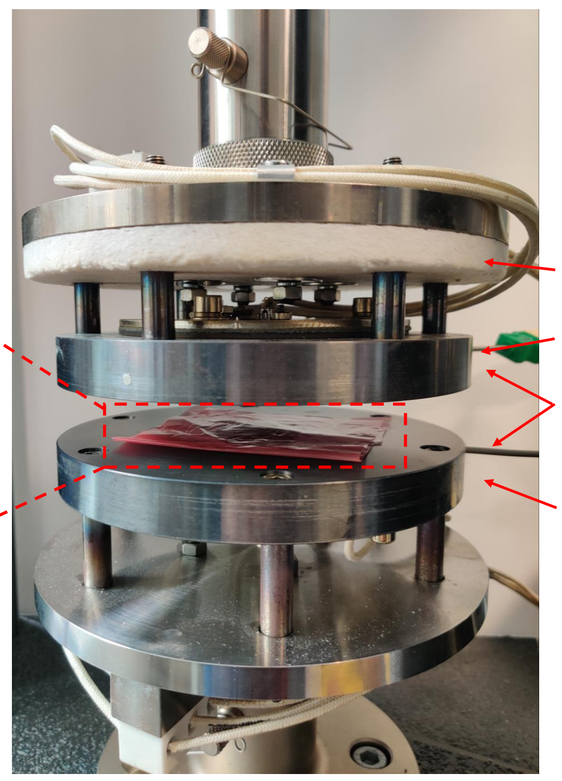
In this work, an investigation of the mechanical response to cyclic compressive loadings of toughened carbon/epoxy prepregs is undertaken. The experimental outcomes were used for further development of an existing state-of-the-art phenomenological material model. The acquired experimental data sets new requirements for the model to include a springback response during load relaxation and provides information for extensive validation.

Materials and Methods

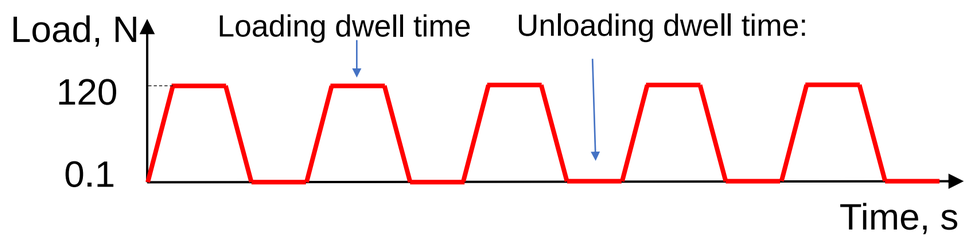
Hexcel® **IM7/8552**
(nominal CPT 0.125 mm)
Hexcel® **IMA/M21**
(nominal CPT 0.184 mm)







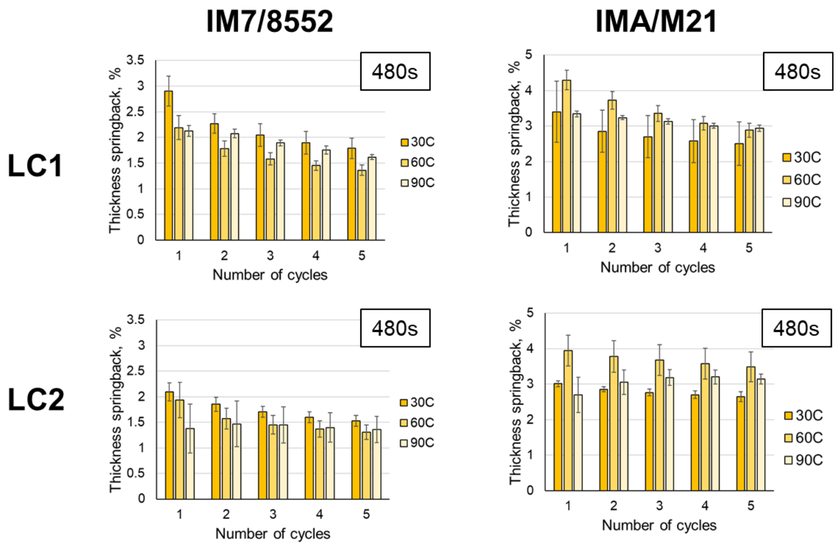
Note: Not to scale



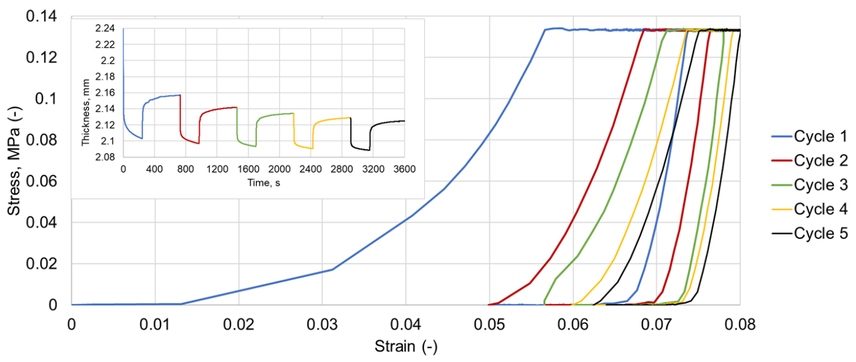
Loading case	Loading dwell time, s	Unloading dwell time, s	Compaction temperature, °C
1 – simulates debulking process	240	120; 240; 360; 480	30, 60, 90
2 – simulates AFP process	6	120; 240; 360; 480	30; 60; 90 for IM7/8552 30; 45; 60; 90 for IMA/M21

Loading/unloading rate - 45 N/s

Experimental Results

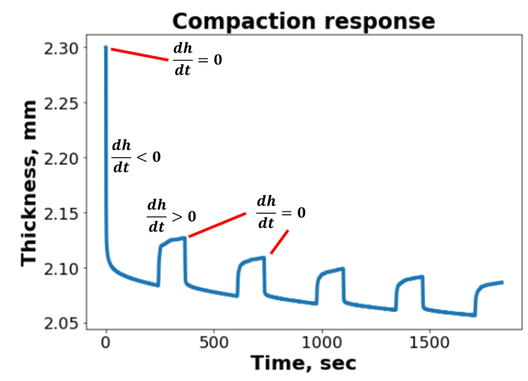


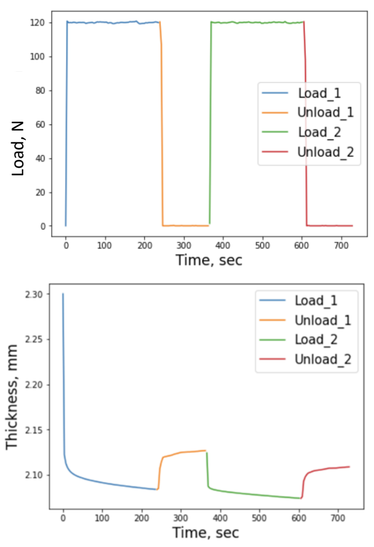
- Springback tends to decrease with each successive cycle
- Higher springback value is different based on material type, loading schedule and dwell time (all these parameters influence compaction level)



Stress –strain curves shows highly non-linear and visco-plastic behaviour. The area of the hysteresis loop initially decreases and then reaches the equilibrium

Modelling Approach





Material model

$$\frac{dh(t)}{dt} = Q(t) * P(t)$$

Gutowski Model

$$P_{pre}(f) = \sigma_A \frac{\sqrt{f/f_0} - 1}{\left(\sqrt{f_{lim}/f} - 1\right)^4}$$

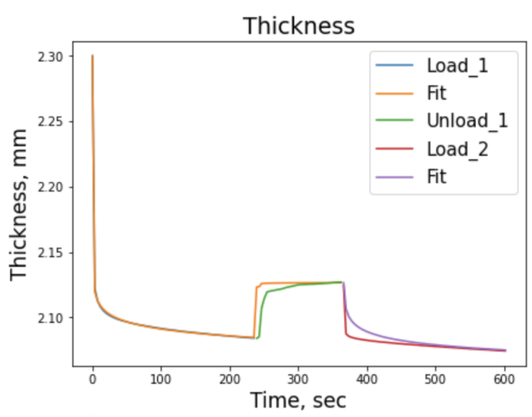
Split the compaction response for loading and unloading sequences

Loading

$$\frac{dh(t)}{dt} = Q(t) * P(t)$$

Unloading

$$\frac{dh(t)}{dt} = Q(t) * (-P_{pre})$$



Pros:
- Easy to use
- Can isolate parameters
- Original model is intact

Cons:
- Springback response is not active during loading

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