Identification of residual strain and stress in cross-ply laminate by using embedded fibre Bragg sensor

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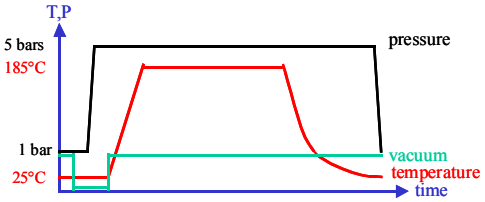
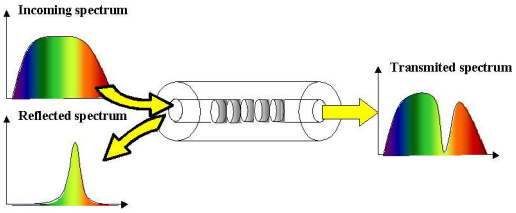
Monitoring LRI process by Fibre Bragg Grating

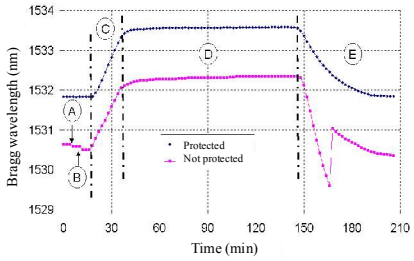


Cure cycle

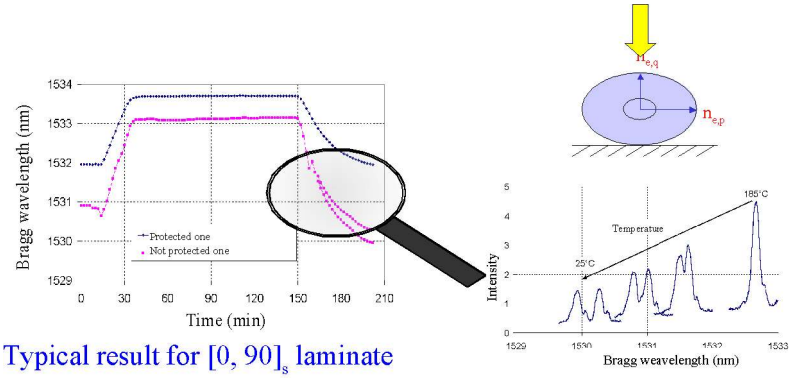


Bragg wavelength: $\lambda_B = 2n_{eff}\Lambda$

Birefringence evidence



Typical result for UD tape



Typical result for $[0, 90]_s$ laminate

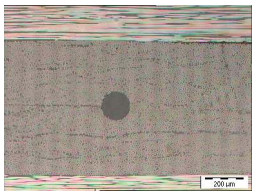
Inverse approach: global opto-mechanical model

$$(\Delta\lambda_{B,p}, \Delta\lambda_{B,q}) \xleftrightarrow[\text{photoelasticity}]{\text{birefringence}} (\varepsilon_1,\varepsilon_2,\varepsilon_3)^f \xleftrightarrow[\text{model}]{\text{Lekhnitskii}} (\varepsilon_1,\varepsilon_2,\varepsilon_3)^\infty \xleftrightarrow[\text{stress}]{\text{plane}} (\varepsilon_1,\varepsilon_2)^\infty$$

$$\begin{pmatrix}\frac{\Delta\lambda_{B,p}}{\lambda_B}\\ \frac{\Delta\lambda_{B,q}}{\lambda_B}\end{pmatrix} = \begin{pmatrix}1-\frac{n_0^2}{2}p_{12} & -\frac{n_0^2}{2}p_{11} & -\frac{n_0^2}{2}p_{12}\\ 1-\frac{n_0^2}{2}p_{12} & -\frac{n_0^2}{2}p_{12} & -\frac{n_0^2}{2}p_{11}\end{pmatrix}\begin{pmatrix}\varepsilon_1\\ \varepsilon_2\\ \varepsilon_3\end{pmatrix}^f + \begin{pmatrix}\alpha^f+\xi\\ \alpha^f+\xi\end{pmatrix}\Delta T$$

$$\begin{pmatrix}\varepsilon_1\\ \varepsilon_2\\ \varepsilon_3\end{pmatrix}^f = \begin{pmatrix}1 & 0 & 0\\ m_{21} & m_{23} & m_{23}\\ m_{31} & m_{32} & m_{33}\end{pmatrix}\begin{pmatrix}\varepsilon_1\\ \varepsilon_2\\ \varepsilon_3\end{pmatrix}^\infty + \begin{pmatrix}0\\ n_2\\ n_3\end{pmatrix}\Delta T$$

$$\begin{pmatrix}\varepsilon_1\\ \varepsilon_2\\ \varepsilon_3\end{pmatrix}^\infty = \begin{pmatrix}1 & 0\\ 0 & 1\\ -\frac{C_{13}}{C_{33}} & -\frac{C_{23}}{C_{33}}\end{pmatrix}\begin{pmatrix}\varepsilon_1\\ \varepsilon_2\end{pmatrix}^\infty$$



Results: 3 strain values

Directions	Experiment	Numerical model
e_1	-291 με	-310 με
e_2	-4439 με	-4503 με
e_3	-4439 με	-4503 με

Directions	Experiment	Numerical model
e_1	-823 με	-857 με
e_2	-458 με	-520 με
e_3	-6007 με	-5820 με