RESIDUAL STRAIN MONITORING DURING COMPOSITE MANUFACTURING USING THE POLARIZATION DEPENDENT LOSS PROPERTY OF FBGS

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In general, structural health monitoring (SHM) of composite structures is considered very valuable certainly in terms of determining a correct maintenance or repair services. SHM, however, can already start at the beginning of the production process! A very important aspect of the composite manufacturing process is the appearance of residual strains and stresses during the curing cycle. Composites exhibit large residual strains after curing, which vary depending on the type of composite constituents, composite lay-up and manufacturing technology. The formation of thermal residual strains in unidirectional and cross-ply laminates arises mainly from the difference in thermal expansion between the reinforcement fibres (~ -0.55 x 10^{-6}) and the matrix (or resin) material (~30 x 10^{-6}) but the origin of strain development is completely different than mechanical induced strains.

Fibre Bragg gratings (FBG) are very well suited to serve as embedded strain sensor to monitor the internal strain state of composite structures. It is the reason why, when embedded into a composite laminate, their spectral response (wavelength shift) will depend on external perturbations (or deformations) of the structure. Next to deformations, temperature as well has a large influence on the spectral behaviour of the FBG. Therefore, during monitoring (in whatsoever application) temperature compensation is necessary. Temperature compensation methods are numerously discussed in literature however in most cases they are impractical for real life and certainly for embedded sensor applications. Therefore, we suggest to combine the wavelength shifts with an extra parameter which we can measure namely the polarization dependent loss (PDL). The PDL is defined as the maximum change in the transmitted power when the input state of polarization is varied over all polarization states. This parameter allows us to do temperature compensation at the exact position of the sensor using a standard single-mode optical fiber. This is particularly interesting in cure cycle monitoring, since because of exothermic reactions the temperature can vary in different locations of the laminate (making temperature compensation a hard job when considering conventional TC-methods).

In this presentation, the authors are investigating the possibility to estimate the magnitude of residual strains during the autoclave manufacturing process of carbon fibre reinforced cross-ply laminates (M18/M55J CFRP) by combining the wavelength shift of the grating, its amplitude spectrum and in addition using the temperature insensitive polarization dependent loss of the grating.