Quantification of Thermal Damage on Carbon Composites

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Carbon fibre reinforced polymer matrix composites are widely used in automotive and aircraft construction etc. They provide light weight material with optimized mechanical strength. However, polymers are thermally degraded at elevated temperatures and they lose their mechanical integrity at lower temperatures compared to metal structures. The characterization of thermal damage of polymer matrix composites is of wide interest, especially in aircraft service. Methods to evaluate degradation effects are preferably easy, fast, non-destructive and of unambiguous significance [1]. A practicable way to indirectly characterize thermal degradation of a composite component is provided by a coating. Colour change and degradation of the binder can be used to estimate thermal damage. Infrared spectroscopy is capable of characterizing degradation of the binder and is widely used to pursue polymer decomposition. New developments in spectrometer construction allow a mobile and in-service application.

This work provides techniques to separately determine temperature and duration of a thermal pre-load as well as residual strength of epoxy based polymer matrix composites on the basis of the degradation of the top-coat. Infrared spectroscopy and colorimetry characterizing binder degradation and colour changes of polyurethane top-coats were used to provide a non-destructive in-service method to quantify incipient heat damage. A multivariate (chemometric) analysis of IR and colorimetric data was performed. The reliability of the calculated values for duration and temperature of the thermal pre-load as well as residual strength for specimen with unknown thermal history is slightly better for the IR analysis. However, the sole analysis of colorimetric data allows a separate prediction of these parameters.