Acoustic Emission Testing: evaluation of damage in composite materials

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Abstract. High performance composites for aviation-related structures are prone to constant aging by environmental agents. Previous data from our work reported on the stiffening behaviour of glass fibre polyester composites used in the manufacturing of wind turbine blades. Airplanes from such composites are already on service nowadays. This justifies the detailed study of the exposure of high performance materials to environmental conditions such as varying temperature, humidity, ultraviolet radiation, in order to assess the impact of these important aging factors on their mechanical behaviour. The dramatic changes in the dynamic mechanical response of polymer matrix carbon fibre composites upon exposure to acceleration aging has been assessed in the present study. In order to assess the synergistic effect action of temperature and humidity on composites subjected to changes of temperature from -35 to +40 °C and humidity variations from <10% to 95% RH (non-condensing) specimens were stored in a climatic chamber for 60 days. Conditions were cycled, as if actual flight cycles of 3-4 hours per flight, were to be simulated. Dynamic mechanical analysis tests were performed in three point bending mode. Scanning of frequency and temperature were performed in order to determine both the viscoelastic response as well as the time-dependent behaviour of the aged materials. All tests were run both for aged and pristine materials for comparison purposes. Three point bending testing was performed in both static as well as in Dynamic mechanical analysis, for a range of temperatures and frequencies. Acoustic Emission damage detection was also performed during the three point bending test both in static and dynamic mode. The aged materials had gained in dynamic stiffness. In addition, that, the gain in the storage moduli, was accompanied by a decrease in the material damping ability, as determined by the tanδ parameter. In the final stages of the study, impact testing was performed on both pristine and aged specimens. The experimentally recorded force/time signals were utilized for concluding on the specimens' condition, by means of signal based damage detection methodologies. Effort was invested in utilizing signal analysis in order to get comparative aging-related information on the tested specimens in order to ultimately validate results of mechanical testing.