Experimental investigations on the mechanical damage behavior of multifunctional composites with printed electronics

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ABSTRACT

Carbon fibre reinforced plastics (CFRP) are frequently used for lightweight structures. Minor damage often occurs inside the CFRP laminate, weakens the structure and may expand quickly. In conventional structures, damage like delamination remains undetected until potentially scheduled non-destructive inspections (NDI).

In the current work, electrical resistance measurements through the laminate thickness is used as a method for Structural Health Monitoring (SHM). Therefore, an electrically conductive material is applied to the top and bottom surfaces of the structure. Alternatively, it may be integrated inside the laminate. Both options allow electrical resistance measurements through the laminate thickness. Since increasing resistance corresponds with growing damage inside the material, e.g. interfiber failure or delamination, a localization and quantification of the damage may be possible.

The applied electrical material is based on conductive particles which are dispersed in a chemical solution. This fluid is used in an inkjet printing process for the manufacturing of electrodes or conductive paths on the CFRP laminate. Since the conductive material becomes an integral part of the structure, the effect on the mechanical behavior of the multifunctional composite needs to be investigated. It has to be ensured, that the conductive material does not become the starting point for delaminations or other damage, which may lead to catastrophic failure of the whole structure.

To investigate the mechanical damage behavior of the multifunctional composite two kind of experiments are carried out on specimens with printed electronics inside, see [1]. A double cantilever beam (DCB) test allows conclusions about the mechanical response to the transverse crack opening mode I. Furthermore, an end notched flexure (ENF) test represents the mechanical behavior under shear opening mode II. Both are highly representative for the structural loading under normal operating conditions. With the test results the relevance of potential delamination is obtained from the distribution of cohesion and adhesion failure modes.

REFERENCES

[1] F. Heinrich, T. Genco, R. Lammering: *On the mechanical behavior of a composite stiffener with inkjet-printed electronics.* Proceedings: EWSHM 2018, Manchester, UK, 10.-13.07.2018.