Non-destructive evaluation of composite aircraft elements based on ultrasonic testing and image analysis

Doctoral dissertation – summary

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The doctoral dissertation covers the development of a methodology aimed at facilitating currently implemented procedures of diagnostics of composite aircraft elements based on ultrasonic testing. According to reports found in the literature and provided by experts performing non-destructive testing of aircrafts it is noted that there is a necessity to aid the procedures of the analysis of the ultrasonic data obtained during inspections in order to properly detect and quantify damage. This need arises from difficulties such as high time-consumption due to excessive amounts of the analysed data and large sizes of the ultrasonic scans. These inconveniences as well as data processing with manually set parameters' values lead to the occurrence of human errors and unrepeatable results.

The main goal of the research was to increase efficiency and reliability of damage detection and evaluation including its localisation, characterisation, quantification, as well as enhanced (three dimensional) visualisation. This objective was planned to be achieved with the use of developed algorithms based on image processing and analysis methods. This allowed formulating a research hypothesis that it is possible to increase efficiency and reliability of diagnostics of composite aircraft elements based on ultrasonic testing by the development of a methodology with the use of image processing and analysis methods.

In order to achieve the determined objectives and verify the set hypothesis, numerous experiments were carried out. For this purpose, artificially damaged specimens as well as aircraft components with damage induced during in-service were used. Firstly, measurement uncertainty factors influencing on the damage detection and evaluation were analysed, which allowed for the selection of the most suitable sets of ultrasonic testing parameters for further experiments. Afterwards, various image segmentation methods (including the proposed approaches) were investigated in the context of their accuracy for the damage detecting purposes. This allowed for the selection of the most suitable methods for the considered application. The next research stage concerned the analysis connected with the three dimensional reconstruction and visualisation of damage based on planar ultrasonic scans. The results were verified based on reference data acquired with the X-ray computed tomography method, which confirmed the accuracy and usefulness of such visualisation. Finally, the developed methodology was tested based on three case studies, which allowed confirming the validity of the formulated hypothesis.

Keywords: non-destructive evaluation; ultrasonic testing; diagnostics; aircrafts; image analysis.