The design of sophisticated algorithms for the control of CFRP composites with a novel fully non-contact Lamb Waves method

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The use of Lamb Waves for the control of Carbon Fiber Reinforced Polymer (CFRP) Composites has been considered as one of the most promising ways to drastically improve the efficiency of Ultrasonic Testing of Composites. However, due to their complex propagation phenomena, mastering Lamb Waves in order to detect delamination or other types of defects is still a challenge. In particular the design of robust and adapted Signal Processing algorithms and the development of non-contact methods for the emission and the reception of the Lamb Waves are important topics of research. In the current research, a novel method for emitting Lamb Waves which is fully non-contact and non-destructive has been developed. This method is based on the use of Laser Induced Plasma Shock Waves (LIPSW) for the mechanical excitation of Lamb Waves. After demonstrating the ability of this novel method to generate Lamb Waves and the possibility to detect delamination, our research focuses on the quantification of the detectability and the improvement of the robustness of the Signal Processing algorithms. In this research, we shown that the robustness of the Signal Processing algorithm is better when sophisticated image analysis methods are used. For this reason, Artificial Intelligence based techniques are investigated and implemented to improve the algorithms and obtain more reliable defects detection results. The demonstration of a high efficiency of the current Lamb Waves based method for the control of CFRP composites, comparable to current widely used Non-Destructive Testing methods such as automated Ultrasonic C-scan, may provide a disruptive change in the industry, and particulary in aerospace industries where the detection of defects in CFRP composites is a daily challenge.