Improvement in interface defect detection using ultrasonic signal modelling and validation of numerical models by experimental investigations

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Recently, adhesive bonding of different materials, such as metals and composites, has become an attractive and useful technique in different fields, such as aerospace, marine, civil engineering and etc. This type of joining reduces the weight of the structure, prevents corrosion, and ensures uniform distribution of the load on the structure. However, interface defects are often formed in these structures: delaminations, disbonds, weak bonds. In order to provide safe and durable use, a reliable technique has to be used to detect and prognose the defects that occur in adhesive bondline between materials. Ultrasonic inspection has become widely used and efficient method for testing adhesively bonded similar and dissimilar materials. The objective of the work is to increase probability of interface defect detection using signal modeling and perform validation by experimental results based on different ultrasonic features. This work focuses on evaluation of ultrasonic wave interaction with structure interfaces in order to learn their behavior in layered structures and to study the propagation and reflection paths as well as to identify the time instances of each reflection. In addition, determination of ultrasonic features and their extraction is under scope of this work. The samples under investigation are adhesively bonded single lap joints of similar and dissimilar materials. Impulses of signal reflections from the sample surface and interfaces were modeled in MatLab in order to analyze the behavior of ultrasonic waves and their propagation path through the structure. The time moments of each reflection were determined. As a result, the time gates for multiple reflections from the adhesive structure interface were determined and applied for the validation of the experimental results. Ultrasonic pulse-echo inspection was carried out using a 15 MHz focused transducer for several adhesively bonded joints. The experimental data collected were analyzed and different ultrasonic features related to interface defects such as peak-to-peak amplitude, time of flight difference, attenuation, mean value of the amplitude, standard deviation and others were determined. These ultrasonic features were extracted from the fixed time intervals of multiple reflections separately and results were compared. The quantification of the improvement of defect detection was also performed by sizing method. It can be concluded that the detectability of interface defects has been improved by defining precise time boundaries and selecting ultrasonic features with higher performance.