Air-coupled ultrasonic inspection with adaptive Lamb wave excitation

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The nondestructive inspection of components by means of Lamb waves is an emerging technology in aerospace. The German Aerospace Center uses Lamb waves excited by air-coupled ultrasound for the single-sided inspection of large-scale aerospace vehicle components made from carbon composites. However, in order to excite Lamb waves in a laminate, the ultrasonic transducers must hit the appropriate incidence angle with respect to the laminate. Since this excitation angle depends upon the layup and curvature of the component, it must be adapted if one or both parameters change from one location to another during the scanning. This is the case on aircraft fuselages for instance. Since it is highly impractical to repeatedly interrupt an inspection process, change the excitation angle manually, and then resume the inspection, an adaptive end-effector was developed that enables the on-the-fly excitation angle adaptation. The adaptation is performed according to an a priori calculated excitation angle map. The automated excitation angle adaptation allows a stable Lamb wave excitation in the component, thereby improving the ultrasonic imaging quality and increasing the probability of flaw detection. Hence, the adaptive end-effector enables the automated single-sided air-coupled ultrasonic inspection of components with varying thicknesses and curvatures. This new inspection mode is called adaptive slanted reflection mode, clearly outperforming the conventional nonadaptive focused slanted reflection mode.