Application of Dual Focusing of Ultrasonic Phased Array Transducer in Two Orthogonal Planes for Non-Destructive Testing of Composite Materials

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Ultrasonic imaging of the internal defects of thin multi-layered composite samples is an actual task for quality control in aerospace sector. The contact type linear ultrasonic phased array transducers (ULPAT) with delay lines can be used for fast pulse-echo detection of different type internal defects (e.g. delaminations) located at different depths inside the sample. However, due to a low lateral resolution in one plane, the in situ application of ULPAT is limited. The objective of this work is to propose technique to enhance the spatial resolution of ULPAT. Solution based on design of a special delay line possessing a convex cylindrical lens has been proposed to achieve the spatial dual focusing. The lens enables fixed geometrical focusing of the excited beam in the elevation plane, while in the other, azimuth, plane the beam is electronically focused on internal defects and scanned to obtain the B-scan image. The proposed focusing technique of the ULPAT (10 MHz, 128 elements) in the elevation plane has been demonstrated using the ray tracing approach, while the focused ultrasonic field at a given distance inside the specimen has been analysed using CIVA simulation software. The simulation results and experiments demonstrate the resolution enhancement and improvement in the defect detection. The number of detected flat bottom holes (diam. 1-2 mm) in test sample was increased by 50 %. The experimental verification of the proposed technique has been performed by application for testing of multi-layered GFRP-metal based composite sample Glare 3- 3/2, having 3 layers of aluminium, 4 layers of GFRP and total thickness of 1.4 mm. The sample consists of artificial delamination type defects of different diameters by appropriate Teflon inserts. Comparing to limitations of conventional ULPAT the relative error of lateral defect dimensions estimation was essentially reduced (more than 30 %). Therefore, the proposed technique is suitable to be applied for contact type testing of composite components from aerospace sector with increased spatial resolution.