A new air-coupled ultrasonic method using membrane-free optical microphone for the detection of micropores in airship envelope materials

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Airships have shown a great potential in various fields such as regional disaster prevention, environmental monitoring, regional communication, etc. However, the presence of micropores in airship envelopes may greatly reduce their long-flight endurance. There is a little research on using nondestructive testing (NDT) methods for the detection of micropores in airship envelope materials described in the open literature. In this study, air-coupled ultrasonic (ACU) method was applied to detect micropores in the envelope material. Numerical simulations have been performed to study the detection ability of a focused ACU transmitter with different center frequencies. Advanced processing algorithms have been used to improve the signal-to-noise ratio and image contrast. Finally, micropores with diameters above 20 μm have been successfully detected using this method. In addition, a new defect scanning localization method has been proposed being based on diffraction time delay inversion. This method employs membrane-free optical microphones instead of using conventional piezoelectric probes. This method has essentially extended the scanning step and improved the detection efficiency. In addition, it saves the resources needed to process and store a great deal of experimental data. If the scanning localization method is used in conjunction with a mechanical arm, it might be possible to detect micropores at the stage of envelope material manufacturing.