Quantitative Measurement and Evaluation of High-Resolution Ultrasonic Sound Fields using a Novel Automated Ultrasonic Immersion Scanner

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Ultrasonic probes are an integral part of the automated ultrasonic non-destructive testing and evaluation (NDT&E) systems to detect and size the defects in a wide-range of structural materials in production lines. A complete quantitative assessment of the performance characteristics of an application-specific ultrasonic probe is needed to be evaluated on the basis of the European Standard DIN EN ISO 22232-2. This requirement of full assessment not only improves the quality assurance of the manufactured probes by evaluating the acceptance criteria but also provides the useful technical information to the end-user to optimize the automated ultrasonic testing on-site. In addition, the evaluation of probe characteristics should be carried periodically throughout their service life. In this work, we developed a novel high-precision ultrasonic immersion scanner to evaluate the full ultrasonic probe characteristics which include the squint angle measurement in three different reference planes (XY, XZ, and YZ), RF-signal and its frequency spectrum at water-steel interface, focal distance, focal range, focal width, focal length and also the angle of beam divergence in different planes of the sound field distribution. In the newly developed ultrasonic immersion scanner, for the first time, we successfully integrated the high-precision motion control unit (Hexapod) with six axes to achieve a few micrometer (~15 µm) spatial-resolution in the measured sound field patterns and a good angular resolution (~0.05°) in the squint angle measurement. In addition, we used a verified ultrasonic testing instrument in accordance with the standard DIN EN ISO 22232-1 to obtain more accurate amplitude values (±0.5 dB) while scanning a test block. The automated scanning, data acquisition, evaluation, visualization and the automated test report generation are carried based on the standard DIN EN ISO 22232-2. The measured sound beam characteristics of both focused and non-focused application-specific ultrasonic probes with center-frequencies ranging from 0.5 - 15 MHz using the pulse-echo technique on a 3 mm half-ball steel reflector are presented. Finally, the quantitative analysis of the measured sound field results and the acceptance criteria in accordance with DIN EN ISO 22232-2 are discussed.