Diffractive Effects on Time-of-Flight Determination for Fluids Speed-of-Sound Measurements

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Modern apparatuses for high pressure speed-of-sound measurements in fluids are based on transient techniques and, consequently on the determination of the time-of-flights of signals that traveled different distances. Considering that, due to the finite dimensions of the ultrasonic source, signals are delayed with respect to the font wave, the obtained time-of-flights values have to be corrected for diffraction effects. Today available analytical models, taking into account these effects, are based on the assumption that emitted wave is periodic and continuous, even if, for practical reasons, waves packet are formed by a limited number of cycles (usually sinusoidal signal bursts of 5-10 cycles). Unfortunately, in this way, analytical models can be considered just as a preliminary approximation of the real effects; thus, precautionary, the corrections are calculated and applied checking that their contribution is much smaller than that one of other uncertainty sources. For many industrial fluids this approach is reasonable, but for those of scientific interest it is not always acceptable. Furthermore, although measurement cells are designed to work in the far-field conditions, it could be happen that, for particular thermodynamics states, the measurements are obtained in near-field region where complex interferences can perturb the signal, leading to incorrect results. In this work, an original and time-dependent function is used in order to better approximate Reyleigh-Sommerfeld integral by a simple numerical algorithm. Using this theoretical approach, it is possible to calculate time-dependent acoustic field both in the near- and far-field conditions, and to use these results to correct experimental time-of-flight measurements. Examples including different geometrical parameters for the source and traveled distances are proposed in the case of speed-of-sound measurements in seawater sample.