Ultrasonic wave field model using the Quasi- Monte Carlo method: Theory, method and application

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Modeling of ultrasonic fields in materials and structures is of great interest to the researchers in the non-destructive test and evaluation (NDT&E). Research into wave fields is helpful for understanding transducer sensitivities, guiding and designing detection schemes, and the quantitative evaluation of flaws or material properties, among other phenomena. In this work, the quasi-Monte Carlo (QMC) method is introduced to model the wave fields generated by ultrasonic transducers, to overcome the conflict between precision and efficiency that arises in current methods of wave field calculation. The proposed method is also extended to model the wave fields propagating in multiple media, scattered by and diffracted trough flaws, and introduced to investigate the effects of surface roughness, et al. The basic modeling process is that: The Rayleigh integral (RI) equation is introduced as the model equation for ultrasonic wave fields, the acceptation-rejection method and Halton sequence are used for pseudo-random sampling from the sound sources, and the sound field distributions are then obtained using the sample mean to solve the integral solutions. Thus, the wave fields in different conditions can be obtained as the boundary conditions can be constructed using the pseudo-random samples. The proposed method is verified by comparing results obtained using other simulation methods or experiments. The potential applications of the proposed method are briefly discussed in terms of their benefits for wave beam modeling and computational ultrasonics.