Viscoelastic characterization of coating layers by ultrasonic interference and critical attenuation

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In previous studies, various approaches were proposed for the nondestructive characterization of coating layers on substrates. The wave velocities of an elastic layer can be estimated by measuring the ultrasonic resonance frequencies if the thickness is known a priori. If the coating material exhibits energy dissipation, the characterization only by the resonance frequencies is not suitable because the effect of wave attenuation on the resonance characteristics is not significant. The magnitude of the reflection amplitude can be an alternative to obtain information about the attenuation property. However, the precise measurement of the amplitude sometimes entails difficulties because of other factors attenuating the wave, e.g., diffusion attenuation and energy dissipation at bonded interfaces. This study proposes a characterization technique for a viscoelastic coating layer on a metal substrate immersed in water, based on ultrasonic interference and critical attenuation phenomena. Theoretical analysis shows that the reflection spectrum for the normal incidence wave has local minima at the resonance frequencies of the coating layer, which provide its elastic property. Furthermore, it is revealed that the lower envelope of the reflection spectrum takes a minimum, whose frequency can be related to the critical attenuation condition. This feature implies a possibility that the viscous property of the coating material can be estimated by similarly measuring a characteristic frequency to the estimation of the elastic property. Experimental results are reported to validate the proposed method and to attempt the characterization of several coating layers.