Geometry effects in Impact Echo Signals - why traditional time-frequency filtering fails to remove them

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Impact Echo signals can sometimes contain a lot of noise, even though the wavelength of the investigated modes is in the order of the specimen thickness. A special type of noise signals are the so-called geometry effects. These effects occur when the lateral dimensions of the investigated structure are not much larger than its thickness. This study compares signals with and without geometry effects using various types of signal processing methods such as classical fast Fourier transform, short-time Fourier transform, and the continuous wavelet transform. Results show that signals without geometry effects have a much more stable resonance frequency, whereas the main frequency content in Impact Echo signals containing geometry effects typically oscillates between two or more discrete frequencies. As this oscillation lasts for the entirety of the signals, traditional time-frequency filters will likely not be capable to remove geometry effects from Impact Echo signals. Resonance frequencies in Impact Echo signals unaffected by geometry effects are much more stable, with no fluctuation or oscillation over time. By comparing time-frequency representations of signals obtained at the same spot with different impactors, it is observed that the peak frequency at the beginning of each signal is similar for all three measurements. This result suggests that, for signals heavily affected by geometry effects, the beginning of the signal, which is usually neglected during Impact Echo inspection, could provide useful information regarding the thickness of the inspected structure. Two ways of obtaining thickness information from the signal beginning are presented and results are compared using a dataset from a reference specimen: one method uses classical Fourier transform of the signal beginning and the other approach uses the maximum frequency determined from the continuous wavelet transform. The results for both approaches show that the Impact Echo signal beginning contains depth information, which could prove valuable for evaluations of noisy datasets.