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Prediction of the Square Plate Natural Frequency by using the Mean Wavelength of the Actual Nodal Lines and the Modal Overlap Factor

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Abstract : In the previous work, Chladni patterns associated to resonant and non-resonant flexural vibration modes were visualized on square metallic plates, in the range of low frequencies, around the first flexural resonant peak. Continuous change of the pattern geometry, gradually leading to shape transitions, was observed at augmentation of the excitation frequency. According to their specific shape, the visualized nodal lines were divided in groups, such as: elliptical, elliptical arcs, parallel segments, hyperbolical arcs, diagonal segments, etc. Control of the micro-particles motion on the vibrating plate by adjusting the excitation frequency was suggested as a possible actual application for these patterns, of simple geometry and fair sensitivity at frequency change. Unfortunately, in the range of low excitation frequencies, predicted values of the natural frequency for square panels, by using the elastic membrane and the thin plate models, are considerably higher than those estimated from the modal testing and analysis. Therefore, in this work, photos of the nodal lines, forming on plates made in copper and bronze in the range of low frequencies, are shown in correlation with the recorded vibration spectra. Resonant peaks corresponding to the rigid plate mode of vibration, as well as the lowest bending plate mode of vibration are identified. Then, the damping ratio at these resonant frequencies is evaluated by using the Q-factor technique. In order to achieve agreement between the predicted and measured frequencies, the mean wavelength is accurately evaluated by taking into account the rounding of the actual nodal lines near the plate edges. Additionally, a frequency correction factor multiplying the core of the frequency expression is introduced to precisely fit the measured values of the frequency. Relationship between the proposed frequency correction factor and the well-known modal overlap factor is explicitly illustrated. In this way, a reliable model able to correlate the excitation frequency with the shape of the actual nodal lines can be achieved, and based on it, control of the micro-particles motion on the vibrating plates, via frequency adjustment, can be successfully implemented.

Keywords : chladni patterns control via frequency adjustment, frequency correction factor, modal overlap factor, square metallic plates
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