Vibration Intensity Computation of A Single Plate with Uniform Force Excitation using FEM

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1. Introduction

The prediction of vibration intensity of a finite plate by using element analysis (FEA) is investigated. The formula of the structural intensity in a thin plate is firstly discussed. Then the structural intensity vectors and rms velocity distributions of a simply-supported thin finite plate have been presented. Harmonic response analysis for three excitation conditions: point force excitation with an attached damper but without structural damping, point force excitation with structural damping and force excitation over a finite area with structural damping. Although the rms velocity distributions give some indication of the vibration mode at a particular frequency, the structural intensity vectors reveal the power flow pattern.

2. Structural Intensity in a Plate

The instantaneous structural intensity component in the time domain can be defned as [1]

$$i_k(t) = -\sigma_{kl}(t)v_l(t), \qquad [1]$$

where σ_{kl} (t) and σ_{kl} (t) are the time history of stress and velocity in the l-th direction.

The structural intensity can be expressed in the form of the net energy flow per-unit width for shells and plates. The energy flow lies in the plane tangential to the midsurface of the structure. Displacements of any point of a thin-walled structure can be expressed by translational and angular displacements of the midsurface. The two components of the structural intensity for a flat thin plate are as follows [1]

$$I_x = -\frac{\omega}{2}\mathrm{Im}\left[N_x u^* + N_{xy}v^* + Q_x w^* + M_x \theta_y^* - M_{xy}\theta_x^*\right] \qquad [2]$$

$$I_y = -\frac{\omega}{2}\mathrm{Im}\left[N_y u^* + N_{yx}v^* + Q_y w^* + M_y \theta_x^* - M_{yx}\theta_y^*\right] \qquad [3]$$

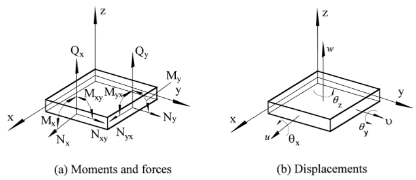

Fig. 1. An element of a plate. (a) Moments and forces; (b) Displacements.

3. Computation Results

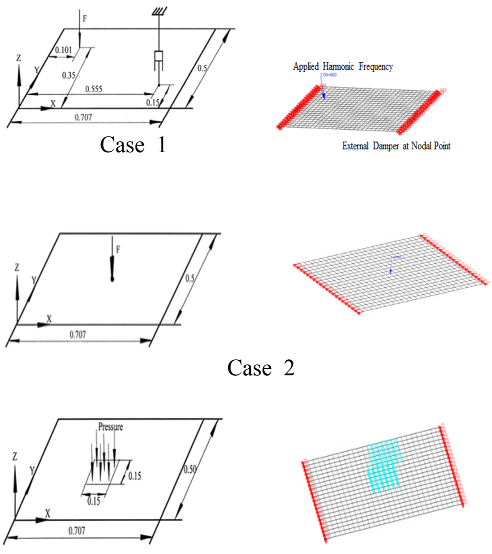

Fig. 2 Case Examples for Computation Results

The computation of the structural intensity was carried out on a simply-supported thin aluminium plate which is 0.707 m long and 0.5 m wide with a thickness of 3 mm. The material properties used for

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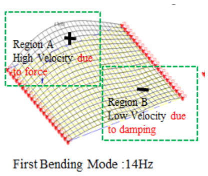
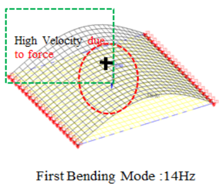
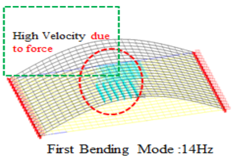
the plate are as follows: the Young's modulus is 70000 MPa, the Poisson ratio is 0.3 and the mass density is 2100 kg/m2. The plate was simply supported along the two short edges and free along the two long edges.



Case 1

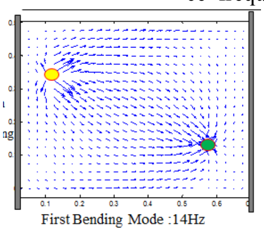


Case2

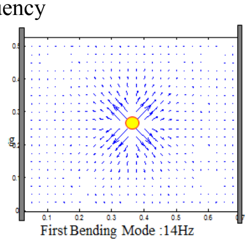


Case 3

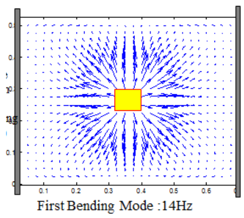
Fig. 3RMS Velocity Distribution at first resonance frequency



Case 1



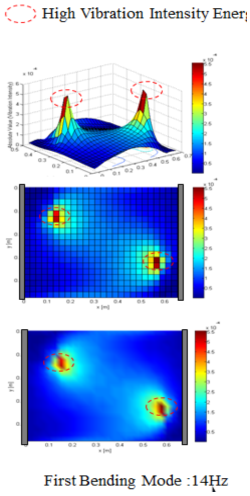
Case2



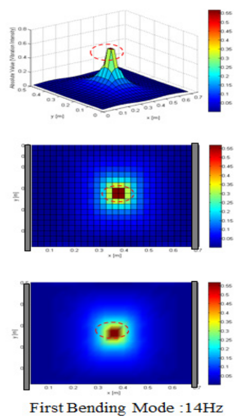
Case 3

Fig. 4Vibration Intensity flow at first resonance frequency

The structural intensity vectors in Figs. 4 clearly reveal the source of the power flow being located at the position where the load is applied. However, the information contained in the rms velocity distributions shown in Fig. 3 is at doubtful and ambiogous.



Case 1



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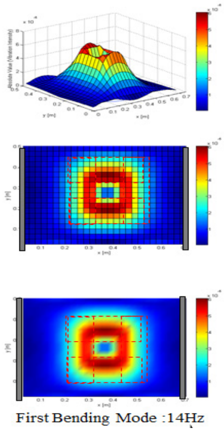

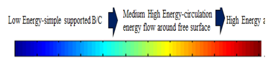

Case3

Fig. 5 Energy Distribution at first resonance frequency

4. Conclusion

1. Vibration Intensity can be used to localize vibrating source.

2. Vibration Intensity Rank can be clearly featured by Vibration intensity Energy Distribution

3. RMS Velocity Distribution cannot provide useful information for Vibration Source Localization

5. References

[1] Gavric L, Carniel X, Pavic G. Structure-born intensity fields in plates, beams and plate-beam assemblies. In. Int Conf on Intensity Techniques, Senlis, France, 27-29 August, p. 223-230.