한국소음진동공학회 2009년 춘계학술대회논문집, pp.222~223

Identification of Exciting Source Location of a Vibrating Plate Using Vibration Intensity

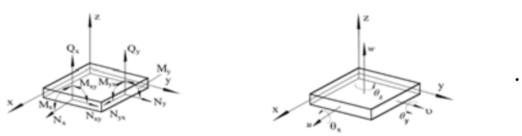
Noor Fawazi *· Ji Hyeon, Yoon*· Joung Yoon, Lee **· Jae Eung, Oh †

1. Introduction

The evaluation of vibration intensity arises for many practical reasons. The distribution of vibration intensity energy transmission offers the location of vibration source which indicates the location of the emerging vibration power and the sinking position where the energy is dissipated from the system. Vibration Intensity also provides information on the transmission path of the mechanical energy throughout the system.

2. Formulation of Vibration Intensity for a single plate

For the purpose of predictive computation by finite element computation, all components required to calculate the vibration intensity are considered. The stress distribution of a plate structure is assumed to be linear through thickness or the cross section. Stress and displacement fields are completely defined by stress resultant, translational and angular displacements of the midsurface as shown in fig. 1



(a) Moments and force (b) Displacements

Fig. 1 Plate Element with defined internal forces and displacements

The Vibration Intensity can be expressed in the form of the net energy flow per unit width. The energy flow lies in the plane tangential to the midsurface of the structure. The two components of vibration intensity for a plate system are as follow

$$I_x = -\left(\frac{\omega}{2}\right) \mathrm{Im}\,[N_x u^* + N_{xy} v^* + Q_x w^* + M_x \theta_y^* - M_{xy} \theta_x^*] \quad (1)$$

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

N_x, N_y, and $N_{xy}=N_{xy}$:complex membrane forces

M_x, M_y, and $M_{xy}=M_{xy}$:complex Bending and Torsion Moments

Q_x and Q_y :complex shear force

u*,v* and w* :complex conjugate displacements in x,y and z

θ_x^*, θ_y^*, :complex conjugate displacements in x,y and z

The computational approach of the vibration intensity in plate structure using FEA has been investigated since 1990. In this study, FEM model was modeled using NASTRAN software and consisted of square elements of QUAD4 type. Finally, Matlab was used to visualize the results.

Components Ix and Iy were computed from the internal shears and moments, which for thin plates are proportional to the spatial derivatives of the plate displacement.

FEM calculations by the means of finite element method the structural intensity is related to the neutral undeformed middle plane of plate. In general case, the plate was subjected to the bending, tension and twisting motions..

The method of structural intensity estimation was based on calculation of displacements in nodes and stresses in inner points. The displacement information at each node was averaged to represent the inner displacement as the inner stress was considered during this calculation. Thus, in this study, the calculation of vibration intensity was based on the central inner displacement and stress. The stress components such as bending, twisting and torsion motions, were utilized to compute vibration intensity using equation (1) and (2).

3. Comparison current FEA Vibration Intensity with Previous researches

Current Vibration Intensity analysis was first compared with previous researches [1] and [2] to validate the computational method. The plate was assumed to be dissipationless which means without structural damping. The plate was simply supported along the two short edges and free along the two long edges. It was modeled using the similar properties to the one used in references [1] and [2]. The properties and plate parameter are again stated in table 1 and figure 2.

Table 1 FEM Plate Model Properties

No.	Properties	Value
1	Plate Parameter	0.707m x 0.5m x 0.0003m
2	Young Modulus	70 000 MPa
3	Density	2700 kg/m3
4	External Damping	2000 Nm/s

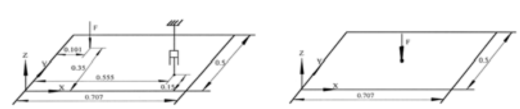


Fig. 2. FEA model (Case 1 and Case 2)

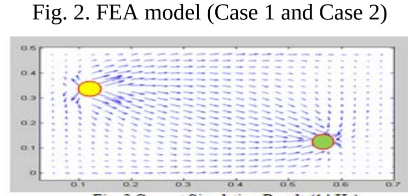
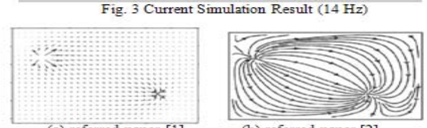


Fig. 3 Current Simulation Result (14 Hz)



(a) referred paper [1] (b) referred paper [2]

Fig. 4 Previous Simulation Results (14 Hz)

† 교신저자; 정회원,한양대학교기계공학부
E-mail : jeoh@hanyang.ac.kr
* 한양대학교 대학원 기계공학과
** 경기대학교 기계시스템디자인 공학부

The simulation vibration intensity vector flow result is shown in Fig. 4 and compared with previous computational vibration intensity results at first bending resonance frequency 14 Hz. Based on the simulation result, the location of source (yellow-red lined circle), sink (green-red lined circle) and power flow path between them can be clearly identified by vibration intensity vector flow. The obtained result is consistent with the results achieved by previous researchers and thus the method utilized to plot vibration intensity vector flow is validated. These simulation vibration intensity vector flows confirm the usefulness of the vibration intensity approach.

4. Case 1 : Vibration intensity Due to point excitation and an attached damper

For further vibration intensity analysis, high order of resonance frequencies numbers is considered to

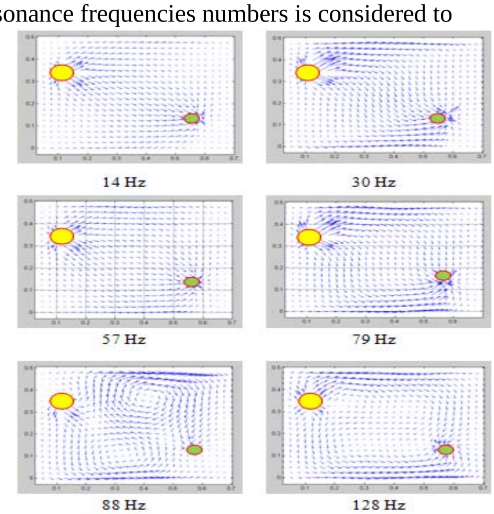


Fig. 5 First Sixth Vibration Intensity Vector Flow

investigate the pattern and the transmission path of the vibration intensity energy flow. This further analysis is important to confirm that the vibration intensity

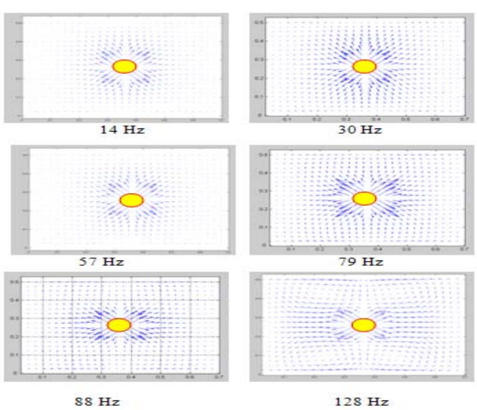


Fig. 6 First Sixth Vibration Intensity Vector Flow

is applicable even at higher resonance frequencies to identify the location of the vibration source and the sink.

Based on the simulation results in Fig. 5, even with the increment number of resonance frequencies modes, vibration intensity vector flows keep the constant information on the location of the applied vibration source and the sink. The vibration energy starts emerging at the point where force is applied and being dissipated at the point where the external damping is mounted. Generally, these simulation results do not show any differences of the vibration transmission path pattern and it is merely numerically modeled as dissipationless structure (purposely with no internal damping and being mounted with a single point external damping).

5. CASE 2: Vibration intensity due to point excitation

Having the previous approach to plot vibration intensity vector flow, the similar plate system but with internal damping input was modeled. A constant

Fig. 6 First Sixth Vibration Intensity Vector Flow

damping ratio of 0.005 was used and a point excitation force with an amplitude force of 1N was applied at the centre of the plate as shown in fig. 2.

Vibration intensity against proves its capability in localizing the location of vibration source. Based on the simulation results in Fig. 6, the location of vibration source at various resonance frequencies can be identified. Vibration Power flow is possible due to the input internal damping (as no external damping is applied) compared to simulation result in Case 1.

6. Conclusion

Finite Element Approach has been used to simulate vibration intensity vector flow in order to localize the location of vibration source and damping element location. Case 1 which is dissipationless (no internal damping) but modeled with external damping provide a specific vibration intensity transmission path from the source to the damping element. While case 2 is purposely modeled without any external damping element and order to ensure the vibration intensity to flow throughout the system, constant internal damping is applied. Based on the simulation results, vibration intensity is useful to localize vibration source, external damping and intensity transmission path.

7. References

[1] “Prediction of Surface Mobility of a finite plate with uniform force excitation by structural intensity” Y.J. Li, Journal of Applied Acoustic 60(2000) 371-383

[2] “Streamline Representation for Stuctural Intensity Field” X. D.Xu, Journal of Sound and Vibration 280 (2005) 449-454

[3] “A Finite Element Method for Computation of Structural Intensity by The Normal Mode Approach” L. Gavric, Journal of Sound and Vibration (1993) 164(1), 29-43.