[N796] Reduction of vibration power transmission in high frequency range by modifying rotational stiffness of isolators

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ABSTRACT

For a performance analysis of vibration isolation system, concept of vibration power flow can be employed preferably when noise radiated from supporting structures is of interest. Although formulas for precise estimation of the power flow are rather easy to derive, oversimplified experimentations are often done under several assumptions due to instrumental limitations. For an example, rotational degree of freedom has not been well treated in bending vibrations of beam or plate-like structures. However, recent studies showed that the moments and rotations play an important role in power transmission and should be taken into account carefully as the frequency range of interest goes to audibly high. Therefore, it is readily agreed that reduction of the noise radiation over the high frequency range can be effectively accomplished by adjusting the rotational stiffness of the isolator without changing the vibration isolation efficiency in low frequency region relevant to the translational stiffness of the isolator.

In this paper, the vibration power flow approach is applied to an A.C. motor on a finite plate in order to illustrate the contribution of the rotational vibration power to the total vibration power transmission. The effects of rotational stiffness of the isolator on the vibration power transmission are investigated by inserting various shapes of isolators with different rotational
stiffness but the same translational stiffness between the motor and the plate. The resultant noise radiation from the plate is presented to verify the proposed approach.

**KEYWORDS:** Vibration Power, Translational Stiffness, Rotational Stiffness, and Isolator

**INTRODUCTION**

Mathematical formulations for the vibration power estimations from the vibratory machine to the supporting structures has been almost completed. However, their applications to practical systems still encounter difficulties mainly due to instrumental limitations especially in rotational motions. It is known that contribution of the vibration power transmission by the rotational terms to the total vibration power should be taken into consideration as the frequency of interest goes up to high. In previous studies, it was shown that the rotational motions coupled with the translational motions at the connection points can possibly lead to the vibration power cancellation[1]. Recent research claimed that both over- and under-estimation of the power transmission can be significant especially over high frequency range [2-4]. It was shown that the moment becomes important even at low frequencies when the translational motion is constrained in the proximity of a discontinuity[5,6]. However, complexity of the vibration isolation systems makes it difficult to analyze the rotational vibration power transmission through experimentation and to investigate its effects to resultant noise radiation from the supporting structure.

In this paper, contribution of the rotational vibration power to the total vibration power transmission is investigated for a simple system that is composed of an A.C. motor and a steel plate with finite dimensions. The effects of rotational stiffness of the isolator on the rotational vibration power are investigated by employing 5 isolators of different rotational stiffness but of the same translational stiffness. Furthermore, comparison of the resultant noise radiation from the plate is presented.

**THEORY OF VIBRATION POWER FLOW IN MULTI-DIMENSIONAL VIBRATION ISOLATION SYSTEM**

For a multi-point vibration isolation system as shown in Fig. 1, the time-average vibration power flow to the supporting structure through \( n \) connection points with 6-degree of freedom(OF) can be simply expressed as follows:

\[
P(\omega) = \frac{1}{2} \text{Re} \left\{ F_{R}(\omega)V_{R}(\omega) \right\} = \frac{1}{2} \text{Re} \left\{ V_{R}(\omega)Z_{R}(\omega)V_{R}(\omega) \right\}
\]

where \( F_{R} \) and \( V_{R} \) are respectively \((6n \times 1)\) force and velocity vectors at the receiver