inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 4.1

USING AN EQUIVALENT SOURCE DESCRIPTOR TO CHARACTERIZE STRUCTURE-BORNE SOUND SOURCES

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Keywords:
STRUCTURE-BORNE NOISE, SOURCE DESCRIPTOR

ABSTRACT
The purpose of this paper is to present a further adapted method based on the "equivalent source descriptor" concept, which provides a simplified overall characterization of a multiple point excited structure. An example of an application is given, involving an air compressor mounted on a frame. Comparisons between the directly measured power transmitted to the receiving substructure (using force transducers) and the transmitted power determined using the simplified method (using the equivalent source descriptor concept) showed good agreement in the $50 - 2000$ Hertz frequency range.

1 - INTRODUCTION

In a low noise design process, it is necessary to have acoustic information about the strength of the structure-borne sound sources. One of the main difficulties which arises in characterizing structure-borne sound sources is due to the fact that the dynamic properties are usually represented by a complex mobility matrix.
A simplified method of characterizing the mobility matrix has been developed by Moorhouse and Gibbs, and Mondot and Peterson have introduced the source descriptor concept, focusing on a single point of contact in a source structure.
The purpose of this paper is to present a further adapted method based on the "equivalent source descriptor" concept.

2 - SIMPLIFIED METHOD OF CHARACTERIZING SOURCE SUBSTRUCTURE

In the general case of a multiple point excited structure, the transmitted power is given by:

$$P = \frac{1}{2}\tilde{f}^{*T}Y.\tilde{f} \tag{1}$$

with $\tilde{f}$ complex vector of the multiple point forces, Y real part of the complex mobility matrix.
Due to the complexity of the previous equation, we present a further adapted method based on the source descriptor concept.

2.1 - Source descriptor D_i for each individual contact point

We consider a source substructure connected to a receiving structure by N contact points.
Each contact point i of the source substructure is characterized by a descriptor D_i, defined by:

$$D_i = \frac{1}{2}\frac{\left|\tilde{v}_i\right|^2}{\left|\tilde{Y}_i\right|^2}Y_i \text{ in Watt} \tag{2}$$

with $\tilde{v}_i$ vibratory velocity surrounding the point i, engine running, $\left|\tilde{Y}\right|$ punctual mobility modulus of the source substructure, Y real part of the mobility.

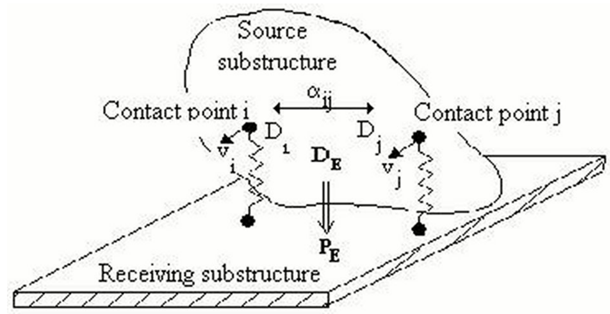

Figure 1: A source connected to a receiving substructure by two contact points.

2.2 - Equivalent source descriptor D_E for the N contact points

We introduce an average value for characterizing the N contact points of the source substructure. The average is possible when the geometry of the structure has a symmetry.
The equivalent source descriptor D_E is determined using:

- the number N of contact points between source and receiving substructure;
- the average source descriptor $<D_i>$ at the N contact points;
- the average coupling coefficient $<\alpha_{ij}>$ between contact points of the source structure

$$D_E = \frac{N.\langle D_i \rangle}{1 + (N-1)\langle \alpha_{ij} \rangle} \tag{3}$$

with:

$$\alpha_{ij} = \frac{\left|\tilde{Y}_{ij}\right|^2}{\left|\tilde{Y}_i\right|^2} \cdot \frac{Y_i}{Y_j}$$

2.3 - Equivalent power P_E transmitted to the receiving structure

The simplify method takes into account an equivalent power P_E transmitted by the N contact points. A relation relates the equivalent power P_E and the equivalent source descriptor D_E.
As previously the simplify method is determined using the average value of the transfer and punctual mobilities.

$$P_E = D_E \frac{\left\langle |Y_T|^2 \right\rangle}{\left\langle |Y_r|^2 \right\rangle} \cdot \frac{\langle Y_r \rangle}{\langle Y_s \rangle} \tag{4}$$

with $\left\langle |Y_T|^2 \right\rangle$ average value of the transfer mobility between the source and the receiver, $\left\langle |Yr|^2 \right\rangle$ average value of the punctual mobility modulus of the receiving structure, $\langle Y_r \rangle$, $\langle Y_s \rangle$ average value of real part of the punctual mobility of receiver and source.

3 - TEST RIG

A test rig has been realized at INRS in order to test the precision of the method and its limitations. The source substructure of the test rig is constituted with an air compressor fixed on a steel plate. The receiving substructure is a frame of steel bars. The four contact points between source and receiving structure are equipped with four transducers in vertical direction.
The power transmitted has been obtained by using the measured forces and also with the simplified method [4].
Comparison between the directly measured power transmitted to the receiving substructure (using force transducers) and the transmitted power determined using the simplified method (using the equivalent source descriptor concept) showed good agreement in the $50 - 2000$ Hertz frequency range (fig. 4).

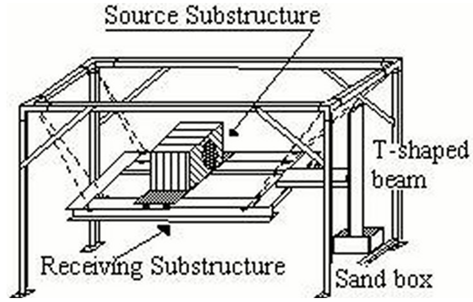

Figure 2: Test rig general view.

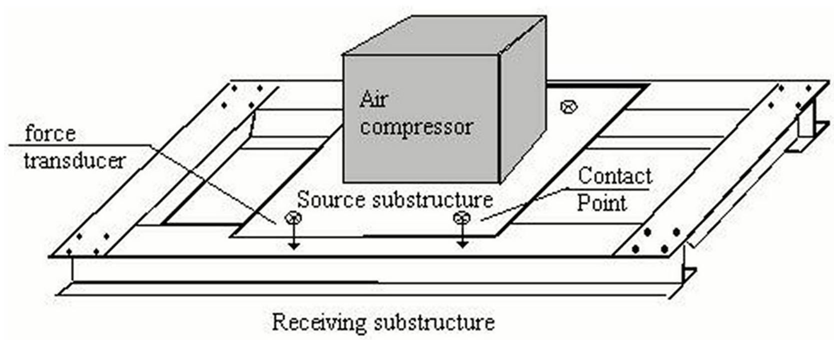

Figure 3: Detail of the coupling between source and receiving substructure.

4 - CONCLUSION

The equivalent source descriptor can be described as an index to the ability of the complete source substructure to deliver real power to the receiving substructure.

The real power transmitted to the receiving substructure is expressed in terms of the equivalent source descriptor of the source substructure, along with the dynamic properties of the mounts and the mobility of the receiver.

On the test-rig, the vertical interaction forces between the source substructure and the receiving substructure can be measured directly using force transducers.

A good agreement is obtained between the directly measured power and the calculated with the simplify method in the $50 - 2000$ Hertz frequency range.

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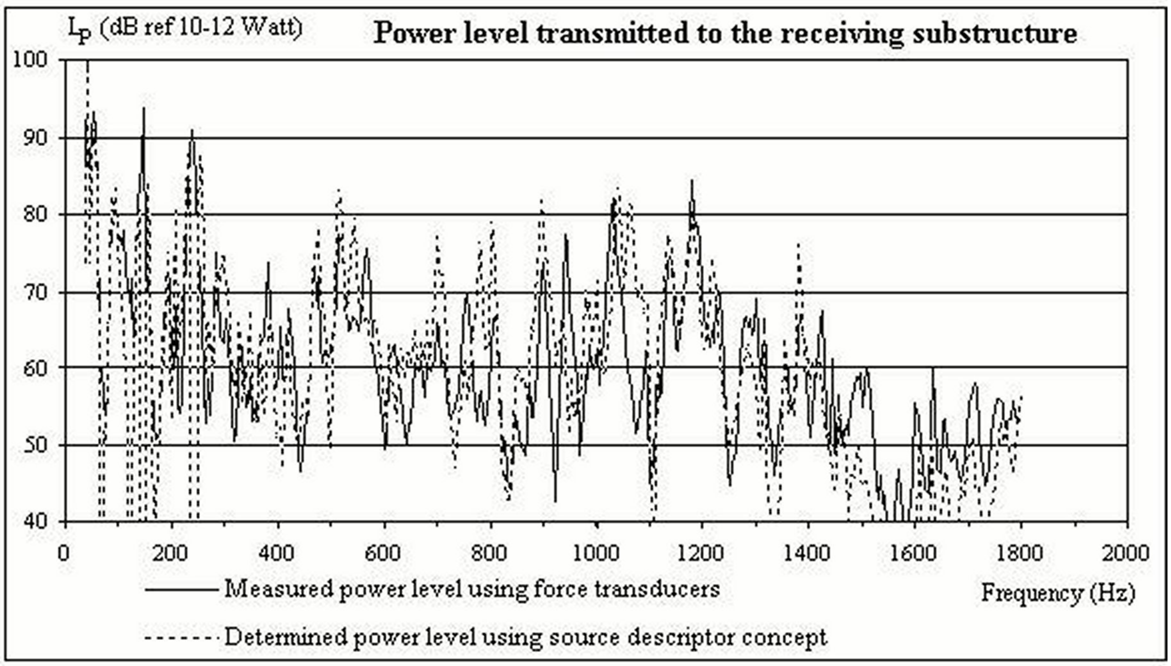

Figure 4: Comparison between measured and calculated vibratory power level.