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THE CHARACTERISATION OF STRUCTURE BORNE SOUND SOURCES

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INTRODUCTION

In this paper the mobility approach is used to predict the vibration in an assembled source and receiver system, starting from data measured on the unassembled subsystems. It is assumed that bending vibration dominates so that three degrees of freedom (normal translation and two perpendicular rotations) are considered at each of the four contact points. This means that a complete description of the subsystems requires a 12x1 free velocity vector for the source, plus 12x12 mobility matrices for both source and receiver structures (all frequency dependent).

CASE STUDY

The assemblage of a small sized fan unit with a beam frame structure is considered. A fan was chosen as a source because fans are present in many machines and are easy to handle experimentally. In industrial situations, active components such as fans are often attached to frames made of beams with added panels, hence a beam frame was chosen as a receiver structure (no panels were added to reduce the risk of an airborne flanking transmission path). The connections between the source and the receiver are made through a screw plus indenter system considered as part of the source. Sources like fan units, compressors, motors are generally compact and are designed to support dynamic forces. Thus, their mobility is governed over a large frequency range by the stiffness of the machine base and below, say 2 kHz, only one or a few modes of the base are present. Hence, with a beam-frame receiver, mobility matching is likely to occur only at a few frequencies. In order to increase the frequency range of mobility matching on one hand, and also to simplify the moment mobility measurements (the L structure of the machine base was too small for the indenter of the moment exciter), a steel plate was added on the source side. The final arrangement under test is illustrated in Figure 1.

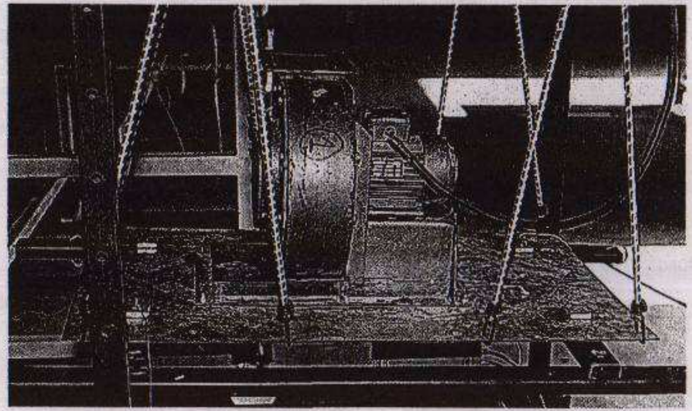

Figure 1: Test arrangement: source (fan+plate); receiver (beam frame)

ACQUISITION AND VALIDATION OF THE DATA BASE

The source and receiver mobility matrices (12x12) together with the free velocity vector are measured on the systems before assemblage. The velocity vector of the coupled systems is also measured for comparison with the calculated velocity vector. Force mobility measurements are carried out using a vibrator, moment mobility using a moment exciter (1), and the free velocities using accelerometers and an angular velocity transducer. The measured data is then transferred to the MATLAB environment for postprocessing. For a better understanding of the transmission several interfaces were considered (one point one degree of freedom, one point three degrees of freedom, four points three degrees of freedom). A large and original data base is thus created. It is believed to represent a unique facility to support analysis of transmission phenomena. An example of the measured mobilities is given in Figure 2 which illustrates the mobility matching between source and receiver structures.

The validation of this data base is a key step in the method because large bias in the measured data will generate errors in the predicted response of the assembled system as well as numerical difficulties. Point mobilities are compared with the mobility of the associated infinite systems and their real part must be positive, Figure 3. Transfer, cross and cross tranfer mobility data is checked by verifying the principle of reciprocity.

After these checks the symmetry of the mobility data is forced by constructing the top half matrix from measured terms or terms obtained using reciprocity. Our experience on cross and cross transfer terms obtained using the moment exciter shows that a significant correction term on the raw data is necessary to compensate for the fact that a pure moment excitation is almost impossible to obtain. Therefore, for these terms to reduce the bias due to measurement errors, reciprocity is applied and the force term is selected. Thus, moment excitation is strictly necessary only for mobilities involving exclusively rotations.

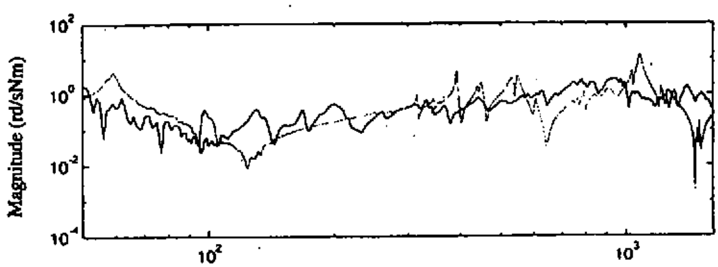

Figure 2: Typical point moment mobilities for the source and the receiver (magnitude)

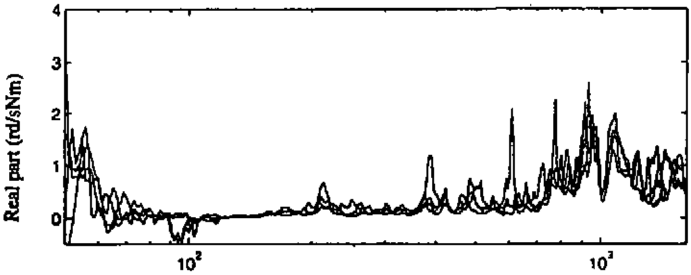

Figure 3: Typical real parts of the moment mobilities of the source

VALIDATION OF THE APPROACH

The calculation procedure is based on the well known mobility formulation of the transmission (2). In the multipoint and multidegree of freedom case it implies a matrix formulation and the resolution of an inverse problem. In MATLAB, a system solving algorithm is used to calculate the force vector , the coupled velocity vector at the contact points and the total transmitted power. The numerical method of resolution is automatically selected and optimised by the MATLAB routine. A systematic comparison between measured and calculated velocities for all degrees of freedom at the contact points is carried out. A few representative results showing a good agreement are presented in Figure 4.

CONCLUDING REMARKS

A complete data base of the structural dynamic and vibration properties of a typical industrial source and receiver structure has been obtained by measurement and validated. Using this data base, a wide variety of investigations can now be carried out in the computer. For example, the relative importance of forces and moments in the transmission of structure-borne sound from source to receiver can be studied as illustrated in figure 5, where the velocity of the assembly for a single point of contact is calculated both with and without the contribution of moments. In this particular case it is seen that the bending moments make a significant contribution and cannot be neglected. Further studies of the transmission, particularly the contribution of bending moments are underway.

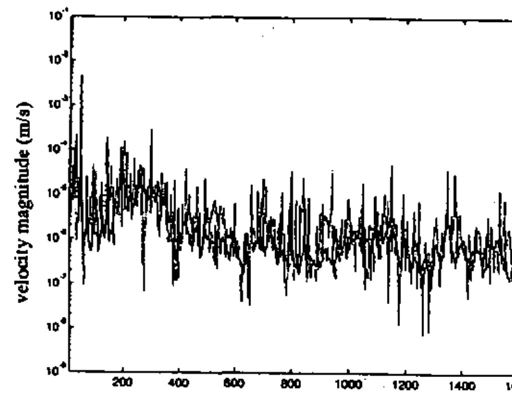

Figure 4: Typical measured and calculated velocity at a contact point (four point interface)

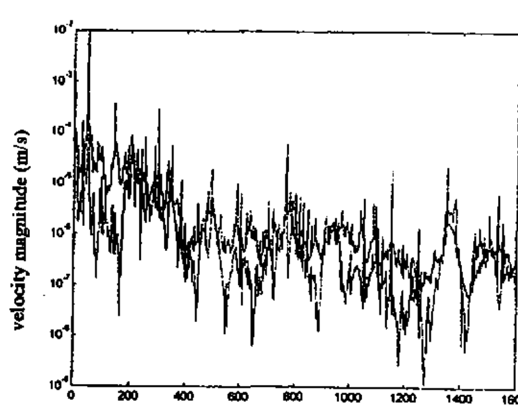

Figure 5: Velocity of the assembly for a single point of contact with and without moments

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