DEVELOPMENT OF AN ANALYSIS PROCEDURE FOR THE ASSESSMENT OF INSERTION LOSS CHARACTERISTICS OF DOUBLE WALL STRUCTURES

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SUMMARY

This paper describes a measurement procedure that will be used to compare the relative insertion loss characteristics of double wall configurations. The proposed measurement procedure includes detailed surveys of the noise and vibration patterns of the double wall configuration in order to enable comparison with numerical elasto-acoustic models (finite element and boundary element).

1. Introduction

In the context of European research projects (BRITE-EURAM and ESPRIT) the K.U. Leuven is involved in the following tasks:

a) development and verification of numerical models to predict interior noise levels in transportation vehicles
b) reduction of interior noise levels in transportation vehicles by advanced noise reduction techniques such as active noise control.

More specifically, K.U.Leuven has to study methods to improve the insertion loss characteristics of double wall configurations. For this purpose an elaborate measurement procedure on double wall sections has been planned. The measurement results will be used to verify the accuracy of elasto-acoustic numerical models. The test set-up has been designed such that comparative insertion loss measurements of various double wall configurations are easy to perform.

Since the implementation of the measurement system was not completed before the submission deadline of the manuscript, experimental results gained from practical measurements will be reported during the oral presentation.

2. Measurement procedure

The lay-out of our measurement procedures as well as the instrumentation system were highly determined by the requirements of the investigations outlined above. The main task of the system is to ensure well-defined and repeatable sound exposure for the structure and to enable comprehensive vibroacoustical data acquisition. The absolute value of the sound insulation is of secondary importance during the model validation tests and the measurements to be done on realistic test sections are also of comparative character. Meanwhile, the majority of the required analyses detailed below does not require diffuse excitation fields which can be assured in standard reverberation chambers only. The use of the testing apparatus available in the structural dynamics laboratory, however, was essential. Therefore it was decided to build a soundproof text box (For its cross section see Fig.1.) such that it is possible to position modelled and realistic test sections (maximum dimensions 1000x700 mm) in the top opening. This concept enables the test rig to be installed in an ordinary laboratory room, though with some absorbing lining on the walls.

The mechanical and acoustical characteristics to be measured on the test structures is determined by the required analyses. Detailed modal analysis of the panel vibrations in terms of acceleration and the acoustical modal analysis of the pressure field in the cavity are envisaged, relative insertion loss measurements as well as intensity mapping of the sound field above the second plate is also planned. These measurements will be compared to the results of FEM and BEM calculations for validation purposes and, on the basis of updated calculations, the control measurements will be carried out on various versions of realistic test structures.

Accordingly, a multichannel measuring system must be used which is capable of measuring the acceleration on both panels and the sound pressures between them. Besides, the incident sound power must be controlled by measuring sound pressure levels within the box. The transmitted sound power can be determined by the intensity probe used for intensity mapping above the structure.

3. Construction of the test box

The crucial element of the development was the construction of the soundproof test box. Most of the problems originated from the low frequency range required for the measurements. The box must have a transmission loss which is at least 10 dB higher than the one of the double wall test section down to 60 Hz. A further practical constraint, namely the demand of occasional removal of the test box, precluded the possibility of applying heavy materials such as prefabricated or mixed-in-place concrete walls which could have been an easy and obvious solution.

After having considered a number of practical solutions, finally a triple house-in-house construction was chosen. The inner and medium layer was made of a special heavy-weight gypsum board material fixed to a wooden frame while the outer one was fabricated from steel, covered with viscous damping material. The specific masses of the layers and the air gaps between them was dimensioned so that the expectable resonance frequencies lie below 5o Hz. In order to avoid reflexions and to increase damping between the layers, mineral wool in thickness of 50 mm was used.

All of the boxes were self-sustaining and independent from each other, in order to avoid any impending flanking transmission between the different layers. Each of the boxes were placed resiliently on the floor of the room and much effort was made to ensure the best possible sealing along the bedding edges as well as between the boxes by using silicon rubber materials. Similarly, the excitation loudspeakers and the microphone array were suspended resiliently and independently.

4. Data acquisition and processing

The data acquisition and processing system is based on an LMS X-Series Fourier System, consisting of a DIFA SCADAS 20-channel fully programmable data acquisition unit connected to an HP 9000/375 type Unix workstation (See Fig.2.). The hardware system is supported by a complete LMS CADA (Computer Aided Dynamic Analysis)-X Software Library.

The incident sound pressures are measured by small-size, low cost PCB electret microphones. For the measurement of sound pressure field in the cavity an array of 60 electret microphones is used. The frequency response of the microphones were previously calibrated in a Kundt tube by using a Brüel & Kjaer 1/2" measuring microphone as reference. The calibration spectra were stored in the database of the measuring system and the measured sound pressure spectra were accordingly corrected each time. For the measurement of the vibration pattern the two panels are each instrumented with 60 fixed PCB Structcell accelerometers to avoid variation of the mass loading by the sensors.

The transmitted sound power is determined by means of a side-to-side intensity probe consisting of two ordinary 1/2" condenser microphones. The probe is fixed in a slender computer-controlled positioning robot, developed especially for acoustic measurements. The calibration of this probe was carried out in the Kundt tube, too. The data acquisition, corrections and postprocessing are performed under automatic program control by means of a number of program stacks, by making use of the powerful user programming facility of the CADA-X System.

5. References

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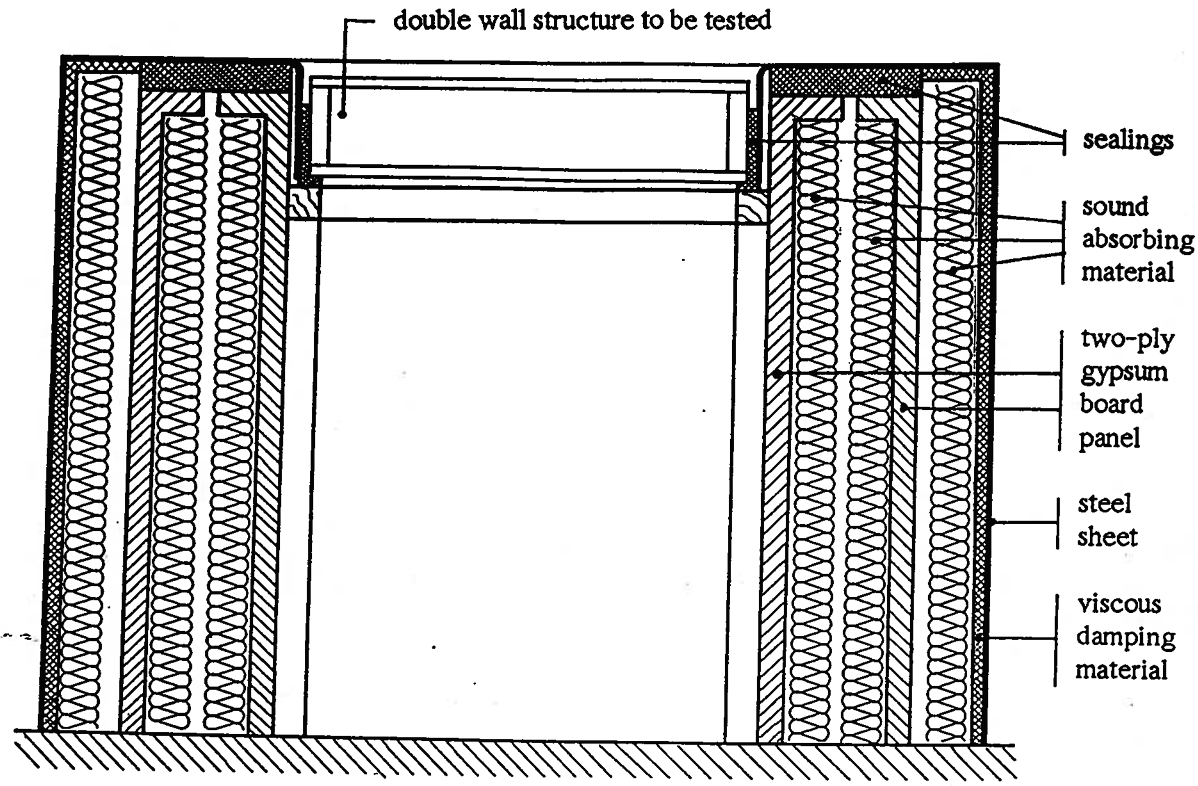
double wall structure to be tested
sealings
sound absorbing material
two-ply gypsum board panel
steel sheet
viscous damping material

Fig. 1.

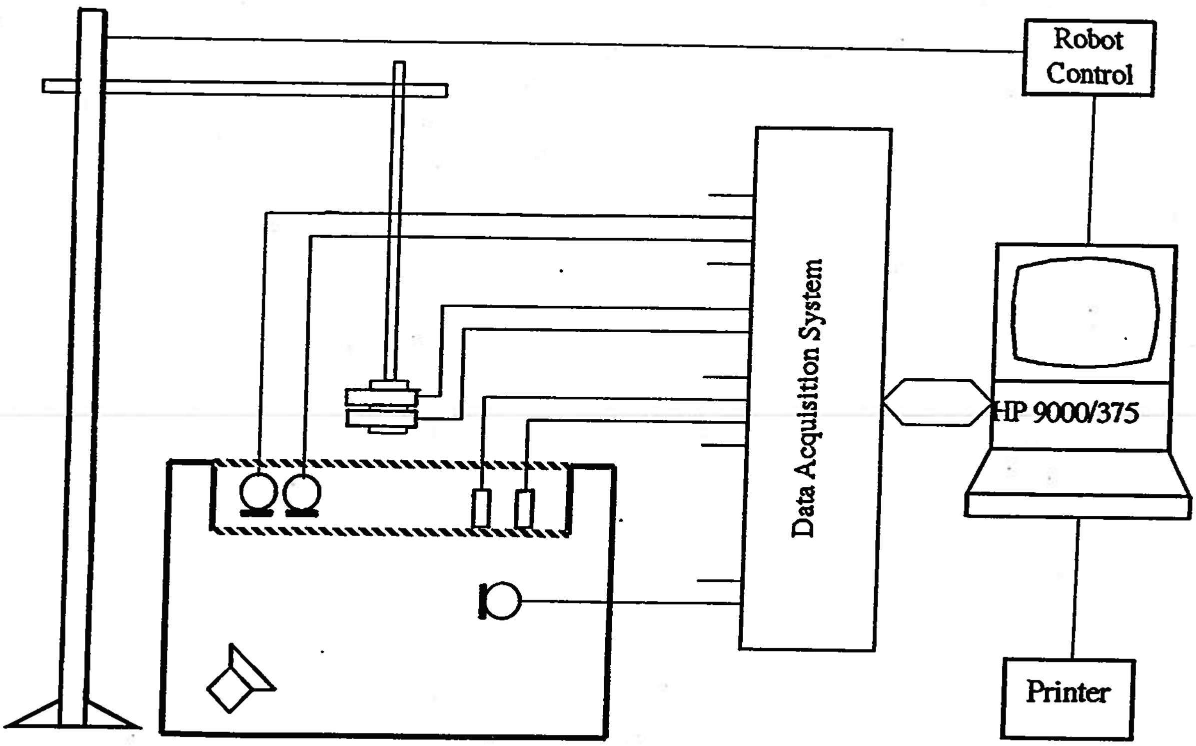
Robot Control
Data Acquisition System
HP 9000/375
Printer

Fig. 2.