A high sound pressure level *in situ* impedance measurement set-up

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Summary

There is a demand for the acoustic *impedance* measurements under high sound pressure levels, particularly in *aerospace* and related industries. Yet standard measurement techniques do not satisfy high demands or are not applicable at all. In this paper a newly developed measurement system is introduced which can be used to measure at sound pressure levels as high as 150 dB. The acoustic impedance can be measured *in situ* in a wide frequency range from 100 Hz - 8 kHz. From this the material *absorption* and *reflection* can be calculated. The method doesn’t impose any restriction on the specimen in terms of shape or mounting conditions. The system has been successfully tested on a highly reactive aircraft engine linear sample; the results are presented in this paper.

Introduction

The system consists of a microphone, which is sensitive to sound pressure, and a Microflown sensor, which is sensitive to particle velocity. By having particle velocity and pressure information at the point, then the surface impedance at a point can be derived directly from the ratio of these two quantities. The measurement procedure involves two steps which each take approx. 10 s; i.e. 1) a calibration measurement without sample and 2) a measurement with the sample. In comparison to the standard *in situ* impedance technique [1] this one also has lower low frequency limit around 100 Hz, mainly due to the higher pressure emission from the loudspeaker.

The measurement with- and without sample can be performed in a regular room such as office or in highly reverberant environment such as car interior. Undesirable reflections are removed via time-windowing the impulse response or by a moving average in the frequency domain [2, 3]. It has been demonstrated that such calibration is equal to an anechoic calibration. Usability of before mentioned techniques depends on the environment conditions, although the usability of the reflection cancelling techniques depends on the measurement conditions.

The impedance measurement system and results

The particle velocity sensor and microphone are positioned at a fixed position, 27 cm from the sound source. The sensors are decoupled from the steel mounting by springs in order to isolate vibrations from the loudspeaker (see Fig. 2). A newly developed type of particle velocity sensor that is suitable for high particle velocity levels is used (see Fig. 1 below)

![Fig. 1: Left: Regular particle velocity sensor. Right: High dB particle velocity sensor.](image-url)
Fig. 2: System to measure the acoustic impedance at high sound pressure levels.

Fig. 3 shows the measurement system that has been developed which is placed directly above a liner sample which consists of small interconnected resonators. Both sensors were positioned approx. 1 cm from the sample surface.

The absorption results obtained by the high sound pressure level method were compared to the ones obtained with the standard *in situ* impedance measurement and can be seen in the Fig. 3 below.

![Absorption graph](image)

**Fig. 3:** Comparison between standard *in situ* impedance measurement (red line) with the high sound pressure level *in situ* impedance measurement (black line).

Fig. 3 shows that the results from the standard set-up and the high sound pressure level set-up are in good agreement for frequencies higher than 300 Hz. At low frequencies deviations were found with the standard set-up because the sound level was insufficient.

Conclusions

A new *in situ* set-up has been developed with which the surface impedance, reflection and absorption of a sample can be measured at sound pressure levels of up to 150 dB OASPL. It has been shown that the method is quick to operate and is accurate, in comparison to the standard PU *in situ* method. According to the preliminary test results it appears that the method has a great potential due to its wide frequency range, portability and dynamic range. However, further testing is required in order to fully evaluate the technique.

References

[1] E. Tijs, H-E de Bree, “Recent developments free field PU impedance technique”, In *proceedings of SAPEM 2008*
