Microflown Technologies B.V.

Particle velocity sensor based in situ impedance measurements

Summary

The combination of a dedicated particle velocity sensor and a miniaturized pressure microphone in one spot opens up new ways of measuring sound intensity, sound energy and impedance.

As compared to the traditional p-p based sound intensity set ups, the new p-u based sound probe has some significant advantages.

The p-u probe offers a full bandwidth sweep up in the range from as low a 5 Hz up to as high as 20 kHz! There is no need anymore to change spacers.
Furthermore, the p-u probe is very compact, and upon request the sensing part can be supplied with remote electronics.
The PU-probe also works in reactive fields.

The availability of the p-u sound probe offers, amongst others, new techniques to measure impedance of various materials in situ.
The traditional method of measuring samples in a calibration tube under laboratory conditions is no longer required!

Laboratory conditions

Within acoustics, the reflection coefficient is an important quantity that provides information on how much sound a material reflects.

The most common way to determine a reflection coefficient is to put a sample in a standing wave tube.

The forward and backward sound wave is determined and with this information the coefficient is calculated.

Although the standing wave tube is a standard way of determining the reflection coefficient, the method has some drawbacks.

To be able to measure one has to cut a sample to fit in the tube, only the normal (perpendicular to the sample) reflection coefficient can be measured.

Measuring the oblique (i.e. the non perpendicular) reflection is simply too difficult.

Real life situations (grass, roads, flowers, humans) are difficult to measure using an impedance tube.

Many scientists have been working on sophisticated mathematical methods to measure the material characteristics in situ.

Microflown Technologies offers solutions based upon solving the real issue, the absence of an adequate dedicated particle velocity sensor!

Two new methods are available now to determine the reflection coefficient:

- sample distance dependent method
- sample distance independent method (intensity over energy method)

Sample distance dependent method

This method has been described in the literature, but has not been widely spread due to the absence of an adequate sensor element.

A 1D p-u sound probe can be put at any convenient position to the user right between the sound source and the material to be characterized.

Thus, the specific acoustic impedance at a certain position in front of the surface can be measured.

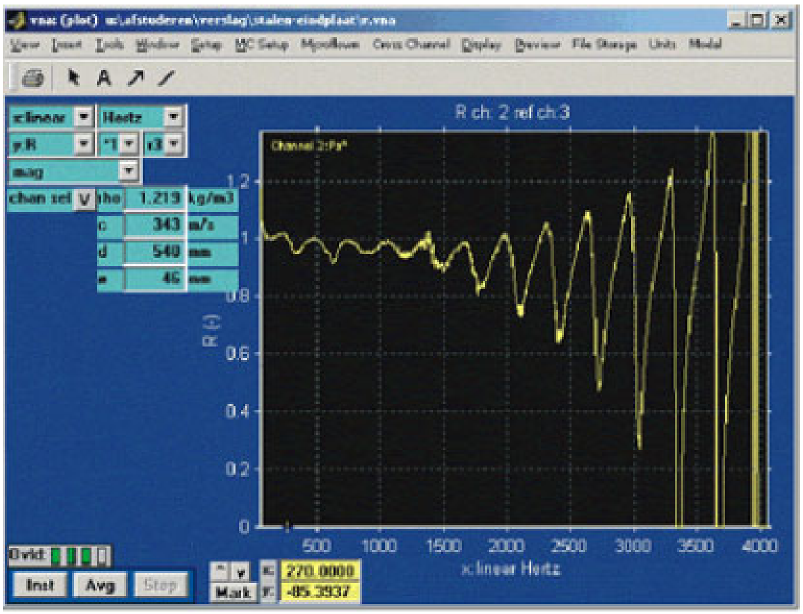
The value obtained can be used to calculate the specific acoustic impedance at the surface.

Apart from measuring the specific acoustic impedance, also the distance from the probe to the surface is essential in this method.

$$Z_{surface} = \frac{Z_{measured} - i\rho c \tan\left(\frac{\omega d}{c}\right)}{\rho c - iZ_{measured} \tan\left(\frac{\omega d}{c}\right)}$$

Where d corresponds to the distance between the probe and the surface of the sample. Once the impedance of the surface is known, the reflection coefficient can be determined.

$$R = \frac{Z_{surface} - 1}{Z_{surface} + 1}$$



Sample distance independent method (intensity over energy method)

This newly proposed method uses of both the measured sound intensity and the measured sound energy at an arbitrary location close to the surface.

This method doesn't depend upon the actual distance, reducing the degree of complexity of the set up.

Sound intensity is defined as the amount of sound energy that moves through a surface.

If sound intensity is measured at a certain position and all the sound is reflected behind the probe, the intensity will be zero.

If the all the sound is absorbed the sound intensity will be a value depending on the loudness of the sound source. To be able to measure independent of the source the sound intensity is divided by the sound energy, and then multiplied by the speed of sound. This ratio is unity if all the sound is absorbed and zero if all the sound is reflected.

$$\frac{I}{cE} = \frac{1-R^2}{1+R^2} \rightarrow R = \sqrt{\frac{cE-I}{cE+I}}$$

Because the method can also be used outside a tube, one is able to perform also oblique (i.e. non perpendicular) measurements.

This method is not worked out yet in detail but is under development.