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ACOUSTIC PARTICLE IMAGE VELOCIMETRY AND SOUND INTENSITY TECHNIQUE IN VISUALISATION OF SOUND FIELDS

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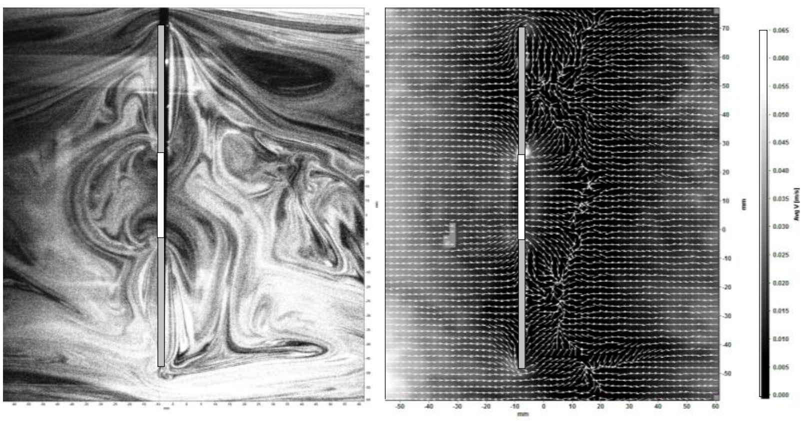
The acoustic field may be described as a spatial distribution of pressure and particle velocity and may be represented by one vectors acoustics parameter – sound intensity (SI). Sound intensity is an energetic parameter which describes the average flow of acoustic energy (Fahy, 1995) and is extremely useful in many cases where the precise acoustic sound source characterisation is needed. Nowadays classical pressure acoustics methods have become omnipresent but its usage does not guarantee correct results in several cases. In order to obtain some reliable results the use of appropriate sound intensity probe is essential and the sensor has to be equipped with a three component acoustic particle velocity transducers and a pressure condenser microphone. The application of the sound intensity probes made possible to visualise many linear and non-linear effects in acoustic field which had never been seen before in conventional acoustics. The main problem with SI technique is its time-consuming procedure. A new system which was recently built uses the virtual instrument technology thus enables automatic and fast measurement procedure. In our paper we suggest an additional possibility that an in-depth analysis of recorded signal leads to more elaborated possibilities of presenting data.



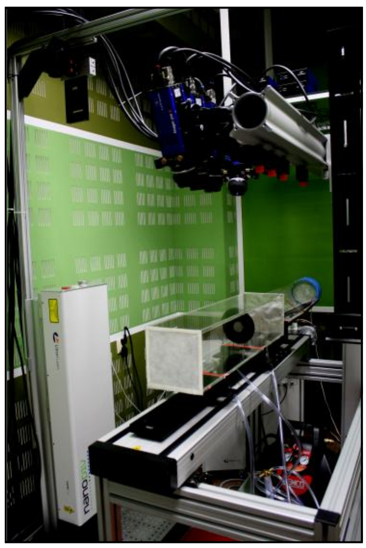


Fig. 1. PIV experimental setup (right) with sample particle image (left) and processed acoustic particle velocity field map (centre)

The data which comes from the sound intensity probe might be used as reference method of sound field visualisation. The main limitation of the typical probe is its size and the potential impact on the measured field. In case of measuring some low frequency sound fields the probe's impact on the acoustic field might be omitted, but in case of interesting phenomena which is observed on high frequencies the influence of the probe dimensions cannot be neglected. Even using the smallest available on market sound intensity probe (5 mm head of Microflown 3D USP transducer) does not allow reaching some particular areas, e.g. acoustic boundary layer in real flow fields.

As we will show in the paper, sound intensity measurement technique even with virtual instrumentation technology support has got some limitations which are not to overcome in some situations where the size of the probe cannot be neglected. In order to improve the correctness of the method a non-intrusive approach is needed.

Particle Image Velocimetry (PIV) is a non-invasive technique based on particles added to the fluid, which enables recording by taking photos of the movement representing the flow in the field (Markus 2007 et al). The PIV is done with the laser as light source and digital cameras as the recording element. From the beginning it is obvious to indicate all areas where the laser-based techniques are superior to so-called traditional methods. The most important advantage of using laser based methods is its non-intrusiveness, so crucial in all observations where any external element may disturb the actual distribution of sound field. Moreover, the laser sheet with its properties evades another problem related to the size of the sensor.

This paper presents a PIV set-up dedicated to acoustic flow in the square acoustic waveguide (Fig. 1.), concerning its ability to measure the acoustic particle velocity in the flow field. Specific aspects of the acoustic velocity have to be taken into account in order to achieve precise measurements, namely to deal with low levels or high frequency. In this areas some optimization of the optics, the mechanical support, and the signal processing are required.

One of the sources of possible problems is the lack of direct pressure data. The necessity to determine the sound pressure is obvious, due to the fact that the acoustic field is described as a spatial distribution of pressure and particle velocity or as a sound intensity. The problem in applying PIV to acoustics testing lies in the fact that we measure only the velocity of the particles but we must calculate the pressure produced by the particle movement. We assume that acoustic pressure has to be calculated in the post-processing part of specially developed algorithm. Since the solution to this problem is not fully described in the literature, we are trying to solve it.

References

Fahy F., *Sound Intensity.* Spon Press London 1995.

Mickiewicz W., Jablonski M., and Pyla M.,(2011) Automatized system for 3D sound intensity field measurement. Proc. MMAR International Conference, vol. 1, 200-203.

Markus R., Willert Ch. *et al.*, *Particle Image Velocimetry: A Practical Guide (Experimental Fluid Mechanics.* Springer-Verlag London 2007.