Open photoacoustic cell for concentration measurements at high flow rates

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Emission monitoring is one of the most important fields of environmental measurements. The pollutants and gases generated by burning of fuels, wood and the illegal burning are harmful to the human body and can lead to severe consequences. Therefore, lots of regulations were made in the last decades in connection with harmful emissions. To fulfil these emission regulations reliable and precise methods and instruments are needed for the authorities as well as for the manufacturers. Photoacoustic spectroscopy is one alternative for this purpose, because of the selectivity of the method, short response time and high sensitivity.

Proper sampling is crucial in the measurement of emission of particulate pollutants and gases mainly in terms of vehicles' emission, but in in other fields as well. Our open PA cell is aiming at the elimination sapling problems, because the complete sample volume flows through the cell. The compact size allows the drastic reduction of response time. However, the realization of this kind of cell is challenging.

In connection with this construction there are more challenges. The gas volume flow can cover wide scale, and noises propagating with the medium and generated by the flow may overload the microphone. The sample flow can easily make the cell dirty, and it can be also really hot which can damage the microphone the optical parts and other instrumentation connected directly to the cell, mainly the parts contacting with the gas. The resonance frequency can be easily alternating with the temperature and the gas composition (in fact with the speed of sound in the medium), so it must be tracked. It is done by chirp measurements and with an ultrasonic sensor. The greatest problem is the noise and the overload of the microphone. The noise can be attenuated with mufflers placed before and after the cell. Besides our developments aiming the reduction of the microphone sensitivity below 7 kHz.

Applications – One of the most important and the most challenging application is in-situ vehicle emission measurement. Exhaust gas is hot, its flowrate fluctuates rapidly, its composition changes drastically. The open cell is a so-called pipe in pipe construction (Figure 1). The inner pipe is the acoustic resonator, the dimensions of the resonator are determined by the desired acoustic mode, the frequency of this mode is around 12500 Hz in room air. The inner pipe is in the centre of the outer pipe connecting with two spokes to it. There are two holes in each spokes, one for the microphone and one for the laser light. The spokes and the resonator are aerodynamically optimised. The cell is water-cooled to avoid overheat.

Another application is connecting to environmental measurements, we are working on the deployment of the open cell to a drone, which could monitor several air components' concentration near the surface without sampling system and with high time resolution. In this case the airflow and the noises are less

disturbing. The measurement seems easier than in the case of vehicle emission, because the conditions are much more stable.

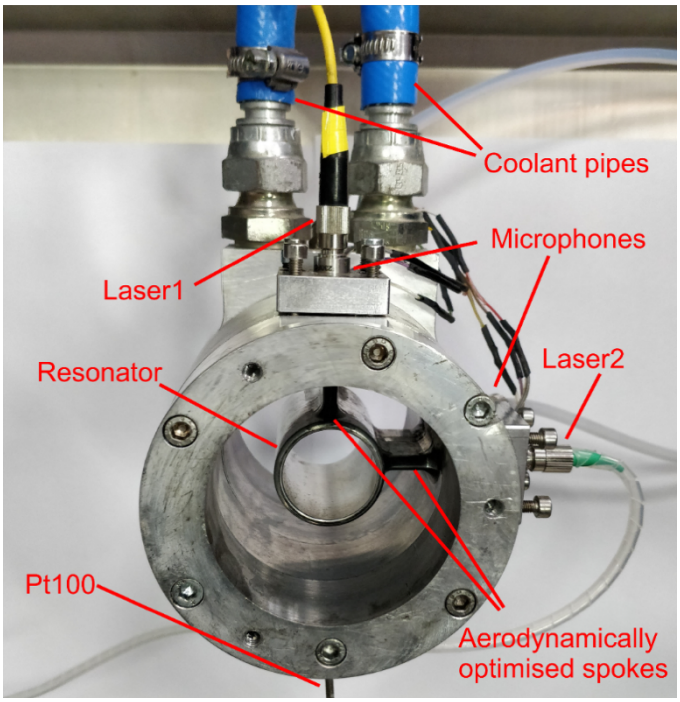

Fig. 1. Open cell optimised for exhaust gas measurement

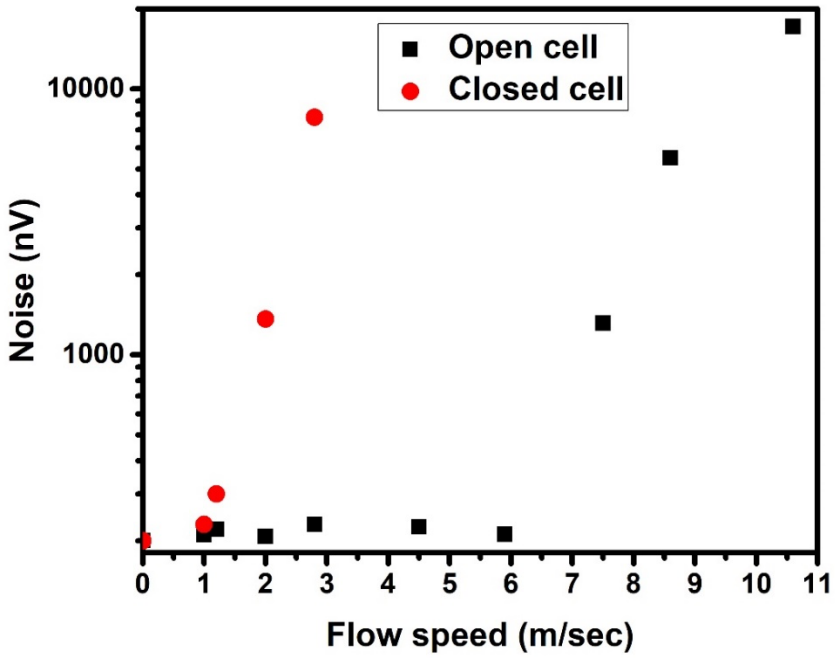

Fig. 2. Flow generated noise in the open cell compared to a conventional closed cell.

Reference

[1] Z. Bozóki, Z., Szabó, A., Mohácsi, Á., Szabó, G. (2010) A fully opened photoacoustic resonator based system for fast response gas concentration measurements. Sensors and Actuators B. 147 (2010) 206-212.