An Intrinsically Pressure Insensitive Low Cost Particle Number Diluter Featuring Flow Monitoring

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Introduction

Particle number (PN) emitted by vehicles has been regulated by European emission standards since 2011 (Euro 5b). The high PN concentrations in raw automotive exhaust exceed the upper measurement limits of state-of-the-art PN sensors, which makes dilution inevitable.

We present a low cost Particle Number diluter including mass flow monitoring. The device consists of a commercial hypodermic needle, a High Efficiency Particulate Air (HEPA) filter and a custom-made flow sensor. The flow sensor is used to monitor the diluter's performance and enable in-time replacement of the low cost elements used.

Dilution

The majority of the sample goes through a HEPA Filter.

A small fraction bypasses filter through hypodermic needle (Figure 1).

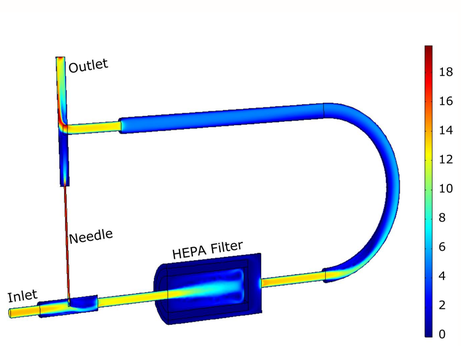

Figure 1: Results of a CFD simulation using COMSOL

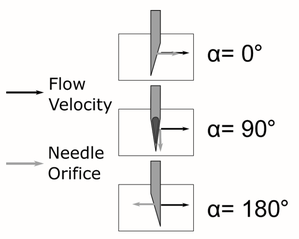

Figure 2: Illustration different needle orifice orientations

A very similar pressure drop to flow dependencies of the needle and the filter yield a robust dilution ratio (DR).

The influence of the orientation of the needle orifice (Figure 2) has been investigate by simulation (Figure 1) and experiment.

The results of CFD simulations (COSMSOL) agree very well with the experimentally observed behavior (Figure 3).

The diluter shows a much lower pressure dependence than other solutions.

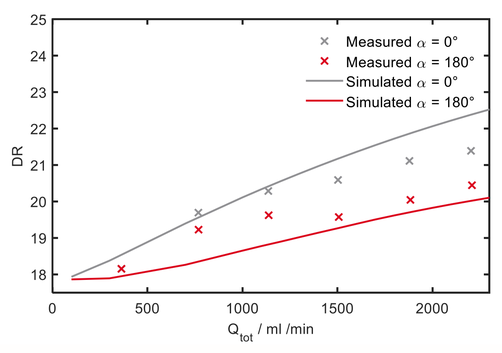

Figure 3: Dilution ratio as a function of the total sample flow rate

Flow Measurement

The flow through the needle is monitored by a flow sensor (Figure 4) consisting of a heating resistor and an NTC and a circuit. The NTC temperature is kept constant by adjusting the heating voltage.

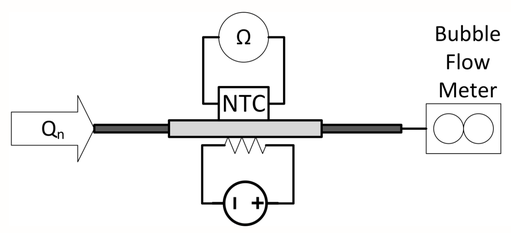

Figure 4: Schematic illustration of the flow sensor

Higher Flow -> More Voltage Required

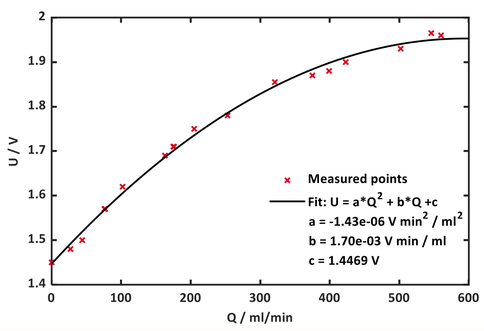

Figure 5: Heating voltage as a function of the flow rate

Figure 5 shows the dependence of the required voltage as a function of the flow rate through the needle.

Measuring the flow rate through the needle enables monitoring of the dilution ratio.

Conclusion

The presented device (Figure 6) provides pressure insensitive particle number dilution, which is very advantageous for vehicle emission measurements. The flow measurement enables monitoring of the introduced dilution ratio.

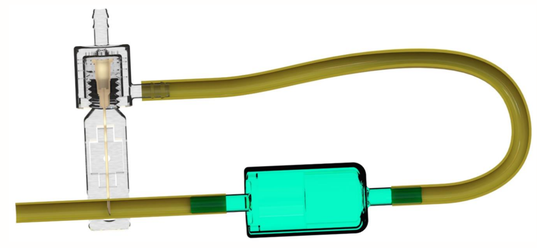

Figure 6: CAD generated picture of the presented diluter

The diluter is used for engine exhaust particle number measurements in the framework of the H2020 project DownToTen.

Funding

This work is conducted in the framework of the H2020 project DownToTen. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nr.724085.

PROJECT PARTNERS

In collaboration with:

The University of California at Riverside

National Traffic Safety and Environmental Lab (Japan)

National Metrology Institute (Japan)

HORIZON 2020

Call: H2020-GV-2016-2017
Technologies for low emission light duty powertrains

Action:
"Measuring automotive exhaust particles down to 10 nanometres – DownToTen"