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

Markus Bainschab and Alexander Bergmann
Institute of Electronic Sensor Systems, Graz University of Technology

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).

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 (COMSOL) agree very well with the experimentally observed behavior (Figure 3).

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

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.

Higher Flow -> More Voltage Required

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.

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