Dependence of Dilution Performance of a Prototype Setup for Sampling Non-volatile Engine Exhaust Particles down to ten Nanometer in Diameter on Pressure Variations in Sample Line

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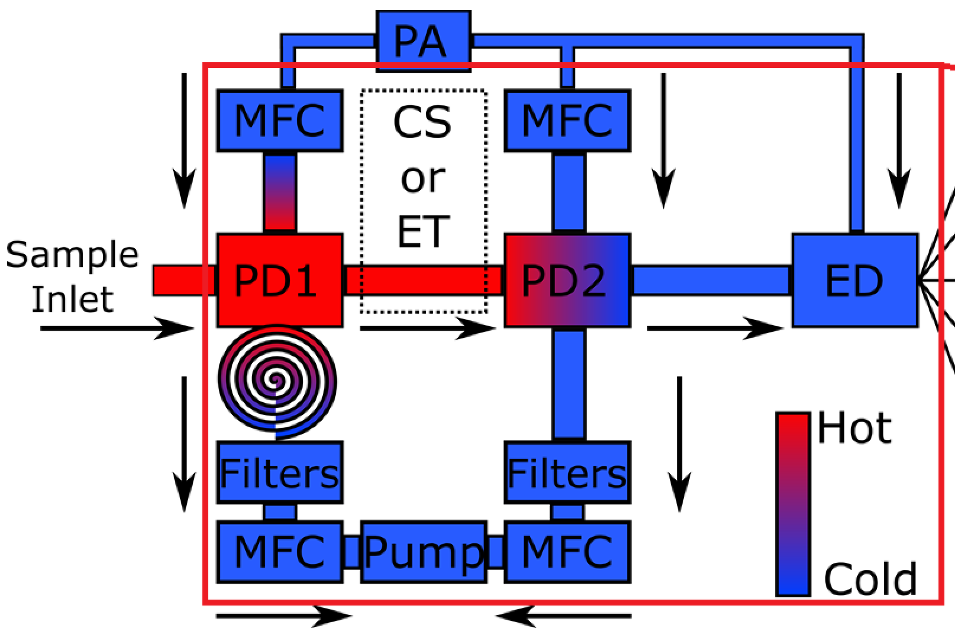
Introduction & background

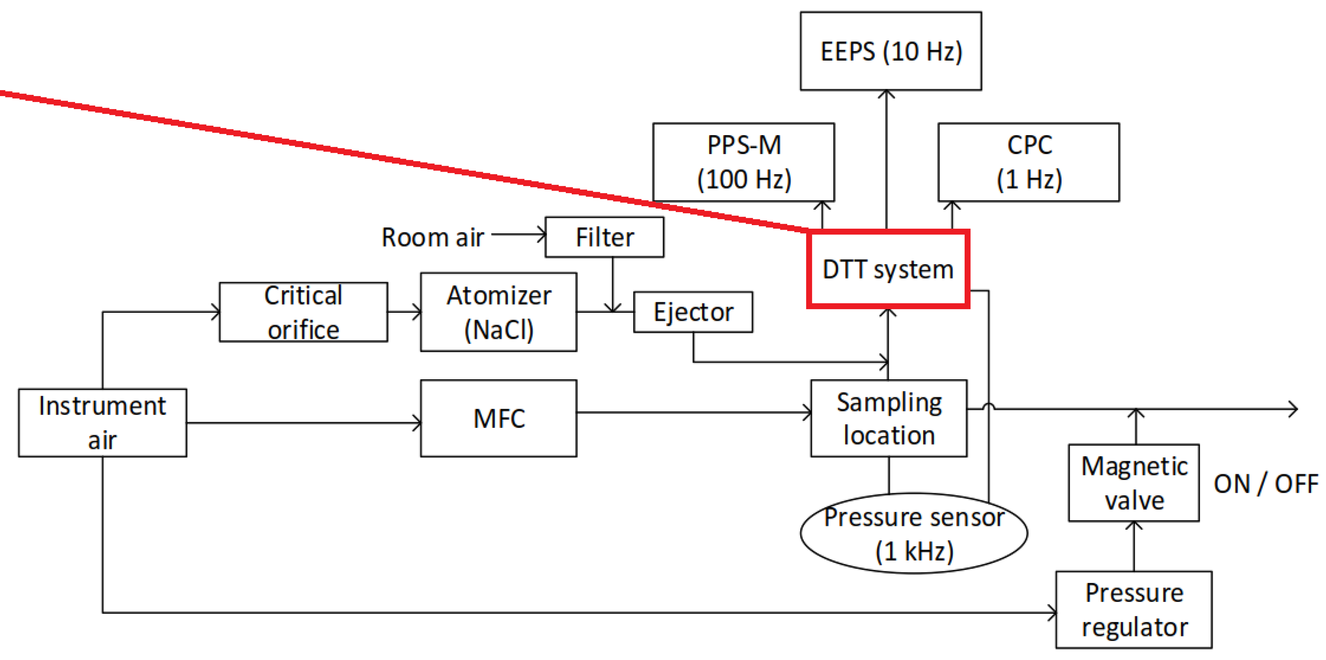
The European Union limits particle number emissions of vehicles by legislation, but particles smaller than 23 nanometers in diameter are left out of consideration. The number of sub-23 nanometer particles emitted by vehicles can be significant, which may lead to increased health risks.

In the project "DownToTen", funded by the Horizon 2020 EU Research and Innovation programme, a prototype setup for sampling non-volatile engine exhaust particles down to ten nanometer in diameter has been built. In order for the setup to be used in a reliable way, its dependence on the operating conditions needs to be well known.

In this study, the setup was tested: the dilution performance was characterized by challenging it with rapid (5-20 millisecond) changes in inlet pressure. A model describing the dilution ratio of the system as a function of time and pressure at the inlet was formulated. The model was then tested by comparing the simulated change in particle concentration to the measured concentration.

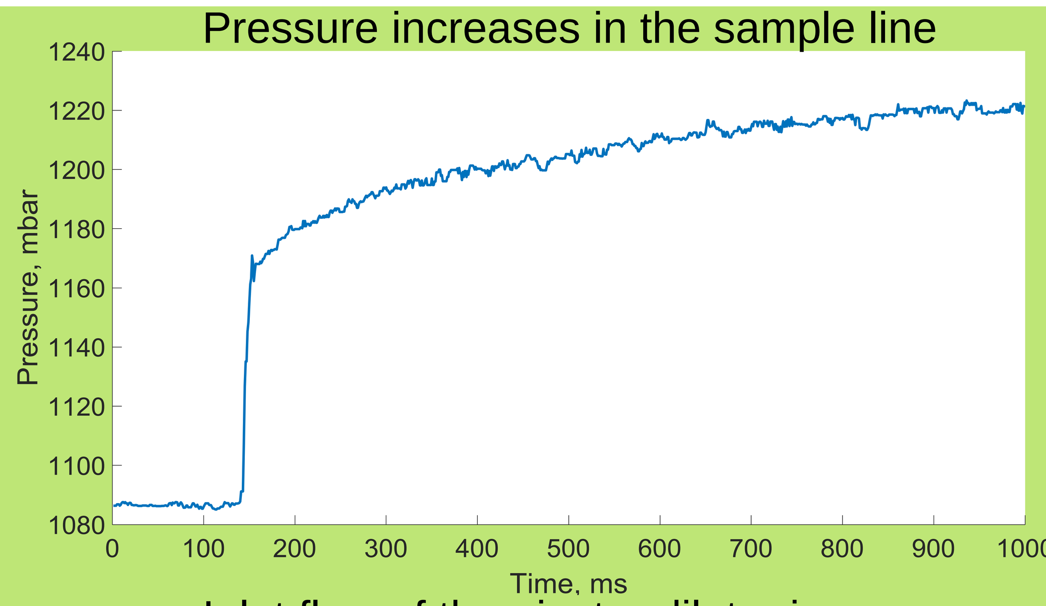
Sampling system and measurement setup



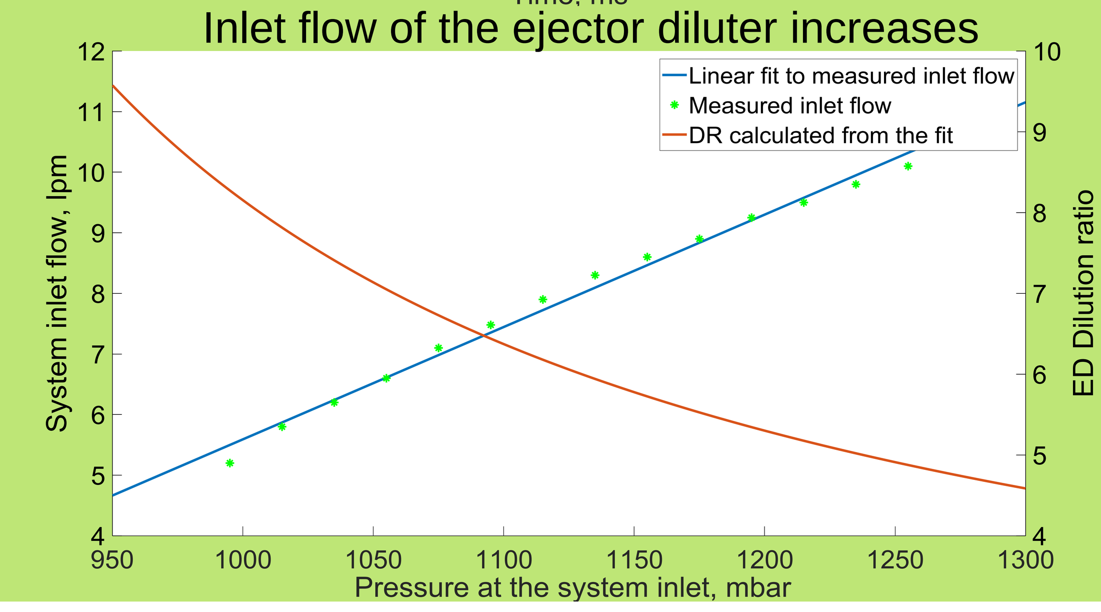


Description of the model

Pressure increases in the sample line



Inlet flow of the ejector diluter increases

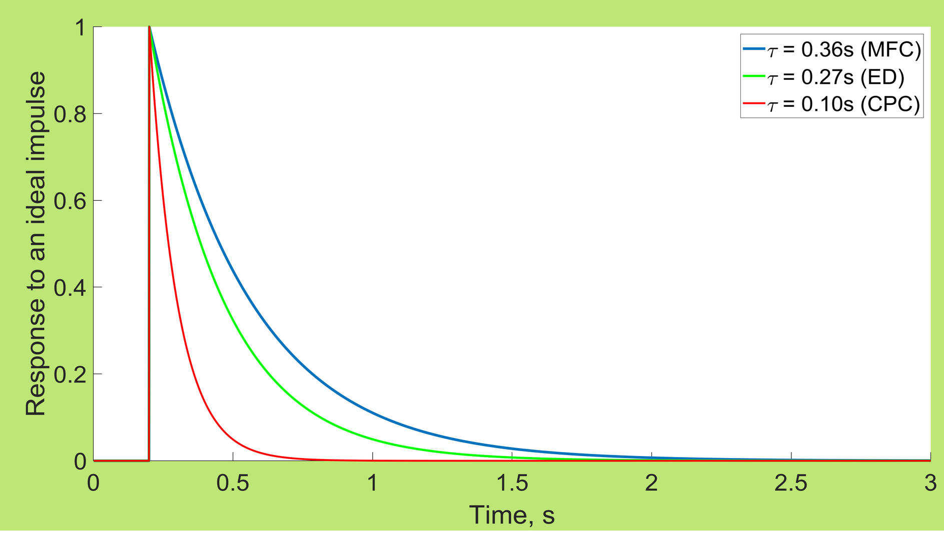


If the increase is faster than the response time of the mass flow controllers, the flow through the excess MFC:s is also higher, but only momentarily.

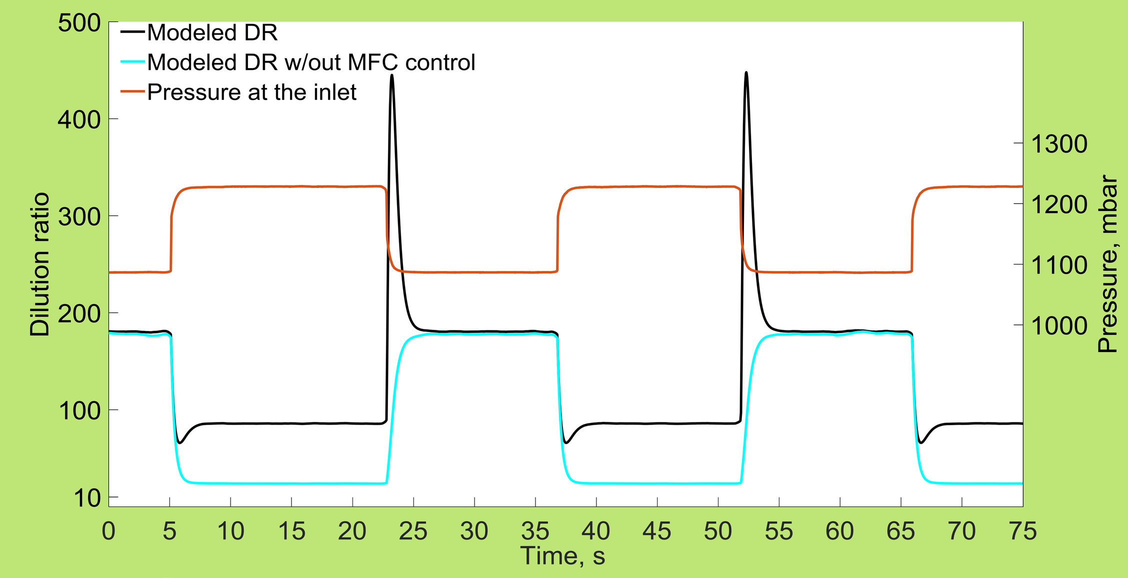
For simplicity, the response of the MFC:s is assumed to follow an exponential function of the form

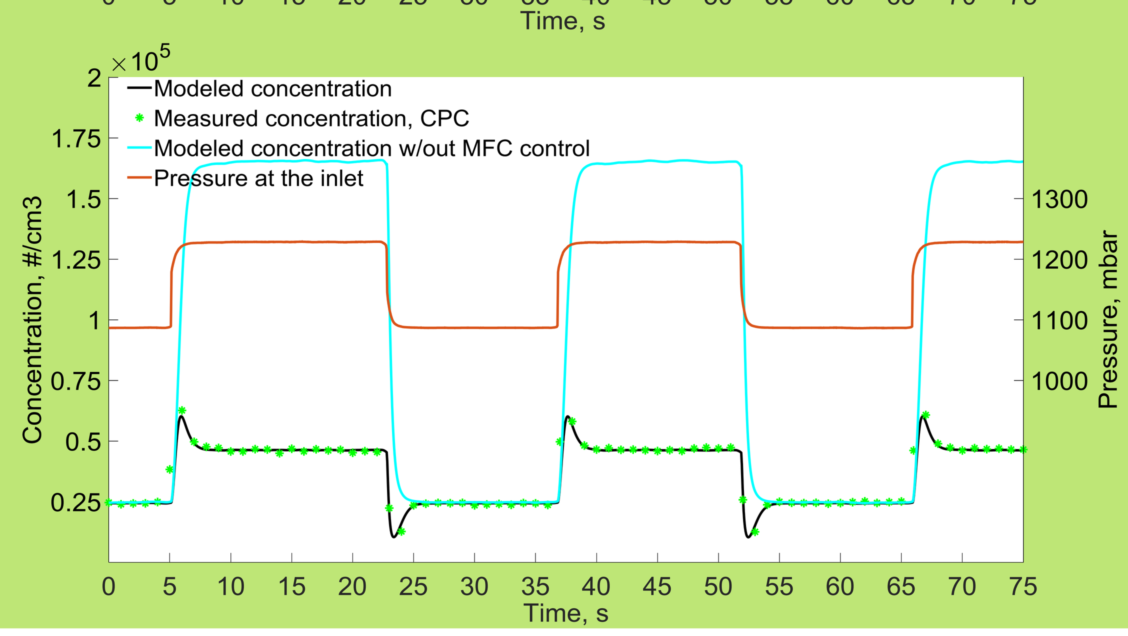
$$IRF = e^{-\frac{t}{\tau}}$$

where τ is the response time. A similar model is applied to take the ejector diluter mixing time and the CPC response time into consideration.



→The combined effect is a rapid increase in the sample flow, followed by settling to a level determined by the ejector diluter pressure dependence.





Summary

- A model describing the dilution performance of a prototype sampling setup as a function of sample line pressure was formulated.
- Prediction of the model was compared to measurement data → good correlation.
- From the results we conclude, that measuring pressure at the inlet of the sampling system does provide a good way for correcting the dilution ratio. However, the time synchronization of the data needs to be extremely precise.

PROJECT PARTNERS

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National Traffic Safety and Environmental Lab (Japan)
National Metrology Institute (Japan)

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