Development of a constant concentration particle source

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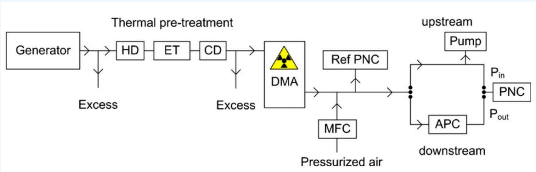
Background and Problem Statement

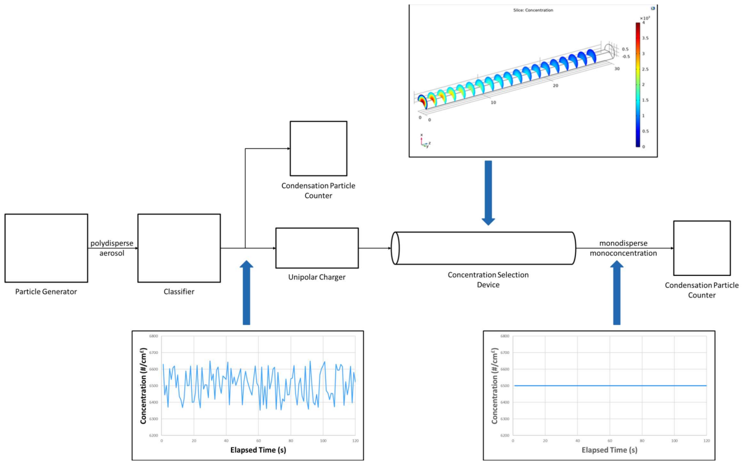
Particle number (PN) standards have been widely adopted in the automotive sector and are becoming convention for regulating PM emissions from mobile sources.

Calibration of PNCs currently rely on comparison with aerosol electrometers as the traceable reference, which has its disadvantages.

A particle generator capable of outputting known, stable concentrations could act as the PN reference standard.



PMP calibration setup [1]

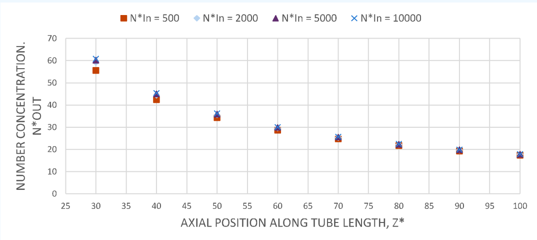


Proposed experimental setup

Research Hypothesis

It is proposed that the effect of electrostatic dispersion can be used to control aerosol concentration by fundamental limits. Boies Research Group [2] have derived equations for aerosol undergoing advection electrostatic dispersion and diffusion in cylinder.

Results from numerical modelling have found that number concentration can be controlled by manipulating the charge stage of the aerosol (electric field) and flow dynamics, but have not been proven experimentally.



Modelled outlet number concentration along the axial position of the cylinder with varying inlet concentration

This project aims to design a series of experiments to validate this trend and subsequently develop a device that can be used for calibrating PNCs.

Research will also extend to investigation into particle generation and charging techniques

Responsible Innovation

The project aims to develop a particle generation method to act as a traceable reference standard for PN regulations. A possible outcome could be to facilitate uptake of the PN standard in more applications. Consideration should also be given to potential particle release and exposure to the end user of such a device.

References

[1] Giechaskiel, B., 2010. Calibration and accuracy of a particle number measurement system. *Measurement Science and Technology*, 21(4)

[2] Boies, A. and Kale, A., 2022. Research. Boies Research Group. Available at: https:/cambridgenanoaerosol.com

Programme and Methodology

The research project with be divided into four work packages

WP1: Modelling
- Familiarisation with developed COMSOL model
- Investigate alternative device geometries, i.e. rectangular channels
- Build polydisperse aerosol distributions into the model function
- Incorporate charging unit geometry to evaluate flow

WP2: Particle source
- Investigate and test potential aerosol generators (SPG, EAG, CAST)
- Size distributions, number concentrations and stability
- Make measurements of particle morphology

WP3: Unipolar Charging
- Testing Cambustion UDAC as potential candidate
- Ion concentrations and charge fractions measurements
- Calculate residence time through the charging region
- Investigate limits of charging

WP4: Concentration Selection Device
- Construct device and design experimental rig
- Generate and analyse data for model validation
- Calculation of uncertainty
- Experimental range finding and sensitivity testing

Scientific Innovation and Challenges

The main innovation of this project is will be to show that a known aerosol concentration can be produced from fundamental first principles (SAIT grand challenge). Applications of the developed device may stimulate further innovation in other disciplines.

Challenges
- Generating sufficiently high particle number concentration
- Charging high concentration concentrations of aerosol
- Characterising unipolar chargers
- Deviations from model assumptions

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