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Comparison of Grimm and TSI Condensation Particle Counters

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10th ETH-Conference on Combustion Generated Particles 21st to 23rd August 2006

Introduction

Condensation Particle Counters (CPC) are intended to give accurate measurement results for particle number concentrations. The CPC sucks the aerosol at a constant flow rate through a saturator, a condenser and an optical detector. Correct measurements require the knowledge of the effective flow rate of the aerosol through the optical detector and the counting efficiency. Above the particle size detection limit the efficiency for the CPC is assumed to be close to one. But high particle concentrations cause coincidence of several particles in the detector. This effect causes too low values and is compensated numerically.

The uncertainties of the above mentioned input quantities have to be optimized when designing a CPC. From the viewpoint of the international System of Units (SI) there is no internationally agreed reference standard for CPC's available. The question arises of how close measurement results agree when measured with instruments from different manufacturers. In this study, the instruments TSI CPC 3022 and Grimm CPC 5.400 are compared.

The aerosol for the comparison was generated by a combustion aerosol standard (CAST) and the particle mobility diameter was adjusted to 110 nm with a differential mobility analyser. Using two rotation disc diluters in series the aerosol concentration was set in the range between 200 / mL to 10 000 / mL.

In order to avoid deviations due to the flow measurement the particle counters were supplemented with external aerosol flow meters. These flow meters compensate the individual flow bias due to the low pressure at the instrument inlet. The linearity of the diluters and the linearity of the particle counters were checked with the same measurement.

Materials and Method (Figure 1)

The aerosol was generated with a Combustion Aerosol Standard (CAST) with a nominal size of about 100 nm. This setting was kept constant during the whole measurement lasting over 6 hours. While the particle size remained the same, the number concentration slowly decreased by 10 %. This was compensated numerically.

The particle concentration was set downstream the CAST with two rotating disk diluters in series. This allows to produce particle number concentrations over two decades.

In a differential mobility analyzer the particle size of 110 nm was selected. The aerosol was fed to three CPCs simultaneously. Two different CPC constructions (Grimm CPC 4.300 and CPC TSI 3022) are compared and the variability of two TSI 3022 is demonstrated.

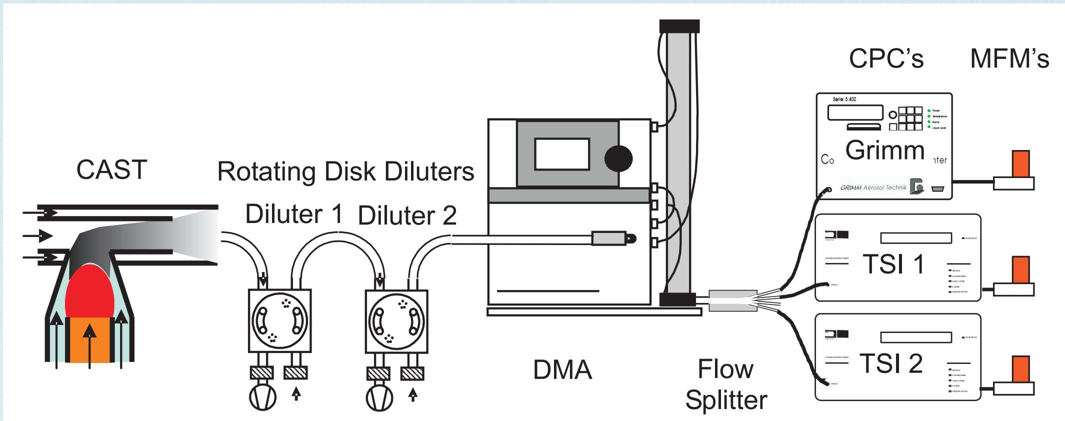

Figure 1: Measurement setup for the comparison of the Condensation Particle Counters: Combustion aerosol from CAST is diluted in two stages size selected in a differential mobility analizer (DMA) and fed to Grimm CPC and two TSI CPCs supplemented with three external mass flow meters (MFM)

Results and Discussion (Figure 2)

In the first experiment the diluters were set so that the influence of the particle coincidence was less important (below 1000 mL^{-1}). The deviation between the two types of CPCs and the deviation from the concentration calculated from diluter settings (diluter concentrations) are below 5 %. They are not significant. In Figure 2a all points for low concentrations lay almost on the straight line with slope 1.

In the second experiment the calibration parameters from the first experiment were used for the calculation of the higher concentrations for the diluter settings (up to 10 000 / mL). Figure 2b shows that the Grimm CPC follows a linear response whereas the two TSI CPC's deviate at higher concentrations.

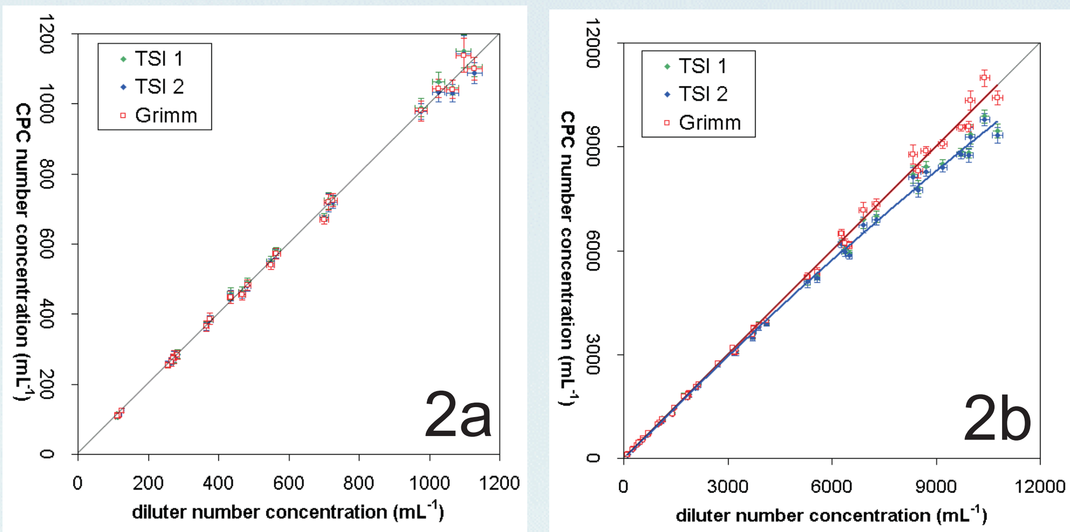

Figure 2: Comparison of the linearity of the diluter and the CPCs at low (2a) and high (2b) concentrations. The concentrations from the CPCs are shown as a function of the concentration from the diluter settings. The bars design the standard deviation of the values (each point represents an average of 30 subsequent measurements), respectively the estimated standard deviation for the calculated diluter concentrations.

Conclusions

The CPC's TSI 3022 and Grimm 5.4000 - supplemented with external aerosol mass flow meters - measured the particle number concentrations up to 1000 / mL with an agreement within 5 %.

Above 1000 / mL particle coincidence starts to cause losses of particle counts and at 10 000 / mL deficiencies of up to 10 % were observed.

Acknowledgment

I like to thank the manufacturers of the CPCs for giving me background information about their instruments. A great thank belongs to my colleagues Hans-Peter Haerri for reviewing the English and METAS, especially Ulrich Feller, for supporting the work.

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