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Memory Effect of Particles in the SMPS

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9th ETH-Conference on Combustion Generated Particles 15th - 17th August 2005

Abstract

The response time of the particle sizer SMPS is limited because of the scanning principle. The scan rate is usually taken as response time. But this is not the only contribution to the response time of the system. The retention and release of particles in the system may cause measuring errors. This memory effect occurs after a change of particle size or particle concentration, if the system cannot be flushed sufficiently. An experimental study with TSI SMPS 3081 shows a retention time exceeding 30 minutes, if the initial particle number concentration reaches 107 particles/mL. The relaxation time depends on the particle size. The time constant for the relaxation can be defined for an exponential relaxation model. It is estimated to be a function of particle size. The reason for the memory effect seems to be the death volume in the aerosol neutralizer (3077) that retains and releases the particles.

Scope

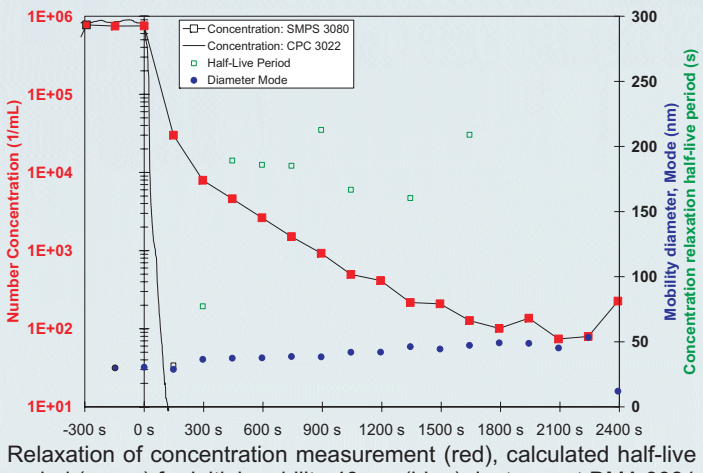
Reliable measurements with scanning mobility particle sizers (SMPS) need constant particle distribution and concentration during the scanning time. Never-theless changing the particle characteristics cannot be avoided nor is even desired. First during slowly changing particle generation and second during the comparison of different particle measuring systems, this experiment shows the effect of fast concentration changements measured with the SMPS (DMA 3081 with CPC 3022 and SMPS 3034 of TSI).

Experimental Setup

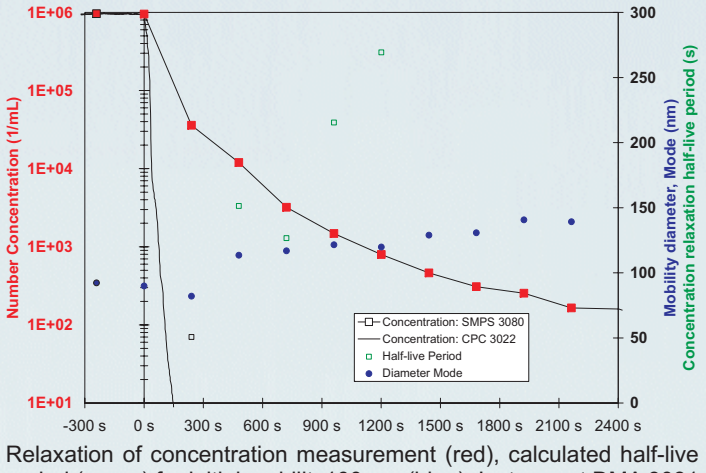
Different combustion aerosols from the CAST (combustion aerosol generator) were used at an initial concentration of 10^6 cm^{-3} and mobility diameters of 40 nm, 100 nm, and 160 nm. The aerosol generation and the measurement (SMPS and a separate CPC 3022) was stabilized. At time zero the aerosol generator was exchanged with a particle filter. The SMPS and CPC measurement was continued for several minutes and the concentration was calculated for each SMPS scan.

Results

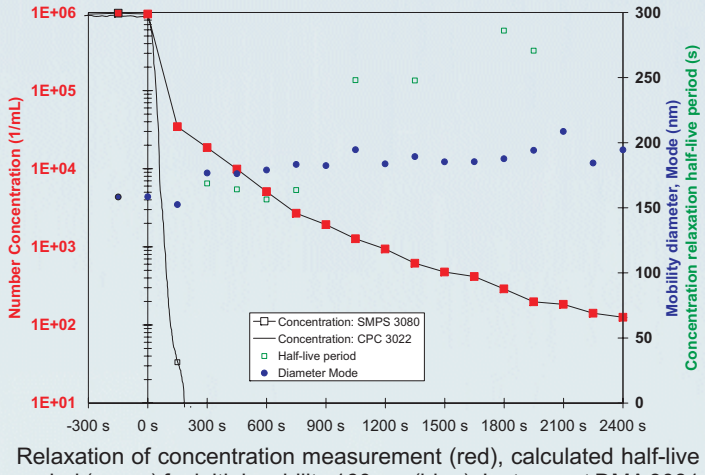
- The relaxation of the concentration measurement with SMPS seems to depend on the instrument construction and the initial particle size and concentration. The relaxation process (red points in Figures) cannot be described with an exponential approximation, the approximation tends to slow down (green dots in Figures don't show constant values).
- Particle coagulation can be observed as the mobility diameter slowly increased during all experiments (blue dots).
- The compact system TSI SMPS 3034 shows the fastest relaxation: Three decades of concentration reduction within 300 s. The long DMA 3081 with CPC 3022 needs for the first three decades of concentration reduction 900 s for 40 nm particles and 1000 s for 100 nm, and over 1200 s for 160 nm. The particles seem to be accumulated or stored in the DMA and are slowly released afterwards (memory effect).



Relaxation of concentration measurement (red), calculated half-live period (green) for initial mobility 40 nm (blue), Instrument DMA 3081 and CPC 3022.



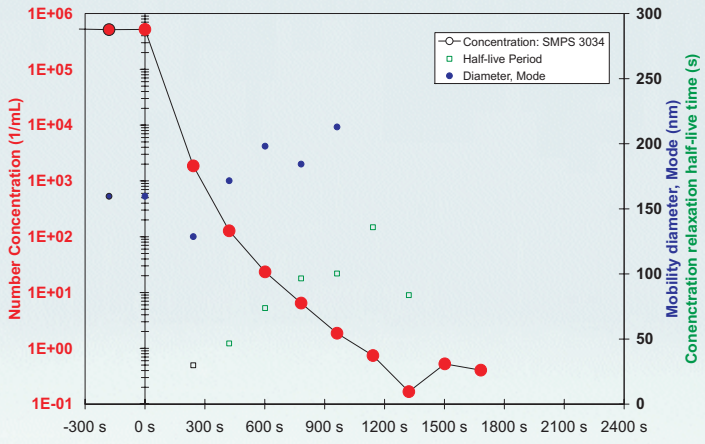
Relaxation of concentration measurement (red), calculated half-live period (green) for initial mobility100 nm (blue), Instrument DMA 3081 and CPC 3022.



Relaxation of concentration measurement (red), calculated half-live period (green) for initial mobility 160 nm (blue), Instrument DMA 3081 and CPC 3022.

Conclusions

The SMPS systems have limited response times not only due to the scanning procedure but also due to a memory effect. This memory effect appears not only in the scanning mode, but also using the DMA at a fixed particle size. That leads to the need to check the actual and total response time for a given instrument configuration before each measurement.



Relaxation of concentration measurement (red), calculated half-live period (green) for initial mobility 40 nm (blue), Instrument SMPS 3034.

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