

Modelling of accidental nanoparticle release into a workplace

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Exposure to nanoparticles is currently discussed within the framework of risk assessment. A potential risk may arise, if an exposure to toxic particles exists. Besides investigations of the toxicity of nanoparticles, the study and eventually the prevention of possible exposure to nanoparticles is thus a major step towards sustainable development of nanotechnology. As of now, exposure has mainly been measured with stationary measurement equipment, such as mobility particle sizers, particle counters or surface area monitors. Some papers have recently been published (e.g. Peters et al., 2006; Evans et al., 2008) that describe mapping of submicron and nanoscale particles using mobile equipment in order to obtain higher spatial resolution of the measurements. Only a few personal sampling devices that determine the personal exposure specifically to nanoparticles exist (e.g. Azong-Wara et al., 2009). However all the abovementioned methods have in common that they can only deliver results with limited or no temporal and/or spatial resolution. Modelling of particle dispersion in a workplace can provide information on temporal and spatial variations of aerosol or particle properties. Furthermore modelling can enable the study of the effects of single particle dynamic processes, such as coagulation or Brownian diffusion on the variation of aerosol and particle parameters. Another advantage of modelling is that boundary conditions, such as wall temperatures or ventilation scenarios can be varied in order to study their effect on particle dispersion and consequently possible exposure to particles in a workplace.

We have developed a simulation grid for a realistic, virtual workplace, including a reactor, transport pipes, furniture, gates and a door. A leak is assumed in the reactor and particle dispersion is studied with the CFD software FLUENT along with the Fine Particle Model. The simulation domain is illustrated in Figure 1.

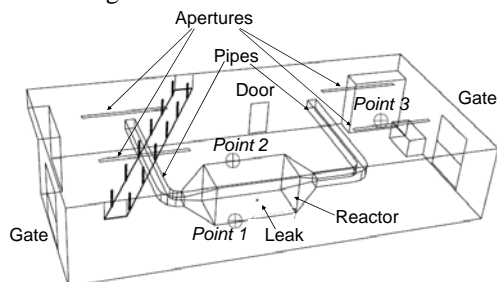


Fig. 1: Simulation domain including reactor with leak, pipes, furniture, gates, and a door

In a basic case, all temperatures in the room were assumed to be 300 K, gates and doors were left open 10 cm at the bottom. The size distribution emitted through the leak was assumed to be lognormal with a median diameter of 50 nm and a concentration of 10^{16} m^{-3} . Parameters affecting particle size distribution and dispersion, including emitted size distributions, ventilation scenarios, background aerosol, and temperatures of floor, reactor wall and leak flow were systematically varied. Figure 2 shows an example of how the size distributions at the three points change, when the temperature of the reactor wall was increased from 300 K to 350 K. In that case, thermophoresis and buoyancy effects can affect particle dispersion in the room.

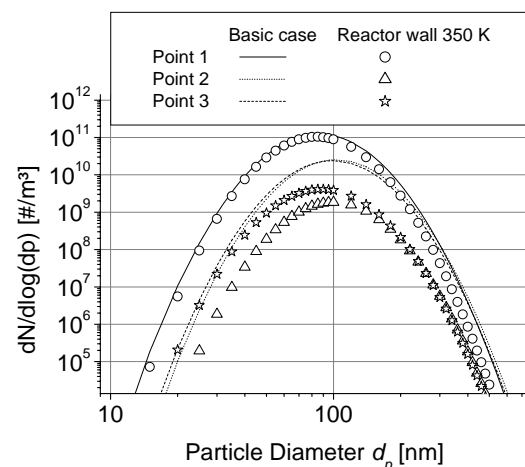


Fig. 2: Change of particle size distribution at three points (see Fig. 1) when the reactor wall temperature was increased from 300 K (basic case) to 350 K

The results show that modelling can be a very efficient tool for studying dispersion and changes of particles during airborne transportation in workplaces. The effect of the modelled variations will be quantitatively discussed in view of importance for exposure assessments and applicability for the design of a safer working environment.

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References

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