Oblique Impact Fragmentation of Nanoparticle Agglomerates

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Keywords: nanoparticle agglomerate, oblique impaction, single stage low pressure impactor, fragmentation
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In order to avoid particle agglomeration or condensation of gaseous components on the particle surface during online sampling from high temperature processes the aerosol has to be heavily diluted. Therefore, the particles usually exhibit high gas velocities in the sampling inlet. Beside high shearing strain particles may impact at different angles on the walls of the sample inlet. Up to now it is unknown, if this mechanical loading is sufficient to change the particle size and morphology, thus, if the sample is still representative for the aerosol.

If agglomerates impact angular, there are two velocity components (schematically shown in figure 1 left). The tangential component impress an additionally shear motion on the agglomerate.

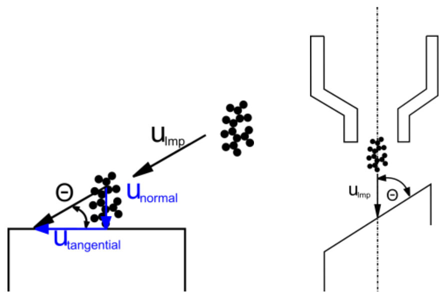

Figure 1. left: oblique Wall impaction of a fractal like agglomerate; right: schematically drawing of a low pressure impactor with an oblique impaction plate

The effect of impact angle on the fragmentation behaviour of nanoparticle agglomerates is poorly investigated. For agglomerates produced in granulation processes with grain sizes in the micron range and agglomerate sizes in millimetre range, it is known, that granules which are sensitive to shear stress, show an increased fragmentation with decreasing impact angle (Samini et. al.).

In order to investigate the role of impact loading and impact angle on the morphology of aerosol particles, their rebound and fragmentation behaviour is investigated in a modified Single Stage Low Pressure Impactor (SS-LPI). The feasibility of agglomerate fragmentation in SS-LPI has already been shown in a number of publications. Particles are impacted on the impaction target with a defined velocity and occurring fragmentation is investigated by determination of the fragment size distribution using Transmission Electron Microscopy. Compared to other studies, the current study also focusses on the rebound of particles after particle wall collisions. Therefore, also the rebound probability of the fragments and their respective size distribution are investigated using a low pressure sampling unit. The fragments are collected until the sampling unit is saturated. Afterwards, the pressure is relaxed to ambient conditions allowing the use of ambient pressure measurement devices such as SMPS. In order to quantify the effect of shear, agglomerates are impacted with different collision angles.

Fractal like platinum agglomerates with a fractal dimension of D_f=1,8 and mobility diameters of x_{ME}=50nm and x_{ME}=70nm were impacted in a single stage low pressure impactor under different impact angles (schematically shown in figure 1 right). The impact velocity is estimated by transferring a three parameter model developed for perpendicular impaction (Rennecke et. al.). First results indicate that the impact angle influence the fragmentation behaviour of nanoparticle agglomerates.
Particles with low fractal dimension tend rather to adhere to surfaces upon collision, while more dense particles are less affected by adhesion force and may easier be re-entrained in the aerosol flow. Further research will focus on the determination of fragmentation threshold and bouncing probabilities of agglomerates of different structures and inter-particle bond strength.

Samini, A., Moreno, R., Ghadiri, M., (2004) Powder Technology "Analysis of impact damage of agglomerates: effect of impact angle"

Rennecke, S., Weber, A.P., (2013) Journal of Aerosol Science, vol. 55, pp: 89-103