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Particle Size Classification by Means of Particle Centrifuge and Diffusion Battery

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The work presented is part of the NanoMet project sponsored by BUWAL, SUVA, and AUVA, which is gratefully acknowledged. The project's aim is the development of a rug, easy to use, and payable measuring equipment for the field testing of airborne particulate matter in the size range below 200 nm.

The measuring technique including dilution is reported by Mr. Kasper in his lecture given at this workshop. It requires, however, a size classification. We shall undertake it in different steps.

The first will be a cyclone acting as a presaparator. Its cut size is 2·5 μm. Cyclones have cut sizes (aerodynamic diameter) depending upon volume flow and thermodynamic properties. Variation of these not only affect the cut size but also the pressure drop.

As a second means in preseparating particles greater than 200 nm (aerodynamic diameter), a particle centrifuge will be applied (a sketch is shown in Fig. 1). In the particle centrifuge, an aerosol stream is exposed to the centrifugal field of a rotating drum forming a solid body vortex. In the flow field, a circular gap between an outer and an inner cylinder, the particles are forced to the outward. Thus regions of enriched and diluted particle concentrations will develop. Unlike in older designs reported in the literature, where the separated particles were collected on a foil cladding the outer inner surface for later determination of the size distribution, the classification serves to produce an aerosol flow fraction reduced of particles greater than the size class of interest, which is fed to the measuring devices downstream (inner flow fraction, Fig. 1).

The centrifuge has two adjustable parameters: Speed (centrifugal force) and throughput (residual time). So it is a freely tunable particle classifier. When operated, it also acts as a ventilator, why the cut size is not coupled with pressure drop. Though for the application in NanoMet the centrifuge's significance will be that of an adjustable presaparator, it can be also used for classifying particles according to their aerodynamic diameter down to below even 50 nm (calculated curves are shown in Fig. 2). After having tested a first design, which shows the practicability but has grade efficiency curves of unsatisfactory steepness (Fig. 3), a new outlay will be investigated soon.

For the size classification of particles according to their mobility diameter, a diffusion battery will be applied. It is of tube type with layers of wire gauze. Here the adjustable parameters are the number of gauze layers, and again the volume flow. A design was tested which comprises a series of layer packages with exits inbetween. Thus cut sizes of 15, 35, 75, and 190 nm (mobility diameter, refer to Fig. 4) could be realised. The reduced gas stream can be fed to connected measuring devices. For testing, monodisperse particles (smoke) were produced with a DMA, while counting was undertaken by a CNC (Fig. 5). The measured data (penetration P, shown in Fig. 6 and Fig. 7 for different flow rates) were fitted with an exponentional correlation, were K is the fitting parameter, n the number of gauze layers, Q the flow rate, and D the diffusion coefficient. Even though the penetration curves are rather flat, they are clearly distinctable for the given diameters. We regard, therefore, the diffusion battery as being well suited for the intended use mentioned above.

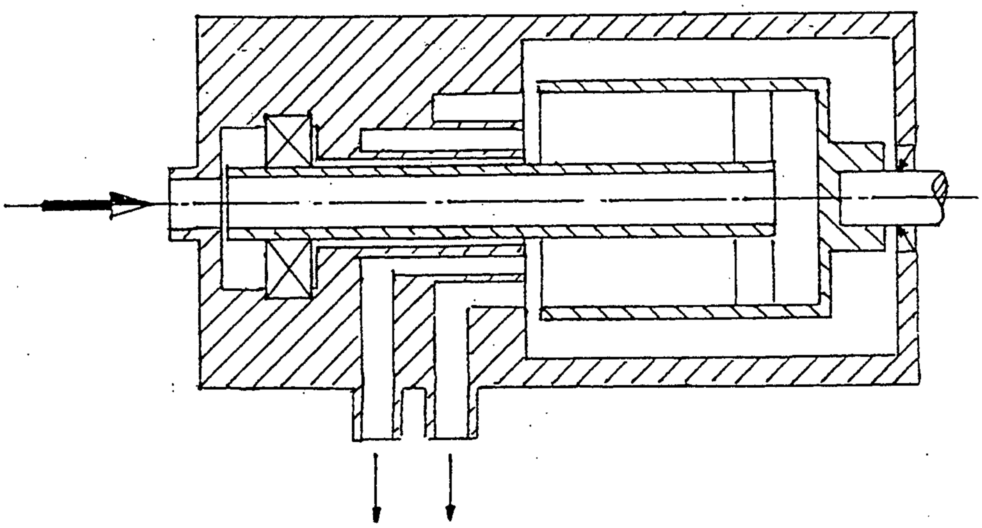

Figure 1 Diagramatic construction of the particle centrifuge

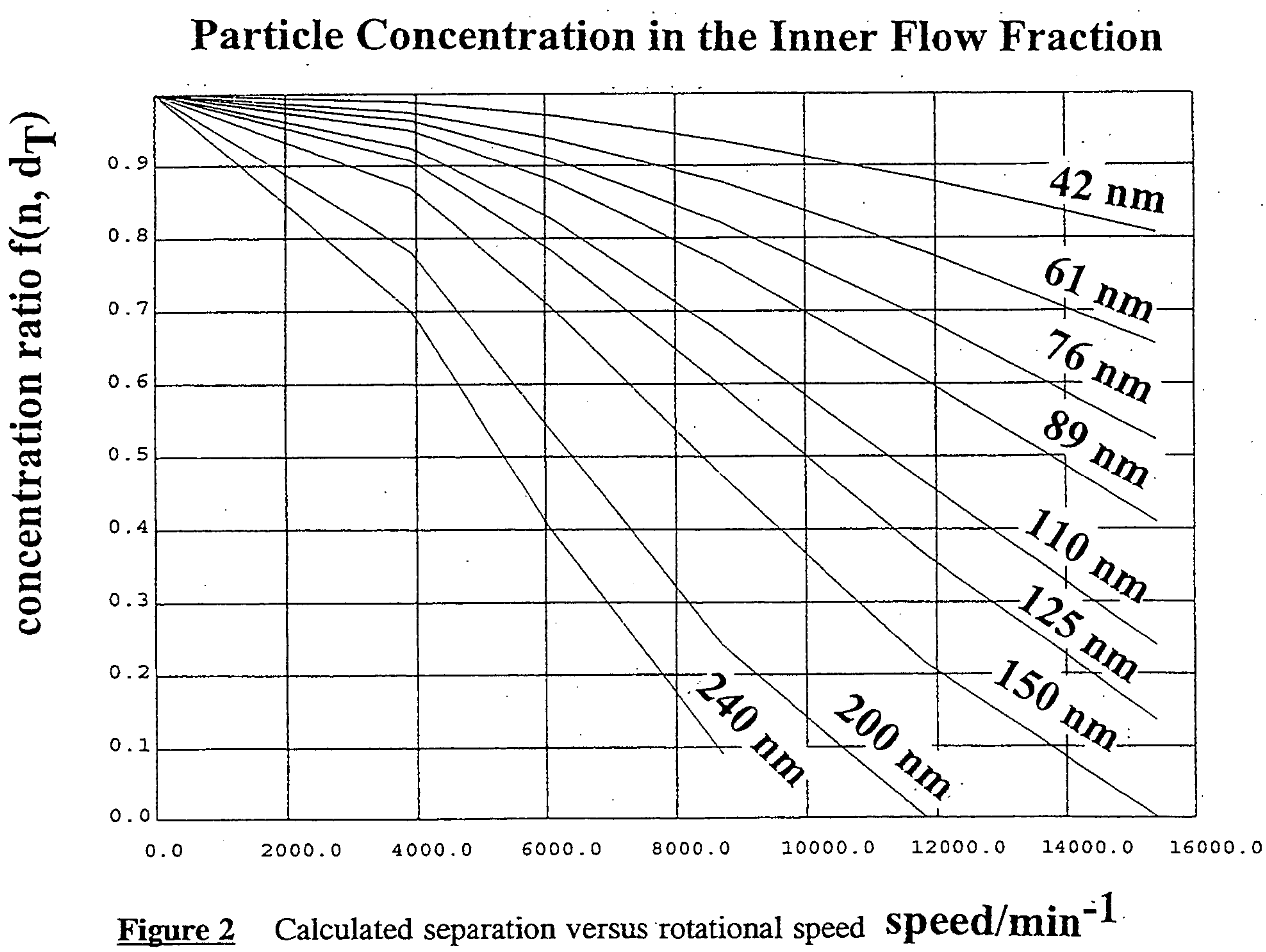

Figure 2 Calculated separation versus rotational speed

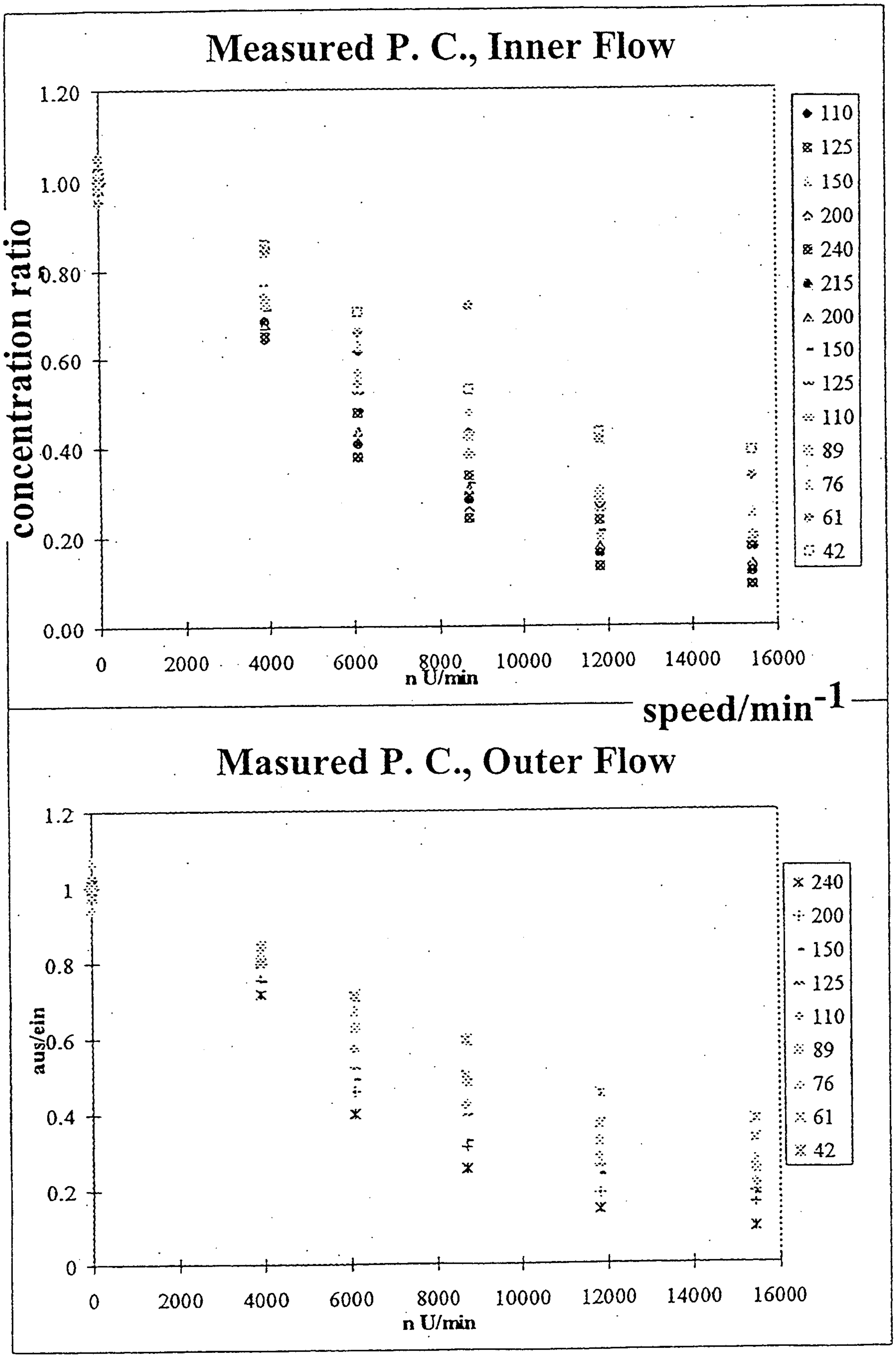

Figure 3 Separtion efficiency of the particle centrifuge

Diffusion Battery

Type: Tube with layers of wire gauze
Adjustable parameters: Number of gauze layers, throughput
Design: Series of packages with exits inbetween
- Cut sizes 15, 35, 75, 190 nm (mobility diameter)
- reduced gas stream for connected measuring devices

Fitting of calibration data:

$$P = \exp\{-K \cdot n \cdot (Q/D)^{-2/3}\}$$

Figure 4 Fitting of the measured data

Experimental Set-up

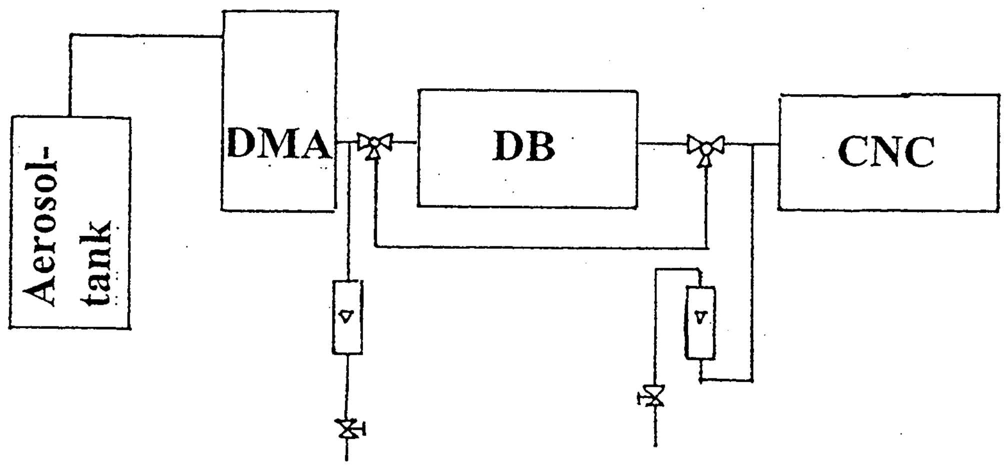

Figure 5 Experimental set-up

Throughput 1·5 l/min

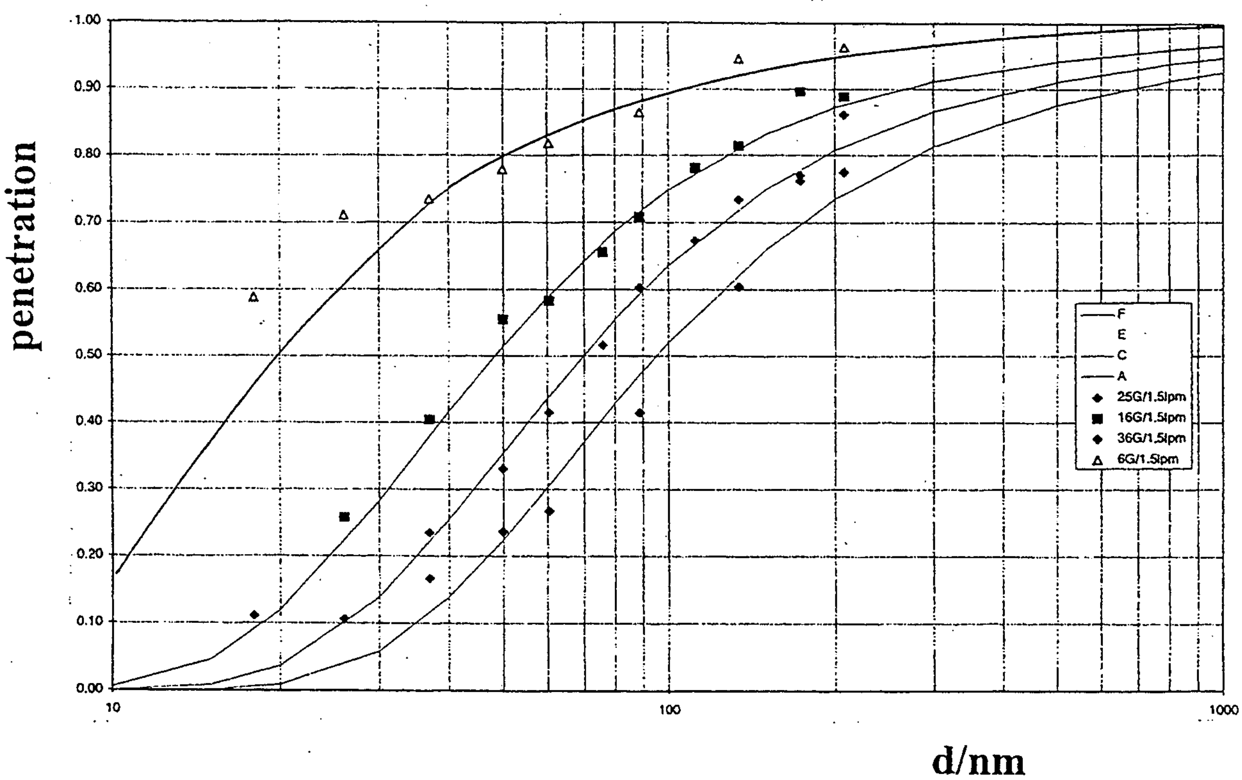

Figure 6 Penetration of the diffusion battery, flow rate 1·5 l/min

Throuput 3 l/min

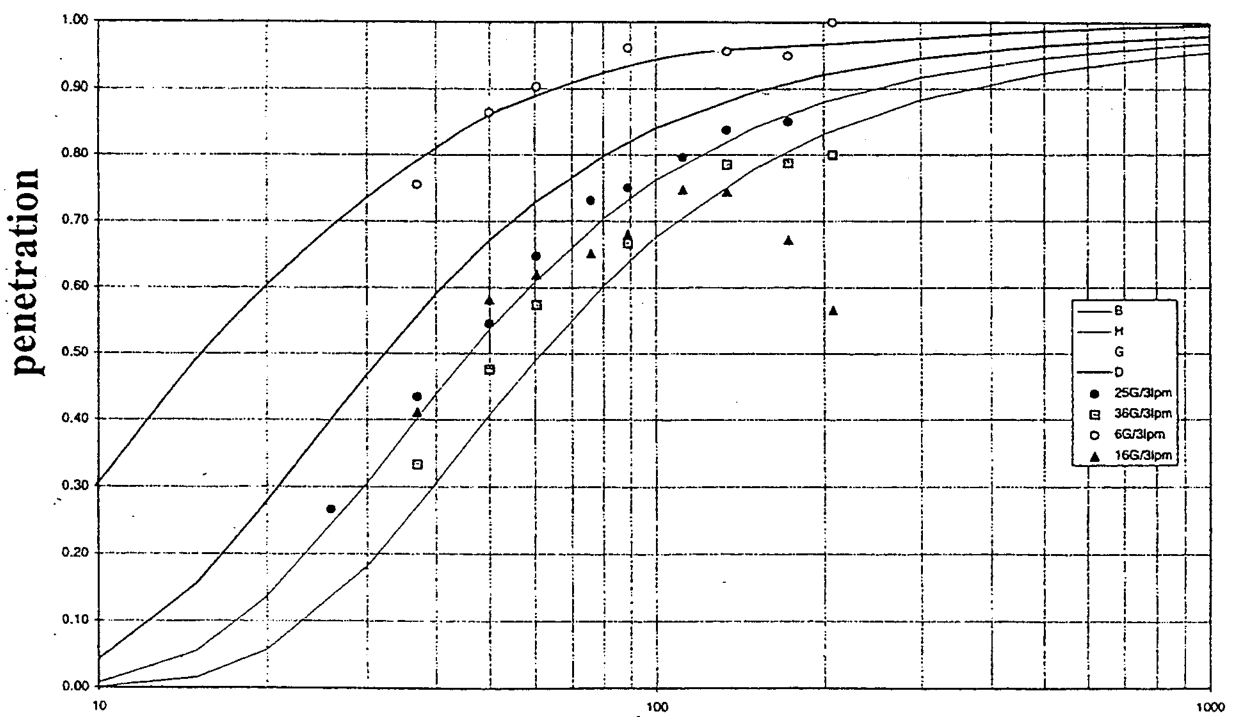

Figure 7 Penetration of the diffusion battery, flow rate 3 l/min **d/nm**