Merseburg, Germany, 23. February 2009

Test case

Particle dispersion in a vertical channel flow

In this test case the particle dispersion in a vertical channel flow is considered. The governing physical effects influencing the particle motion are turbulent dispersion, wall collisions including the effect of wall roughness and transverse lift forces. The flow configuration is shown in Fig. 1. A plane particle-laden air jet mixes with two co-flowing plane jets within a vertical channel. The walls of the channel were made of milled aluminium alloy plates. The roughness has not been analysed, but it can be assumed that the roughness height is about 10 - 20 µm. Two flow conditions with different particles are considered. The particles were spherical glass beads (ρ_p = 2.5 g/cm^3) with a mean number diameter of 45 and 108 µm, respectively. The measured number size distributions of both kinds of particles are given in Fig. 2 and Table 2. The particle mass loading in the central channel was 0.02 for the flow condition with the small particles and 0.17 for the large particles. Therefore, the influence of the particles on the gas phase may be neglected. The velocity profiles of the gas and particles at the inlet are shown in Fig. 3 and the flow conditions for both cases are summarised in Table 1.

For the gas phase the transverse velocity component was not measured. Therefore, it is suggested to assume zero mean velocity and a velocity fluctuation corresponding to a fully developed channel flow (e.g. Laufer, 1950). The particle velocity fluctuation in the transverse direction was found to be related to the RMS-value in the streamwise direction as given in Table 1 for both cases. With these correlations the transverse fluctuations of the particles at the inlet may be estimated from the profiles of the streamwise fluctuation.

The measurements for both phases were performed using Laser-Doppler anemometry. Measurements are available for the cross-sections 100, 300, 550, and 1050 mm above the inlet. The measured data for the two test cases are available on two data files (case 1 and case 2). More details about numerical calculations on these test cases using the Euler/Lagrange approach may be found in the following references (Sommerfeld and Zeisel 1988, Sommerfeld 1990, Sommerfeld 1992, and Sommerfeld 1996).

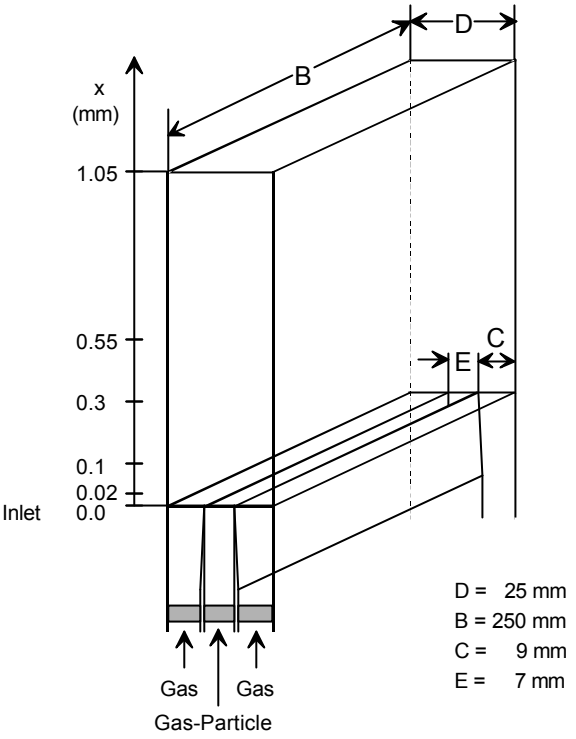

Fig. 1 Configuration and dimensions of the vertical channel

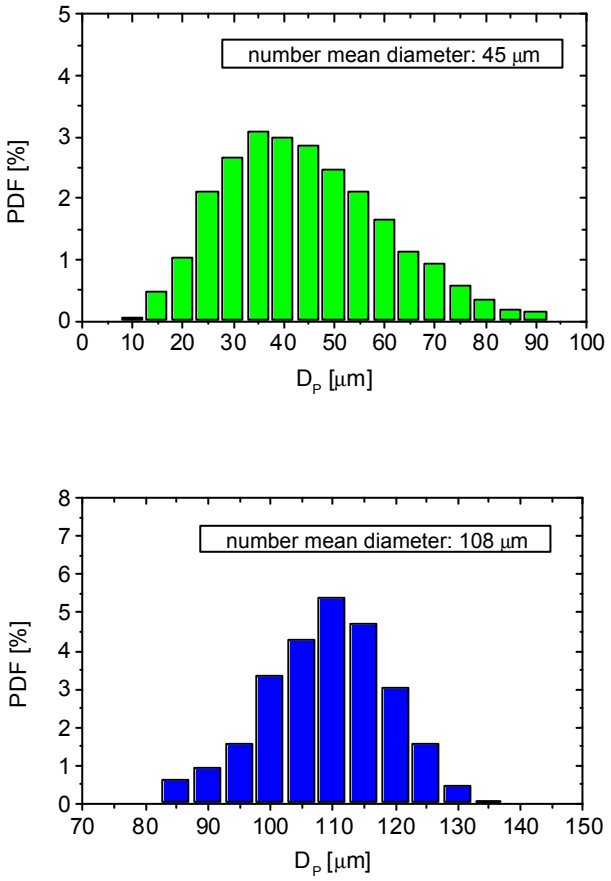

Fig. 2 Measured size distributions of the gas beads (number fraction), a) $\overline{D_p}$ = 45 μm, b) $\overline{D_p}$ = 108 μm

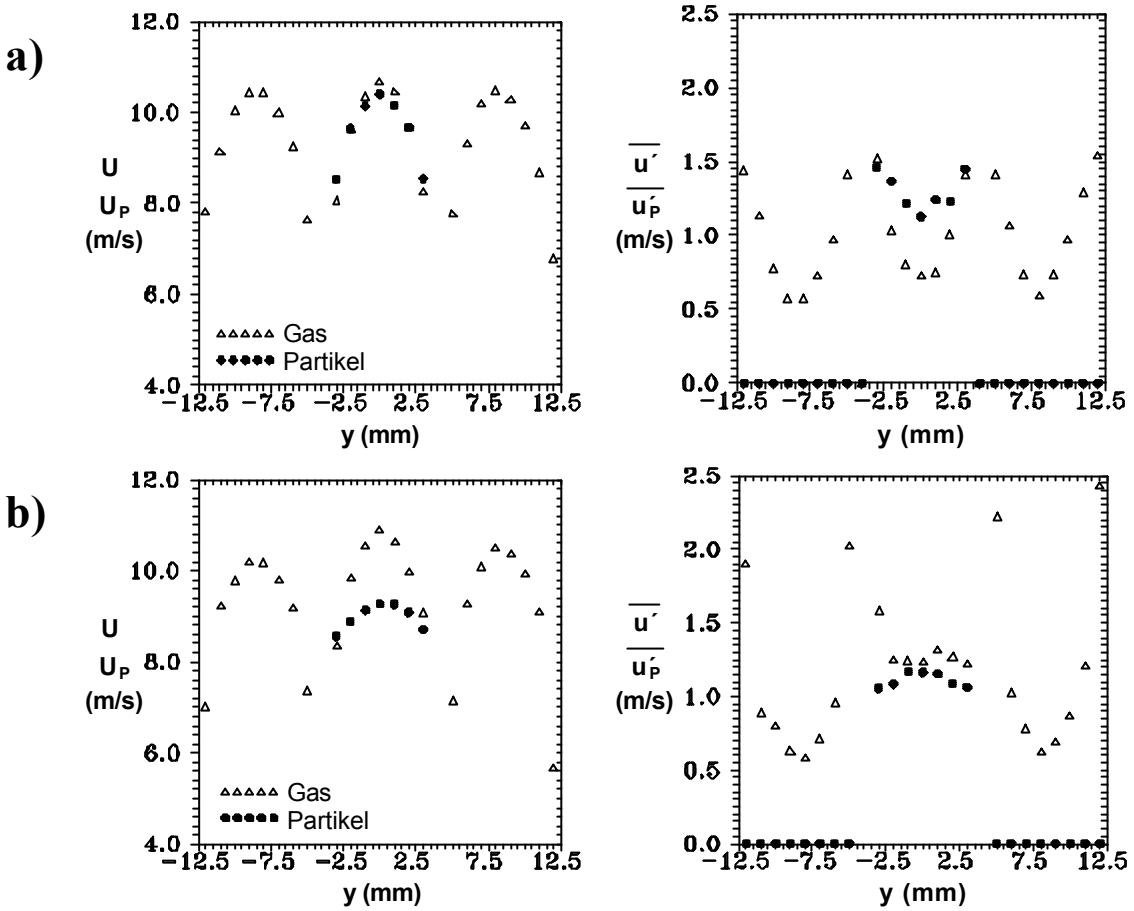

Fig. 3 Profiles of axial mean velocities and RMS-values for both cases, a) $\overline{D_p}$ = 45 µm, b) $\overline{D_p}$ = 108 µm

	Case 1	Case 2	
Number mean particle diameter	45	108	µm
Particle mass flow rate	0.04	3.21	g/s
Mass loading	0.002	0.17	-
Mass flow rate of air in central channel	18.93	19.1	g/s
Mass flow rate of air in both outer channels	41.59	41.72	g/s
Average air velocity in the channel $\overline{U_0}$	8.56	8.6	m/s
Reynolds number based on total channel width	13 009	13 070	-
Transverse velocity fluctuation of particles v'_P	0.35 u'_P	0.23 u'_P	m/s

Table 1 Flow conditions for both test cases, air density: $\rho = 1.1307 \mathrm{kg/m^3}$, dynamic viscosity of air: $\mu = 18.6 \cdot 10^{-6} \mathrm{kg/(ms)}$

Particle Size [µm]	Number Fraction [%]
10	7.50E-02
15	4.70E-01
20	1.05
25	2.1
30	2.67
35	3.1
40	3.0
45	2.86
50	2.48
55	2.1
60	1.67
65	1.14
70	9.50E-01
75	5.70E-01
80	3.60E-01
85	1.90E-01
90	1.43E-01

Particle Size [µm]	Number Fraction [%]
80	3.00E-02
85	6.50E-01
90	9.50E-01
95	1.6
100	3.35
105	4.3
110	5.4
115	4.7
120	3.05
125	1.55
130	5.00E-01
135	5.00E-02

Table 2 Particle size distributions (number fraction in size classes of 5 µm width), left: 45 µm, right: 108 µm.

References

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