Test Case

PARTICLE DISPERSION IN A PLANE SHEAR LAYER
6th Workshop on Two-Phase Flow Predictions
Erlangen, 1992

Description of test case, inlet and boundary conditions

1. Experimental set-up

The flow configuration used in the experiments is shown in Fig. 1. Two air streams separated by a splitter plate enter the test section (width 100 mm) through a converging nozzle with different velocities. Two flow conditions were considered with different bulk velocity but with about the same velocity difference:

- $U_b = (U_1 + U_2)/2 = 17$ m/s with: $U_1 - U_2 = 8$ m/s
- $U_b = (U_1 - U_2)/2 = 8.5$ m/s with: $U_1 - U_2 = 9$ m/s

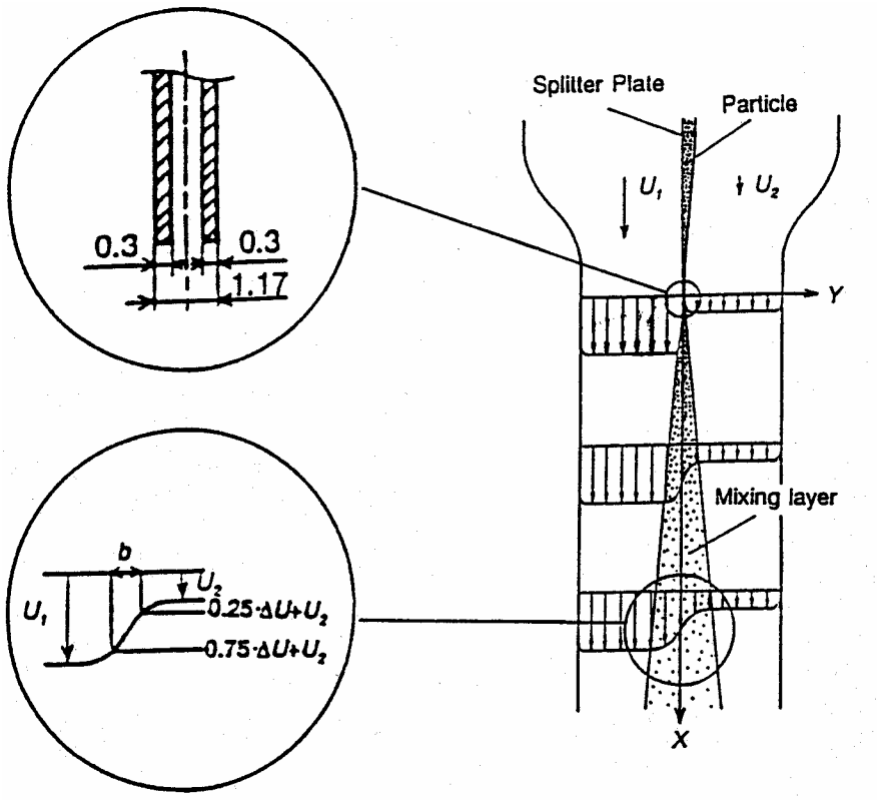

Fig. 1. Flow configuration of the experiment

The particles were introduced into the flow through a 0.57 mm slit in the splitter plate (Fig. 1). Different kind of glass beads with mean number diameters of 42, 72, and 135 μm and a material density of ρ_p = 2590 kg/m^3 were used in the experiments. The size distribution of the particles is shown in Fig. 2.

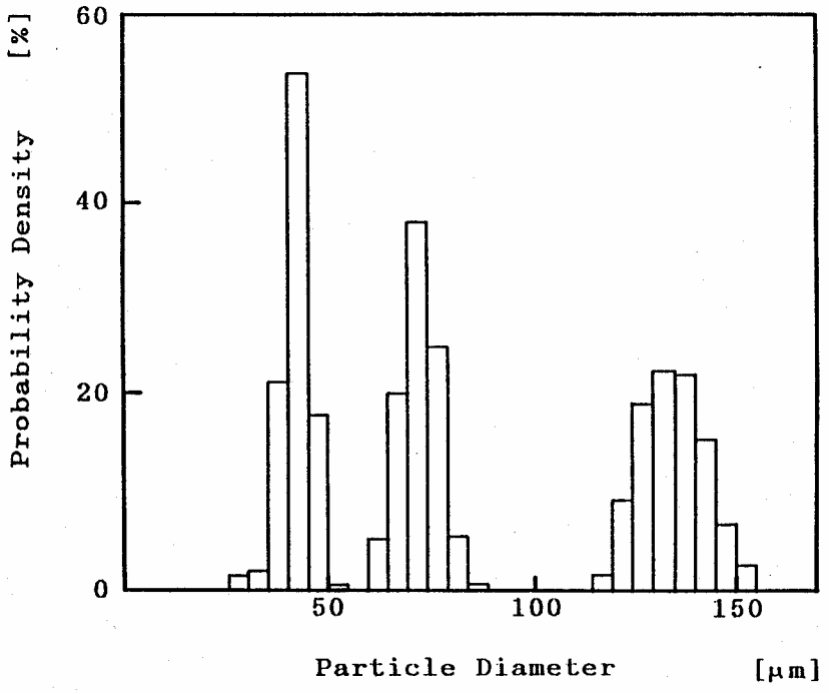

Fig. 2 Particle size distributions

2. Flow and inlet conditions for the gas flow

Measurements have been performed by laser-Doppler anemometry using particle size discrimination by a light scattering intensity method to distinguish signals from tracer particles and the dispersed phase particles. The inlet profiles for the air flow were measured 5 mm downstream of the end of the splitter plate. The different velocity components and the Reynolds shear stresses are listed in Table 1 for both cases considered.

Furthermore, the particle velocities and the particle number densities were measured 5 mm downstream of the edge of the splitter plate for the two flow conditions and different particles. These data are summarised in Table 2 and 3, where ND is proportional to the number density of the particles. The measured values were normalised by the maximum value obtained in the measurements. Please note that this maximum value of the particle number density is in some cases slightly shifted away from the centre towards the low speed side which might be associated with the vortices developing just downstream of the splitter plate.

y (mm)	u_g (m/s)	u'_g (m/s)	v_g (m/s)	u'_g (m/s)	$u'_g v'_g$ (m^2/s^2)
-48.0	13.1460	0.1010	-0.1440	0.1140	-0.00016495
-44.0	13.1360	0.1040	-0.1690	0.1100	0.00069277
-40.0	13.1290	0.1100	-0.1580	0.1120	0.00000000
-36.0	13.1020	0.1090	-0.1720	0.1170	-0.00008247
-32.0	13.1060	0.1080	-0.1920	0.1120	0.00029690
-28.0	13.1210	0.1080	-0.1620	0.1120	0.00000000
-24.0	13.0880	0.1150	-0.1770	0.1150	0.00069277
-20.0	13.0750	0.1170	-0.1740	0.1120	-0.00008247
-16.0	13.0930	0.1090	-0.1760	0.1140	0.00000000
-12.0	13.0830	0.1080	-0.1090	0.1120	-0.00032989
-8.0	13.0750	0.1050	-0.1430	0.1100	-0.00098967
-4.0	13.0970	0.1030	-0.1560	0.1120	0.00059380
-2.0	12.8460	0.1320	-0.1580	0.1100	0.00059380
4.0	4.1220	0.0900	-0.3380	0.1090	0.00009897
8.0	4.0850	0.0930	-0.2600	0.1060	0.00000000
12.0	4.0530	0.0850	-0.2340	0.1040	-0.00024742
16.0	4.0450	0.0870	-0.2270	0.1020	0.00009897
20.0	4.0220	0.0890	-0.2060	0.1080	0.00019793
24.0	4.0250	0.0890	-0.2130	0.1040	-0.00016495
28.0	4.0230	0.0900	-0.1910	0.1090	-0.00008247
32.0	4.0160	0.0870	-0.1830	0.1050	0.00059380
36.0	4.0070	0.0890	-0.1770	0.1070	0.00000000
40.0	4.0000	0.0860	-0.1650	0.0990	-0.00008247
44.0	4.0110	0.0870	-0.1580	0.1090	0.00000000
48.0	4.0040	0.0920	-0.1520	0.1070	0.0000

y (mm)	u_g (m/s)	u'_g (m/s)	v_g (m/s)	u'_g (m/s)	$u'_g v'_g$ (m^2/s^2)
-21.0	20.8756	0.2999	-.0787	0.2771	0.00029435
-17.0	20.9319	0.2585	-0.1320	0.2259	-0.00058870
-13.0	20.9719	0.2622	-0.1278	0.2293	-0.00163527
-9.0	21.0357	0.2704	-0.0437	0.2340	-0.00418628
-5.0	21.1099	0.2658	0.0300	0.2320	-0.00078493
-1.0	20.9613	0.3230	0.1548	0.2867	-0.00268184
-0.5	14.8494	0.8873	0.1231	0.4162	0.08339855
1.0	6.6664	0.8366	-0.4880	0.3200	-0.04297478
2.0	12.5779	0.2291	-0.8860	0.2185	-0.00104657
3.0	13.0943	0.2118	-0.8590	0.2262	0.00039900
5.0	13.0282	0.2100	-0.7715	0.2056	0.00069989
7.0	12.9681	0.1992	-0.6539	0.1810	0.00000000
11.0	12.9007	0.2092	-0.5272	0.1844	-0.00078493
15.0	12.8845	0.2071	-0.4205	0.2020	0.00099424
19.0	12.8635	0.2031	-0.3357	0.2200	0.00059524
23.0	12.8795	0.2055	-0.3004	0.2290	-0.00039246
27.0	12.8639	0.2074	-0.2553	0.2414	-0.00006541

Table 1 Gas velocities at the inlet (upper table U_b = 8.5 m/s, lower table U_b = 17 m/s)

U_b = 8.5 m/s, 42 micron

y (mm)	u_p (m/s)	u'_p (m/s)	v_p (m/s)	u'_p (m/s)	$u'_p v'_p$ (m^2/s^2)	ND
0.5	0.6230	0.0920	-0.0370	0.0810	0.00029690	0.4288
0.7	0.7530	0.1000	-0.0260	0.0870	0.00049484	0.8037
0.9	0.8150	0.1090	-0.0260	0.0880	0.00049484	1.0000
1.1	0.9150	0.1140	-0.0280	0.0900	0.00019793	0.9447
1.3	0.9500	0.1190	-0.0320	0.0920	0.00019793	0.6964
1.5	0.7820	0.1310	-0.0250	0.0870	0.00179790	0.4481

U_b = 8.5 m/s, 72 micron

y (mm)	u_p (m/s)	u'_p (m/s)	v_p (m/s)	u'_p (m/s)	$u'_p v'_p$ (m^2/s^2)	ND
-1.0	1.6870	0.1430	-0.3520	0.0990	0.00109689	0.0078
-0.5	1.0610	0.0950	-0.1900	0.0920	-0.00082473	0.1182
0.0	0.9230	0.0680	-0.0760	0.0700	-0.00016495	0.7077
0.5	0.9430	0.1070	-0.0680	0.0660	0.00019793	1.0000
1.0	0.9140	0.1200	-0.0320	0.0600	-0.00032989	0.4289
1.5	0.8470	0.1020	0.0430	0.0810	0.00029690	0.0290

U_b = 8.5 m/s, 135 micron

y (mm)	u_p (m/s)	u'_p (m/s)	v_p (m/s)	u'_p (m/s)	$u'_p v'_p$ (m^2/s^2)	ND
-0.8	0.9710	0.1550	-0.1980	0.2070	-0.00494836	0.0023
-0.6	0.8830	0.1320	-0.1270	0.2010	-0.00197934	0.0037
-0.4	0.8440	0.1380	-0.0630	0.1770	-0.00206182	0.0229
-0.2	0.8760	0.1360	-0.0180	0.1760	-0.00074225	0.0753
0.0	0.9320	0.1310	0.0180	0.1780	-0.00008247	0.0706
0.2	0.9550	0.1320	0.0170	0.1710	0.00049484	0.7120
0.4	0.9660	0.1310	0.0290	0.1670	0.00059380	0.9067
0.6	0.9590	0.1370	0.0280	0.1630	0.00009897	0.9869
0.8	0.9700	0.1360	0.0240	0.1550	0.00009897	1.0000
1.0	0.9730	0.1430	0.0290	0.1480	-0.00016495	0.7251
1.2	0.9810	0.1420	0.0370	0.1430	-0.00032989	0.3532
1.4	0.8980	0.1330	0.0620	0.1380	0.00000000	0.0735
1.6	0.8670	0.1380	0.0800	0.1320	0.00049484	0.0180
1.8	0.8310	0.1310	0.1180	0.1400	0.00279582	0.0056

Table 2 Particle velocities at the edge of the splitter plate for U_b = 8.5 m/s (data sets: small42, small72, and small135)

U_b = 17 m/s, 42 microns

y (mm)	u_p (m/s)	u'_p (m/s)	v_p (m/s)	u'_p (m/s)	$u'_p v'_p$ (m^2/s^2)	ND
-1.6	5.2263	0.8595	-0.3741	0.1484	-0.01295130	0.0173
-1.4	4.8075	0.8780	-0.2921	0.1599	-0.01026947	0.1216
-1.2	4.4595	0.8089	-0.2498	0.1389	0.00119701	0.2802
-1.0	3.6958	0.6620	-0.2007	0.1512	0.00639716	0.6432
-0.8	2.4148	0.2805	-0.1626	0.1304	0.00179879	0.9627
-0.6	1.8385	0.1880	-0.1499	0.1284	0.00009812	0.9871
-0.4	1.6235	0.2012	-0.1302	0.1273	-0.00045787	1.0000
-0.2	1.5375	0.2110	-0.1135	0.1358	-0.00058870	0.8160
0.0	1.5306	0.2118	-0.0972	0.1236	-0.00085034	0.5560
0.2	1.5390	0.2055	-0.0923	0.1277	0.00069989	0.2027
0.4	1.5612	0.1802	-0.0825	0.1249	0.00039900	0.2189
0.6	1.6662	0.1469	-0.0770	0.1168	0.00059524	0.1731
0.8	1.5265	0.2220	-0.0908	0.1333	-0.00156986	0.7617
1.0	1.5071	0.2077	-0.0773	0.1280	-0.00039246	0.5920
1.2	1.5321	0.1801	-0.0706	0.1242	-0.00058870	0.4122
1.4	1.6731	0.1393	-0.0587	0.1232	-0.00019623	0.3057
1.6	1.9890	0.1600	-0.0555	0.1171	-0.00137362	0.1326
1.8	2.3891	0.2510	-0.0545	0.1085	-0.00196232	0.0773
2.0	2.8321	0.3265	-0.0488	0.1061	-0.00575614	0.0771
2.2	3.2635	0.4807	-0.0207	0.1157	-0.00739140	0.0340
2.4	3.4922	0.5700	0.0214	0.1267	-0.01033488	0.0191
2.6	3.7112	0.6275	0.0584	0.1412	-0.00627942	0.0093
2.8	3.8006	0.6462	0.1008	0.1244	-0.00026164	0.0035

U_b = 17 m/s, 72 microns

y (mm)	u_p (m/s)	u'_p (m/s)	v_p (m/s)	u'_p (m/s)	$u'_p v'_p$ (m^2/s^2)	ND
2.0	2.2289	0.1343	.1941	0.1105	-0.00215855	0.0000
1.8	2.0195	0.1352	.1505	0.1041	-0.00078493	0.0020
1.6	1.7735	0.1330	0.1003	0.1041	0.00059524	0.0061
1.4	1.5905	0.1409	0.0764	0.1042	-0.00065411	0.0163
1.2	1.6315	0.1715	0.0732	0.1052	0.00149790	0.0394
1.0	1.4217	0.1577	0.0382	0.1123	-0.00124280	0.0985
0.8	1.3892	0.1709	0.0056	0.1123	-0.00268184	0.1959
0.6	1.4055	0.1825	-0.0153	0.1124	-0.00268184	0.3619
0.4	1.4250	0.2042	-0.0457	0.1108	-0.00215855	0.7878
0.2	1.4378	0.2169	-0.0718	0.1168	-0.00045787	1.0000
0.0	1.4702	0.2136	-0.0951	0.1225	0.00009812	0.9020
-0.2	1.4634	0.2038	-0.1171	0.1221	-0.00039246	0.9122
-0.4	1.4646	0.1836	-0.1414	0.1304	-0.00039246	0.8324
-0.6	1.4850	0.1659	-0.1721	0.1341	0.00049712	0.6716
-0.8	1.6347	0.1655	-0.2100	0.1253	0.00089613	0.3733

-1.0	2.0701	0.1853	-0.2653	0.0990	0.00109890	0.1954
-1.2	2.6116	0.2073	-0.3034	0.0902	0.00189691	0.0851
-1.4	3.1829	0.2191	-0.3739	0.1187	0.00439559	0.0291
-1.6	3.5661	0.2149	-0.4284	0.1386	0.00289769	0.0077
-1.8	3.8187	0.1981	-0.4698	0.1625	0.00289769	0.0019

U_b = 17 m/s, 135 microns

y (mm)	u_p (m/s)	u'_p (m/s)	v_p (m/s)	u'_p (m/s)	$u'_p v'_p$ (m^2/s^2)	ND
2.4	1.8404	0.1268	0.1921	0.0913	-.00039246	0.0101
2.2	1.7005	0.1181	0.1461	0.0982	.00119701	0.0398
2.0	1.5966	0.1310	0.1213	0.0964	.00079801	0.0581
1.8	1.4954	0.1371	0.1137	0.0950	.00069989	0.1002
1.6	1.3660	0.1466	0.0791	0.0906	.00119701	0.1783
1.4	1.2546	0.1566	0.0620	0.0811	.00059524	0.2533
1.2	1.2253	0.1590	0.0499	0.0782	.00029435	0.3266
1.0	1.2139	0.1690	0.0339	0.0771	0.00000000	0.4712
0.8	1.2494	0.1805	0.0097	0.0735	-.00085034	0.6791
0.6	1.2656	0.1889	-0.0056	0.0771	-.00019623	0.8279
0.4	1.2839	0.2123	-0.0255	0.0770	.00019623	0.9048
0.2	1.2864	0.2096	-0.0493	0.0812	.00079801	0.9825
0.0	1.3154	0.2073	-0.0624	0.0805	.00119701	1.0000
-0.2	1.2994	0.1882	-0.0846	0.0759	.00099424	0.9264
-0.4	1.2744	0.1701	-0.1032	0.0810	.00089613	0.6783
-0.6	1.3911	0.1660	-0.1174	0.0871	.00009812	0.4942
-0.8	1.6938	0.1615	-0.1353	0.0997	-.00085034	0.3229
-1.0	2.0260	0.1689	-0.1789	0.0918	.00059524	0.1813
-1.2	2.3311	0.1599	-0.2257	0.1032	-.00026164	0.0688
-1.4	2.5809	0.1644	-0.2640	0.1103	.00099424	0.0244
-1.6	2.7131	0.1636	-0.3391	0.1129	.00069989	0.0060

Table 2 Particle velocities at the edge of the splitter plate for U_b = 17 m/s (data sets: large42, large72, and large135)

More details about the measurements may be found in Ando et al. (1990) and Hishida et al. (1992). The data were also used as a test case for validating numerical calculations at the 6th Workshop in Two-Phase Flow Predictions (Erlangen, 1992). A discussion of the results may be found in the Proceedings (Sommerfeld, 1993).

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