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LDA DIAGNOSTICS OF VELOCITY CHARACTERISTICS IN WATER-PARTICLE MIXTURES

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KIIRUSPARAMEETRITE MÄÄRAMINE LASERMEETODIGA VEE JA OSAKESTE SEGUDES. Pavel VLASAK, Zdeniek CHARA, Miroslav SEVERA

ОПРЕДЕЛЕНИЕ СКОРОСТНЫХ ХАРАКТЕРИСТИК В СМЕСЯХ ВОДЫ С ЧАСТИЦАМИ ЛАЗЕРНЫМИ МЕТОДАМИ. Павел ВЛАСАК, Зденек ЧАРА, Мирослав СЕВЕРА

Key words: sedimentation of cloud of particles, "laser-knife" visualization, two-point radiometric method, laser-Doppler anemometer, the two-spot optical LDA system.

The purpose of this paper is to present the results of the sedimentation of model suspension in the intermediate region of settlement, as there is a significant lack of theoretical solution and even of experimental data on the sedimentation of a cloud of particles in the intermediate region; also, it deals with the measurements of some turbulent characteristics (mean velocity distributions, turbulence intensities, frequency power spectra) of water-solid two-phase flow, using LDA methods.

The paper gives the results of an experimental investigation of continuous sedimentation of the model monodisperse and binary particle-liquid mixtures in the intermediate region of a settlement in a vertical as well as gently inclined sedimentation vessel.

The model suspension consisted of water and several species of glass-bead particles of the average diameter from 150 to 850 mm; the density of the particles was 2640 kg·m; the volumetric concentration of the mixture varied from zero to 11.4%. The experimental equipment consisted of a sedimentation vessel-glass tube of the inner diameter 0.05 m, length 2.3 m, and a feeding device, which kept constant concentration of model suspension.

Three different experimental methods were used. The LDA technique was used to measure both the local absolute fall of individual particles and the local velocity of the displaced water in monodispersion and the cross-concentration distribution, while in the vertical and inclined sedimentation vessel a "laser knife" visualization was used. The third, the two-point

radiometric method in pulse modification was used to determine the mean fall velocity of individual species in monodisperse and also in binary mixture. The results of the presented experimental investigation confirm that:

– The absolute particle-fall velocity distribution exhibits expressive arch-wise profiles (Fig. 1). On the contrary, the values of the local relative particle-liquid velocity are nearly constant along the diameter of the vessel (Fig. 2).

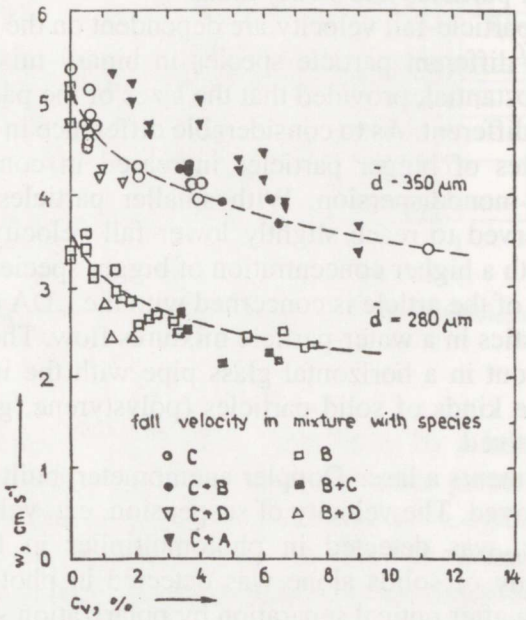

Fig. 1. The effect of concentration and particle sizes on the absolute fall velocity.

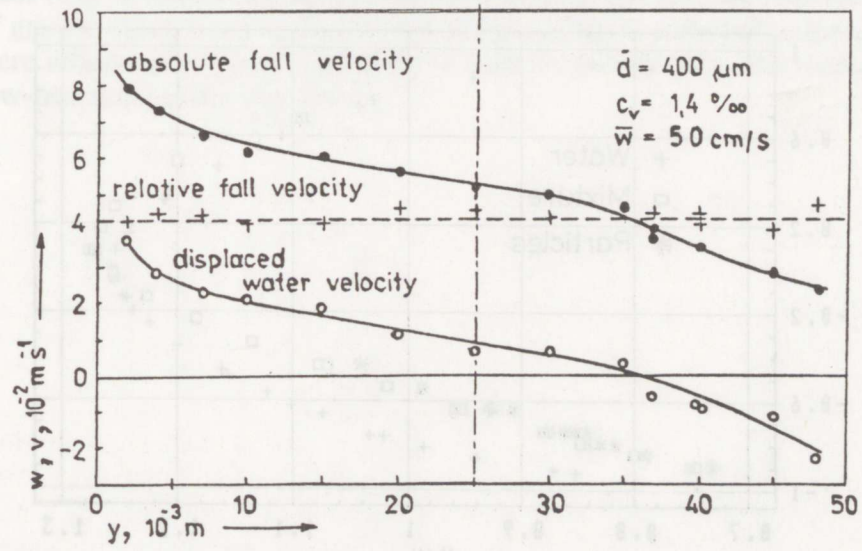

Fig. 2. The relative and absolute velocity profiles in an inclined vessel (inclination of vessel – 1%).

– The process of sedimentation is highly sensitive to the inclination of sedimentation vessel, which causes considerable change of the structure of sedimentation process and forms asymmetric absolute particle-fall velocity profiles. The significant upward flow of the displaced liquid near the downward-facing surface (DFW) and highly concentrated descent stream near the upward-facing wall (UFW) of the vessel, was observed.

– A significant transversal migration of particles combined with the increase of local concentration near the UFW was observed as well as wavy trajectories of particles and swirly areas.

– The values of particle-fall velocity are dependent on the concentration of suspension. For different particle species in binary mixture the total concentration is substantial, provided that the sizes of the particles of both species are not too different. As to considerable difference in particle sizes, so the fall velocities of bigger particles increased in comparison with values reached in monodispersion. With smaller particles in binary, a tendency was observed to reach slightly lower fall velocity than that in monodispersion with a higher concentration of bigger species.

The second part of the article is concerned with the LDA diagnostics of velocity characteristics in a water-particle mixtures flow. The experiments have been carried out in a horizontal glass pipe with the inner diameter 39.4 mm, and three kinds of solid particles (polystyrene, glass and sand particles) were involved.

For these experiments a laser-Doppler anemometer, built of DISA 55L sections, was employed. The velocity of suspension, e.g. velocity of water and solid together, was detected in photomultiplier in forwardscatter position, the velocity of solids alone was detected in photomultiplier in backscatter location after optical separation by polarization section.

The two-spot optical LDA system was used for measurements of transverse liquid velocity correlations. The two-spot LDA system was developed at the Institute of Hydrodynamics in Prague. It is based on

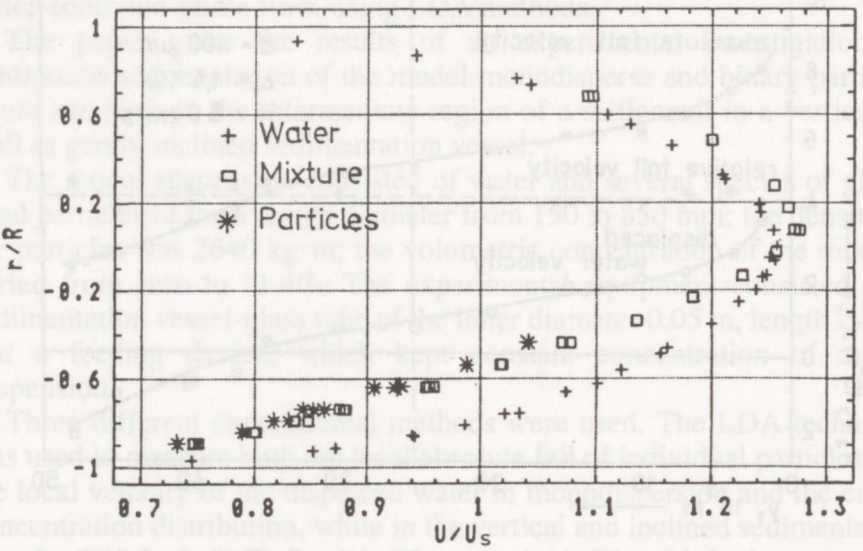

Fig. 3. Vertical velocity profiles of suspension of glass particles $d = 1.9$ mm, $cv = 1.18\%$.

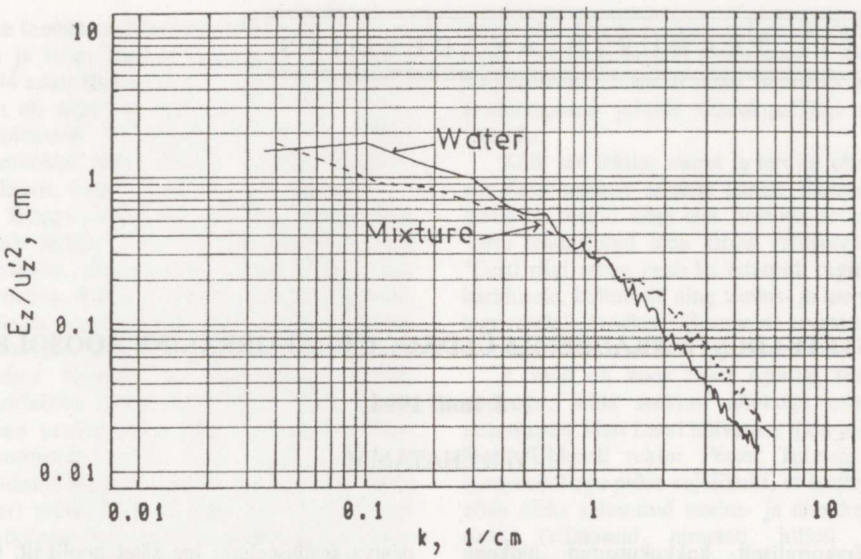

Fig. 4. Energy spectrum function for suspension of glass particles $d = 1.9$ mm, $cv = 1.18\%$ ($r/R = -0.537$).

colour separation of multicolour laser beam by a beam splitter into two symmetric patterns of an outer blue and inner green parallel couples of beams. One couple of beams is processed by a cylindrical lens and the second couple by an annular lens, so that two mutually exactly defined separated optical intersections are obtained as measuring spots.

In the presence of polystyrene particles, flattening of particle velocity profile was remarkable, but the effect of these particles on turbulence and energy spectra of suspension was not observed. The velocity profiles of glass (Fig. 3) and sand suspensions show asymmetric distributions because of gravity force. The energy spectra of glass (Fig. 4) and sand suspensions were influenced so that an increase in high-frequency parts and a decay in low-frequency parts was noted.