The near wall velocity measurements in microchannels with different diameter particles by microPIV/PTV

Zhanhua Silber-Li and Xu Zheng
The state key laboratory of nonlinear mechanics, Institute of Mechanics,
Chinese academy of sciences, Beijing 100190, China
lili@imech.ac.cn

ABSTRACT

In near wall measurements with microPIV/PTV, whether seeding particles can be effectively used to detect local fluid velocity is a crucial problem. This talk presents our recent measurements in microchannels [1][2]. Based on measured velocity profiles with 200nm and 50nm in pure water, we found that the measured velocity profiles are agreed with the theoretical values in the middle of channel, but large deviations between measured data and theoretical prediction appear close to wall (0.25μm <z<1.5μm). Moreover, these deviations depend on the particle sizes. Considering the volume illumination [3] and particle physical behavious [4], we try to analysis the influence of focal plane thickness and particle concentration distribution near wall on the velocity deviation appeared in shear flows.

1 Experimental method

The measurements were carried out by a microPIV/PTV system at the LNM, Institute of Mechanics, CAS[1]. The PDMS-glass hybrid microchannels (20μm × 50μm× 1cm) were used. The glass bottom is hydrophilic, which is a theoretically no-slip surface. The velocity profiles in the main filed (1μm<z<20μm) were measured by MicroPIV [1] and velocities near wall (0.25μm <z<1.5μm) [2] were measured by MicroPTV with 200nm and 50nm fluorescent particles respectively. A piezo-transducer is used to adjust vertical position with nano-scale (10nm) precision. A threshold of the grey-scale value was chosen to filter out the out of plane particles in order to limit the influence of focal plane thickness in MicroPTV measurements.

2 Experimental results

(1) The velocity profiles measured by MicroPIV at 14 horizontal planes are compared with theoretical no-slip 3D velocity profiles and Poiseuille 2D velocity profiles for a rectangular channel [1]. The measured data in the main flow region are in good agreement with White's theoretical values [5], which is better than comparing with 2D velocity profile. This indicates that, for a rectangular channel with aspect ratio α=0.35, 3D theoretical velocity gives a perfect prediction.
(2) However at near wall region, large deviations appeared. With MicroPTV method, we measured the velocity profile from 250nm to 1.5um [2]. The average deviation at z=250nm is 93% with 200nm particle, while the deviation decreases to 43% with 50nm. We also measured the particle concentration distribution C at 250nm< z <2μm. C is found non-uniform along the vertical direction of the microchannel.
(3) We analysis the influences of the focal plane thickness, particle concentration distribution near wall and the shear flow on the velocity deviation appeared. With a velocity profile correction, the deviation for 50nm particles can be reduced to 10%.

3 Conclusions

In micro scale measurement by microPIT/PTV system using tracer particles, the influences of particle sizes, particle surfaces and solid wall behaviours should be noticeable (是否需要再详细些？).

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