Modeling the Effects of Small Particles on Near Wall Shear Stress

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Abstract

Small particles in near wall region provide complex conditions in fluid flow and shear stress behavior on solid surface. Fluid-particles and particle-particle interactions in these kinds of flows make a two way coupling problem in a two phase flow complicated phenomenon.

In this research the effect of small particles in near wall zone was investigated by implementation of their force effects on fluid flow instead of particle implementation in fluid flow. The forces on particles were obtained from flow conditions and the effect of particles on fluid flow in previous steps of modeling, in the other words local velocity and local pressure fields make effective force on particle position while particle effects, equal and in opposite direction, imposed on fluid flow, based on second Newton low, in particle position and in each step. Added Mass, Drag, Lift, gravitational-buoyancy, and Pressure forces were accounted in this study. These force elements leads to particle dynamic motion and they are presented respectively in Equation 1. Figure 1 shows sample of calculated forces in a duct flow.

$$m_p d\frac{\vec{U}_p}{dt} = \vec{F}_A + \vec{F}_D + \vec{F}_L + \vec{F}_{gW} + \vec{F}_P \qquad \text{Eq. 1}$$

To decrease computer's CPU time, particles were not tracked in recent modeling; however particle positions calculated by a statistical model in steps of solution and effective force apply on their position, for small particles. This statistical model of particles dispersion was imposed in each solution step based on experimental results and flow general conditions (e.g. laminar or turbulent flow). OpenFOAM capabilities are used to mathematical and statistical modeling implementation on laminar background flow and evaluation of numerical results of statistical model to find particle dispersion positions; also it was used to apply calculated amounts of effective force on fluid flow from particle position, Fig. 2.

Initial obtained results illustrated that, low density small particles, e.g. air bubbles, smooth the changes of near wall velocity profile or decrease shear stress, Fig. 3 and Fig. 4, as reported by some researchers [1, 2].

Key words: **Two phase flow, near wall, Shear stress, OpenFOAM**

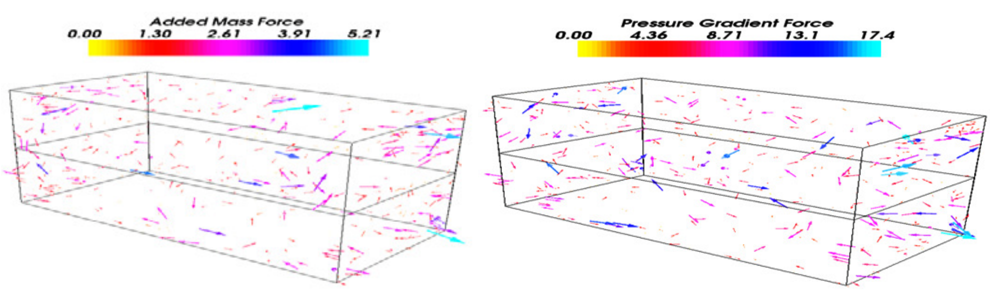

Fig.1 Sample of obtained forces in a duct flow

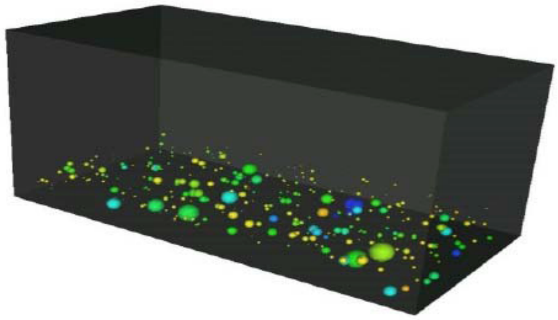

Fig.2 Effective forces in particle places (near wall region)

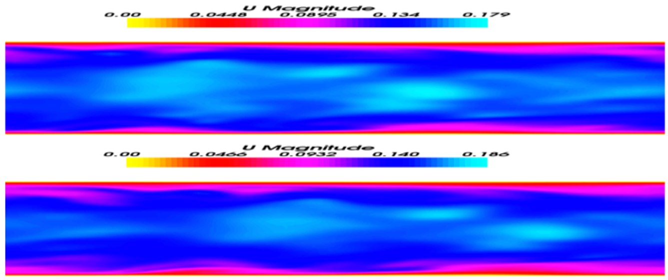

Fig.3 Qualitative effect of air particles in near wall region (up: w/o particle effects, Down: with particle effects)

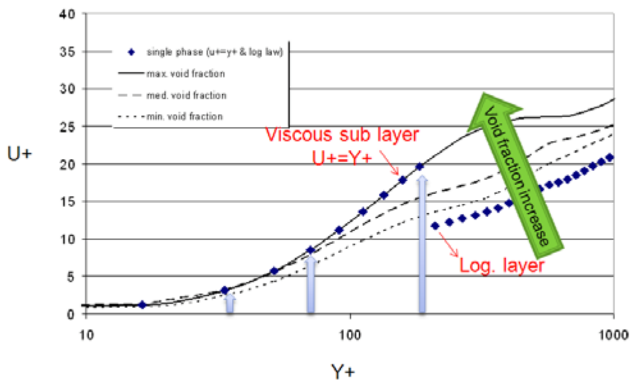

Fig.4 Near wall region behavior by increasing air particles presents

References

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