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Effects of finite-size particles on the turbulent flows in a square duct[1] ZHAOSHENG YU, ZHAOWU LIN, XUEMING SHAO, State Key Laboratory of Fluid Power Transmission and Control, Department of Mechanics, Zhejiang University, Hangzhou 310027, China, LIAN-PING WANG, Department of Mechanical Engineering, University of Delaware, Newark, Delaware 19716, USA — Fully resolved numerical simulations of the particle-laden turbulent flows in a square duct are performed with a direct-forcing fictitious domain method. The effects of the finite-size particles on the mean and root-mean-square (RMS) velocities are investigated at the friction Reynolds number of 150 (based on the friction velocity and half duct width) and the particle volume fractions ranging from 0.78% to 7.07%. For the neutrally buoyant case, our results show that the mean secondary flow is enhanced and its circulation center shifts closer to the center of the duct cross-section when the particles are added. The reason for the particle effect on the mean secondary flow is analyzed by examining the terms in the mean streamwise vorticity equation. The particles enhance the wall-tangential component of the RMS velocity (i.e. Reynolds normal stress) more than its wall-normal component in the near-wall region near the corners, resulting in the enhancement in the gradients of the normal stress difference, which we think is mainly responsible for the enhancement in the mean secondary flow. The particles accumulate preferentially in the near-corner region in the neutrally buoyant case. In addition, the effects of particle sedimentation are examined at different Shields numbers.

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