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SHORT COMMUNICATION

Dynamic shape and wall correction factors of cylindrical particles falling vertically in a Newtonian liquid[‡]

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Results of numerical calculations of dynamic shape and wall correction factors for the flow of a Newtonian fluid over a vertically oriented cylindrical particle in a cylindrical tube are reported. Mathematical model of the flow was solved using the finite element method by means of the COMSOL Multiphysics software. Dependences of the shape factor on the cylinder aspect ratio and of the wall correction factor, F_{W}, on the ratio of the cylindrical particle diameter to the tube diameter, and on the aspect ratio were obtained. Numerical dependences were approximated by simple relationships suitable for dynamic shape and wall correction factors prediction.

Keywords: cylindrical particles, free fall, Newtonian fluid, dynamic shape factor, wall effects

Terminal falling velocity of a rigid particle is one of the basic hydrodynamic characteristics of particle movement in fluids. Its knowledge is necessary for the solution of numerous theoretical and practical problems such as falling particle viscometry, design calculations of clarifiers and thickeners, hydrocyclones, fluidised bed equipment, pipeline transport systems, etc.

A useful application of spherical particle equations for the prediction of the non-spherical particle terminal velocity, u_{t}, is their correction using the dynamic shape factor, φ, of the non-spherical particle defined as

$$\varphi = \frac{u_{\mathrm{t}}}{u_{\mathrm{t0}}} \tag{1}$$

where u_{t0} is the terminal falling velocity of the sphere with the diameter equal to the volume equivalent diameter, d_{v}, of the non-spherical particle considered.

In the creeping flow (Stokes) region, the terminal falling velocity of a spherical particle in an unbounded Newtonian fluid is given by

$$u_{\mathrm{t0},\infty} = \frac{F_{\mathrm{D},\infty}}{3\pi d_{\mathrm{v}}\mu} \tag{2}$$

where $F_{\mathrm{D},\infty}$ is the magnitude of the drag force acting on the particle and μ the liquid viscosity. Diameter of a cylindrical particle, d_{v}, is given as

$$d_{\mathrm{v}} = d\sqrt[3]{\frac{2}{3}\frac{h}{d}} \tag{3}$$

where d represents the cylinder diameter and h the cylinder height.

Interaction of the particle with the containing walls depends on the particle shape, orientation, and position, as well as on the fluid rheological behaviour, flow regime, and the geometry of the walls. Owing to this interaction, the particle terminal velocity is reduced in comparison with that reached in an infinite medium. In the experimental determination of the terminal falling velocity of a particle, the particle fall in a

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