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über

Modeling of Flow and Heat Transfer in a Gas-Droplets Turbulent Flow in a Pipe Sudden Expansion. Eulerian and Full Lagrangian Approach.

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Modeling of Flow and Heat Transfer in a Gas-Droplets Turbulent Flow in a Pipe Sudden Expansion. Eulerian and Full Lagrangian Approach

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Introduction. Turbulent separated flow laden with small, dilute droplets used in a wide range of engineering such as pollutant dispersion in the atmosphere, in combustion chamber, etc. Knowledge of the turbulent flow and heat transfer in separated flows is important from both theoretical and practical points of view. The mechanism controlling the turbulence modification and droplets dispersion is of great importance in accurate prediction of flow patterns and heat and mass transfer processes in two-phase flows. Better understanding of physics of droplets dispersion and evaporation in the mist separated flow is important for development and optimization of power engineering systems as well as for reduction of weight and pollutant emission.

The aim of the present study is modeled the effect of numerical Eulerian and Lagrangian models on droplets evaporation, flow, gas phase turbulence, particle dispersion and heat transfer in two-phase mist flow downstream in a pipe sudden expansion.

Numerical model. From a review of literature, it is not apparent if the Eulerian or the Lagrangian approaches of the dispersed phase is more valid to simulate dilute two-phase flow and heat transfer downstream of a pipe sudden expansion. In this study, both modeling approaches are employed and a comparative analysis of performances and accuracy between the two models are carried out. The flow is treated as a steady-state and axisymmetrical. The two-fluid Eulerian model Terekhov and Pakhomov (Int. J. Heat Mass Transfer, 2009) is used to describe the averaged characteristics of two phases, including droplets dispersion, turbulence, its dissipation and heat transfer downstream of a pipe sudden expansion. In the paper gas-droplets turbulent flow is numerically predicted by the set of axisymmetric RANS equations. Gas phase turbulence was modeled with the use the elliptic blending second moment closure of Fadai-Ghotbi et al. (Flow, Turbulence and Combust., 2008). Particle–turbulence interaction (turbulence modulation) is described by a two-way coupling model. The partial Reynolds stresses and temperature fluctuations, and turbulent heat flux equations of Zaichik (Phys. Fluids A, 1999) in the dispersed phase were utilized. The Lagrangian approach is used for comparison analysis. The effect of drag, turbulent dispersion, turbulent migration, pressure gradient and lift force at the motion of droplets is studied. The full Lagrangian approach by Osiptsov (1998) is used for comparison analysis. The effect of drag, turbulent dispersion, turbulent migration, pressure gradient and lift force at the motion of droplets is studied. The droplets mass fraction is then obtained algebraically from the continuity equation in the Lagrangian form. An examination of the full Lagrangian approach suggests that it has the strong potential when knowledge of the particle concentration field is required. Osiptsov's method is rooted in Lagrangian theory, the particle concentration being obtained from the Lagrangian form of the mass conservation equation by computing the change in volume of an element of 'particle fluid' along its pathline.

Fine droplets (Stokes number Stk < 1,) are responsive to fluid velocity fluctuations and get readily entrained with the detached flow, spread throughout the whole pipe cross-section. Large particles (Stk > 1), due to its inertia, are unresponsive to fluid velocity. Large droplets do not appear in the recirculation zone and present only in the shear layer and axis region. The presence of fine dispersed droplets in the flow attenuates the gas phase turbulence up 25 % in the axis zone. In the wall area, due to droplet evaporation, the concentration of liquid droplets is much lower than in the axial region of the pipe. The heat transfer in the case of gas-droplet flow increases appreciably.

Numerical predictions are obtained from the two different approaches for two-phase flow in a pipe sudden expansion and compared with the measured by Hishida et al. (Int. J. Heat Mass Transfer, 1995), Founty and Klipfel (Exp. Thermal Fluid Sci., 1998) and numerical data of Mohanarangam and Tu (AIChE J., 2009). Eulerian and Lagrangian models are shown a good agreement between the predicted and observed fluid and particles velocity in the axial and radial directions, for the turbulent stresses and heat transfer.

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