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CLUSTER-INDUCED TURBULENCE MODELLING OF MASS TRANSFER IN GAS-PARTICLE FLOWS

Stefanie Rauchenzauner[1,*] **and Simon Schneiderbauer**[1,2]

[1] Christian Doppler Laboratory for Multi-scale Modelling of Multiphase Processes, Johannes Kepler University, Linz, Austria, stefanie.rauchenzauner@jku.at

[2] Department of Particulate Flow Modelling, Johannes Kepler University, Linz, Austria, simon.schneiderbauer@jku.at

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One of the main challenges in modelling reacting multiphase flows is the large number of involved scales. In gas-particle flows, the particles are usually several orders of magbitude smaller than the reactor dimensions, therefore, simulations that resolve all forces acting on the individual particles are unfeasible due to computational limitations. In order to obtain a correct prediction for the flow physics on the micro-scale, averaged equations of motion such as the Two-Fluid Model (TFM) can be employed. On the meso-scale, clusters of particles are forming due to the momentum coupling between the phases in the presence of a mean body force, such as gravity. Employing computational grids that do not resolve these heterogeneous meso-scale structures, however, leads to severely false predictions for the macro-scale flow properties, such as volume fraction, temperature and species distribution inside the reactors [1].

Therefore, we developed a turbulence modelling framework based on spatially averaging the TFM balance equations in order to predict the influence of the unresolved meso-scale structures on the macro-scale flow properties in coarse-grid simulations of gas-particle flows. We found that, in addition to a correction to the resolved drag force, the drift velocity, the resolved heat transfer can be corrected by a drift temperature, which represents the gas-phase temperature fluctuations 'as seen by the particles' and is a measure for the heterogeneity of the flow [1]. Finally, we found that a similar drift scalar correction can be applied to the resolved mass transfer in order to obtain the correct temperature and species distributions, and reaction rates inside the reactors. Closure models for the drift scalars involve the local dynamic estimation of correlation coefficients between physical properties through the application of test-filters [2].

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