Mechanical Engineering Thesis Defense

Preliminary studies of scalar transport in turbulent jets using point-particle DNS simulations

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Abstract

The current work aims to understand the influence of particles on scalar transport in particle-laden turbulent jets using point-particle direct numerical simulations (DNS). Such turbulence phenomena are observed in many applications, such as aircraft and rocket engines (e.g., engines operating in dusty environments and when close to the surface) and geophysical flows (sediment-laden rivers discharging nutrients into the oceans), etc.

This thesis looks at systematically understanding the fundamental interplay between (1) turbulence, (2) particles, and (3) scalar transport. This work considers a temporal jet of Reynolds number of 5000 filled with the point-particles and the influence of Stokes number (St). Three Stokes numbers, St = 1, 7.5, and 20, were considered for the current work. The simulations were solved using the NGA solver, which solves the Navier-Stokes equations, advection-diffusion equation, and particle transport equation.

The statistical analysis of the mean and turbulence quantities, along with the Reynolds stresses, are estimated for the fluid and particle phases throughout the domain. The observations do not show a significant influence of Stokes number in the mean flow evolution of fluid, scalar, and particle phases. The late-time turbulent kinetic energy (TKE) of the fluid medium decreases with an increase in the Stokes number. The scalar mixture fraction variance increases slightly for the St = 1 case, compared to the particle-free and higher Stokes number cases, indicating that an optimal Stokes number exists for which the scalar variation increases. The current preliminary study establishes that the scalar variance is influenced by particles under the optimal particle Stokes number. Directions for future studies based on the current observations are presented.

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