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Direct Numerical Simulation of a Laboratory-Scale Jet in Cross-Flow with Pulverized Coal Combustion

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Extended Abstract

The cross-jet injection technique is commonly used in a variety of applications, such as injecting powdered coal into combustion chambers and discharging smoke into crosswinds from stacks due to its superior mixing properties [1,2]. Numerical simulations are essential for observing particle motion relative to gas flow and providing insights into the behavior of coal particles during combustion. Direct numerical simulation (DNS) is particularly valuable for providing detailed three-dimensional information, resolving all scales of turbulence and chemical reactions, thereby enhancing our understanding of particle and turbulence behavior during combustion. However, compared to the extensive research on liquid jets in cross-flow, studies on solid-fuel jets in cross-flow remain relatively limited. Previous research on solid-fuel jets in cross-flow has primarily focused on individual coal particle combustion and burnout characteristics, lacking sufficient details to describe the behavior of particle groups within complex turbulence structures, which motivate this work.

In this study, we use a configuration of laboratory-scale jet in cross-flow [3], and performed DNS to investigate jet in cross-flow with pulverized coal combustion under atmospheric conditions. The jet diameter is 2 mm, and the jet velocity is 2 m/s. The temperature of the coal particles and carried gas is 298K. By varying the jet-to-crossflow momentum ratio, Stokes number, and equivalence ratio, we obtained the DNS data base on coal combustion. The effects of particles on turbulence are examined. We also explore the influence of turbulence on the particle behaviour, and examine the characteristics of heat transfer, particle distribution and turbulence modulation. Our findings indicate that the momentum ratio not only affects the evolution of the jet in cross-flow but also the rate of heat transfer between coal particles and turbulence. Moreover, higher mass flow rates can lower heat transfer among particles. The enhanced aggregation of particles is attributed to the shear vortex that is specifically related to the surface of the counter-rotating vortex pair (CVP).

References

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