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Mixing in 3D Sparse Multi-Scale Grid Generated Turbulence

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Flat 2D fractal grids are known to alter turbulence characteristics downstream of the grid as compared to the regular grids with the same blockage ratio and the same mass inflow rates [1]. This has excited interest in the turbulence community for possible exploitation for enhanced mixing and related applications. Recently, a new 3D multi-scale grid design has been proposed [2] such that each generation of length scale of turbulence grid elements is held in its own frame, the overall effect is a 3D co-planar arrangement of grid elements. This produces a 'sparse' grid system whereby each generation of grid elements produces a turbulent wake pattern that interacts with the other wake patterns downstream.

A critical motivation here is that the effective blockage ratio in the 3D Sparse Grid Turbulence (3DSGT) design is significantly lower than in the flat 2D counterpart – typically the blockage ratio could be reduced from say 20% in 2D down to 4% in the 3DSGT. If this idea can be realized in practice, it could potentially greatly enhance the efficiency of turbulent mixing and transfer processes clearly having many possible applications.

Work has begun on the 3DSGT experimentally using Surface Flow Image Velocimetry (SFIV) [3] at the European facility in the Max Planck Institute for Dynamics and Self-Organization located in Gottingen, Germany and also at the Technical University of Catalonia (UPC) in Spain, and numerically using Direct Numerical Simulation (DNS) at King Fahd University of Petroleum Minerals (KFUPM) in Saudi Arabia and in University of Warsaw in Poland. DNS is the most useful method to compare the experimental results with, and we are studying different types of codes such as Imcompact3d, and OpenFoam. Many variables will eventually be investigated for optimal mixing conditions. For example, the number of scale generations, the spacing between frames, the size ratio of grid elements, inflow conditions, etc. We will report upon the first set of findings from the 3DSGT by the time of the conference.

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References

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