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Large Eddy Simulation Of Three-Dimensional Plane Turbulent Free Jet Flow

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A detailed study of a three-dimensional spatially developing planar turbulent jet has been carried out by large eddy simulation (LES). The jet Reynolds number is 4000 based on the inlet velocity and jet width. The dynamic Smagorinsky model (DSM) is used to resolve the subgrid scale stress tensor. The transition from laminar to turbulent flow has been numerically identified and discussed in details. The evolution of vortex roll ups, their transportation and final disintegration to smaller vortices have been visualized by the plot of isosurface of Q criterion. The coherent structures in a turbulent planar jet have been well demonstrated. The time series plots of λ_2 criterion shows the swirl and shear nature of the evolving vortices and their passage in the downstream. The time averaged velocity at far downstream ($\frac{x}{D}$=10 and 15) shows a self-similarity behaviour where the flow has established a fully turbulent nature. The energy spectra are shown to exhibit the -5/3 power law. The proper orthogonal decomposition (POD) shows that 90% of the fluctuating kinetic energy is contained within the first 100 modes. The probability density function on the centerline ($\frac{y}{D}$=15 and $\frac{z}{D}$=2.5) for different $\frac{x}{D}$ locations are plotted and the corresponding skewness and kurtosis values are reported for $\bar{u}, \bar{v}$, $\bar{w}$ and $\bar{p}$.

Keywords: planar free jet; LES; shearing and swirling vortices; proper orthogonal decomposition; coherent structures

Nomenclature

Roman Symbols

C	Smagorinsky coefficient
C^*	Smagorinsky coefficient at previous time step
D	nozzle width (dimensional)
I	turbulence intensity

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