Large-Eddy Simulation of the Air Flow Around a Truck

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Abstract

With increasing pressure on industry to reduce carbon emissions, newly designed vehicles are required to be more fuel-efficient. Understanding the relationship between the flow structures around a vehicle and its corresponding aerodynamic properties will help mitigate the large drag forces associated with today's heavy goods vehicles. Moreover a commonly adopted solution to improve efficiency is to reduce the vehicle's weight, which has implications on vehicle stability.

A Large-Eddy Simulation (LES) is a mathematical model used in Computational Fluid Dynamics (CFD); it is well suited to understanding the behavior of airflow around a vehicle, as it is capable of resolving large-scale vortex structures, in addition it models the expensive smaller scales. A LES has been made on a 1:25 scale model truck traveling in headwinds, at a Reynolds number of 200,000 based on the free stream velocity and the height of the vehicle. The subgrid scales have been modeled using a standard Smagorinsky model with the Van-Driest damping function. To isolate the effect of the mesh resolution on the LES results, two different meshes, coarse and fine have been used they consist of 2.8×10^6 and 11.0×10^6 cells, respectively. The mesh analysis shows that the results of the fine mesh are deemed to be similar to those of the coarse mesh, with regards to surface pressure and aerodynamic coefficients. In addition the LES Simulations have been compared with experimental data for validation and show a reasonable agreement. Further to the LES computations, two different Reynolds-Averaged Navier-Stokes (RANS) turbulence models, realisable k-epsilon and k-omega SST, were employed. The time-averaged vortex structures around the vehicle have been analysed, the flow separates at the leading edges of the container, generating separation bubbles. The time-averaged pressure distributions have been identified to find locations of critical peak and trough pressures. By visualising the instantaneous temporal development of vortex structures, coherent structures have been observed propagating along the roof of the truck. The aerodynamic forces on the truck were computed and using spectral analysis techniques the dominant frequencies of the fluid flow motion around the body were determined. The complex vortex structures that are generated underneath the vehicle have been detailed and their contribution to the pressure field has also been investigated.