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Investigating the Impact of Wind Tunnel Ground Conditions on Vortical Structures in the Turbulent Wake of an Ahmed Body

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Extended Abstract

The flow topology in the turbulent wake of a moving vehicle significantly influences the aerodynamic performance of the vehicle as well as the dispersion characteristics in the wake. The system of vortices formed just behind the vehicle body plays an essential role in determining the dispersion scales in the vehicle wake [1]. Researchers perform wind tunnel simulations to study the flow around simplified vehicle models (e.g. MIRA, DrivAer, Windsor, Ahmed body, etc.). To simulate the actual road conditions in the wind tunnel, it is desired to have a moving ground with respect to the vehicle model. However, due to the complications in designing and fabricating the rolling road in the wind tunnel, people often use a stationary wind tunnel floor or a false floor technique.

This study focuses on investigating the effects of the wind tunnel ground conditions (stationary/moving floor) on the flow topology in the turbulent near wake of an Ahmed body [2] with a rear slant angle, $\phi = 25°$. Particle Image Velocimetry (PIV) measurements were performed with the help of smoke particles (ethylene-glycol, $d_p=1\ \mu m$) to obtain the velocity in the near wake with stationary and moving wind tunnel floor. A continuous wave laser (5000 mW, $\lambda_{laser}=532\ nm$) along with sheet optics was used to form a laser sheet (2 mm thickness) to illuminate the smoke particles. The experiments are performed in an environmental wind tunnel (test section; *2 m ×2 m* and length *14 m*) at model length base Reynolds number, $Re_l = \frac{U_\infty \times l}{\nu} = 1.21\times 10^5$. A rolling road system along with boundary layer suction was used to provide the correct moving ground conditions. The boundary layer suction eliminates the boundary layer formed on the stationary floor ahead of the rolling road, and the moving ground translates with the wind tunnel free stream velocity (U_∞) to avoid further development of the boundary layer.

The time-averaged velocity and flow streamlines behind the Ahmed body were obtained and compared for stationary and moving ground cases. It is observed that the flow topology in the near wake is significantly affected by the ground plane conditions. For the stationary ground, two spanwise counter-rotating vortices (upper and lower vortex) are observed just behind the rear vertical of the model (as also observed previously by [3] and others). However, In the present study, we observed another anticlockwise vortex (Vortex 3) formed close to the ground just beyond the separation bubble. A similar vortex was also noticed earlier [4]. For the moving ground case, the upper and lower spanwise vortices (upper and lower) are present. However, the third vortex near the ground is absent due to the moving ground underneath the vehicle model. Results show that the wind tunnel ground conditions significantly alter the system of spanwise vortices in the near wake. Since these spanwise vortices are one of the primary factors affecting the dispersion phenomenon in the recirculation region [5]. Therefore, it is expected that the wind tunnel ground conditions will have significant effects on the pollutant dispersion in the near wake.

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