Numerical simulation of a freight wagon subjected to crosswinds

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Abstract

There is an international trend with the increasing speed of freight trains. As their aerodynamic forces are nearly proportional to the square of the speed there is a high risk of freight containers being blown off, causing damage to, and disrupting the running of the train lines. In this paper the aerodynamic performance of an isolated freight wagon, subjected to 15^{o} and 30^{o} side winds, has been analysed using large-eddy simulation and RANS methods (k-ε and k-ω turbulence models). The Reynolds number of the flow was 300,000 based on the height of the wagon from the floor and the side-wind relative velocity. The freight wagon model was a 1/20 scale of the FE freight type with single container and freightliner. The accuracy of the results of the large-eddy simulation was determined by performing two different LES computations on two different meshes: coarse mesh consists of 7 million cells and fine mesh consists of 12 million cells, respectively. The results of the two computations are compared and the comparison was deemed to be adequate.

Time-averaged flow and surface pressures developed from large-eddy simulation and RANS were analysed and their behaviour was explained. The surface pressure on the box was integrated to compute the aerodynamic forces. The fluctuating nature of the aerodynamic lift and side force coefficients was also analysed. Comparison between the time-averaged and instantaneous flows showed that at 30^{o} yaw angle large portions of the flow are steady and the unsteady behaviour of the flow appeared on the downstream half of the wagon. It has been also shown that the k-ω turbulence model provides comparable results to those of the time-averaged flow of the large-eddy simulation for this situation.

Moreover, the flow around a freight wagon at the middle of multiple-wagon train has been obtained and its aerodynamic performance has been analysed and compared with those of the isolated wagon. The main objective is to investigate the flow structure, force coefficients and vortex shedding frequencies experienced by the freight container.