Numerical Investigation of Time-Dependent Cross-Wind Effects on an Idealised Leading Rail Car

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For the optimization of modern high-speed trains it is essential to fully understand the physics of the instantaneous and time-averaged flow around the train body. Hence in the study presented here we conducted large eddy simulations (LES) of the flow around a simplified concept high-speed train model. Since the front of a train is subjected to the largest aerodynamic forces [1], the focus of this study was laid on the flow around the train's leading rail car. In terms of train aerodynamics a low Reynolds number flow ($Re = 2.1 \times 10^5$), based on the model's width, was investigated in order to restrict the already quite high computational costs usually needed for LES. So far simulations with the standard [2] and the dynamic Smagorinsky [3] model for subgrid-scale modelling were performed. The filtered Navier-Stokes equations were solved using a finite volume method based on cell-centred velocities and a PISO corrector method to realise the pressure velocity coupling on an unstructured grid with more than 13 Mio cells. Discretisation is realised with $2nd$ order accurate central differences in space and a $2nd$ order accurate backward scheme for the time-advancement.

One of the objectives will be to validate the predictions by comparing the results to those obtained in wind tunnel experiments with a down-scaled train model.
The simulations predicted the transition of the laminar flow in the vicinity of the train's nose to a fully turbulent flow in the wake region. It is shown that the LES used in the study is capable to predict the unsteady flow structures forming in the train model's wake.

References

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