University of Birmingham

Dominic Flynn: Numerical Investigation of the Effect of Crosswinds on the Slipstreams of Freight trains

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Background

The slipstreams of freight trains have been recognised as a safety concern due to the high velocities that are produced and their potential effect of moving passengers or objects waiting on platforms. A further issue is when the ambient wind conditions cause the slipstream velocities to be greatly increased by convecting the slipstream towards the leeward side of the train. This phenomenon has been observed experimentally but due to the scatter in the data the issue remains somewhat unresolved. Therefore clarification of the effect of crosswinds on the slipstream of freight trains is required to ensure potential safety risks are anticipated before an incident can occur.

Research aims and objectives:

Aim

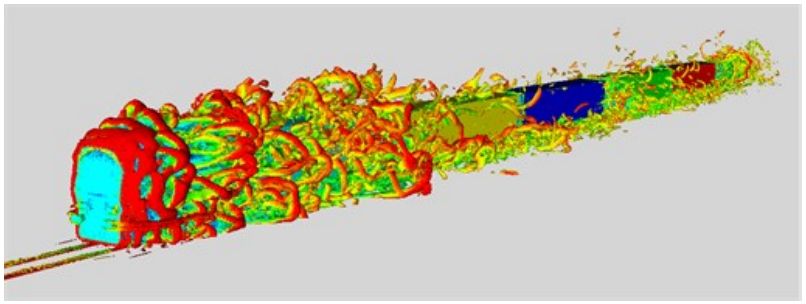
- To investigate the effect of crosswinds on the slipstream of a freight train and the force and moment coefficients on its wagons

Objectives

- Develop a numerical model in order to conduct simulations with representative inlet turbulence characteristics of the crosswind generator used in the validation experiments
- Conduct and validate numerical simulations of a model-scale Class 66 train subjected to no crosswind, 15 degree and 30 degree crosswinds in order to determine their effect on the slipstream of the Class 66 train and on the force coefficients on each container wagon
- Conduct and validate numerical simulations of a model-scale container wagon in isolated and artificial-consist formats in order to determine whether these formats give solutions which are representative of the flow experienced by the wagons in the Class 66 train

Method

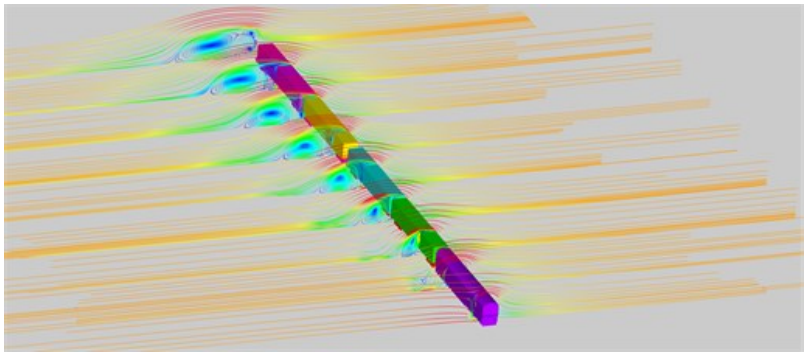
In order to determine the effect of crosswinds on the slipstream of a freight train the slipstream must be understood without any external effects i.e. no crosswind. Computational fluid dynamics (CFD) simulations using detached-eddy simulation (DES) will resolve the flow around the Class 66 freight train with 4 container wagons in tow. The results from the simulations will be compared to experimental data in order to validate the simulations. The time-averaged and instantaneous data from the simulations gives an insight into the flow which would not be attainable from experiments alone.



Vortices generated in train's slipstream

Once the slipstream of the Class 66 is analysed an additional crosswind will be added to determine the effect of crosswinds on the slipstreams of freight trains. The crosswind simulations will be validated against the physical experiments at 30 degree yaw by surface pressure coefficients on each container wagon. Further crosswind investigations will simulate the flow at 15 degree yaw.

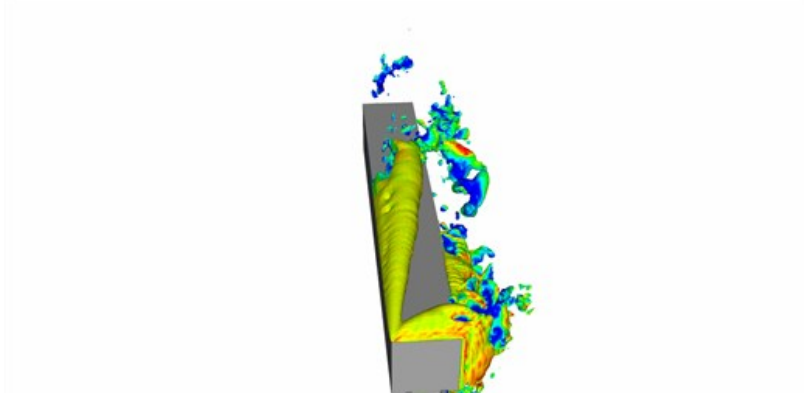
The work will not only focus on the slipstream of the Class 66 freight train but also on the force coefficients experienced by each wagon. The flow regime that each wagon will experience along the length of the train will change and therefore will experience different force coefficients. The effect of loading position and yaw angle on the force coefficients experienced by each wagon will be briefly investigated.



Leeward vortex generated along the length of the Class 66 train when subjected to a 30 degree crosswind

The computational cost of using advanced methods of CFD such as DES are relatively high compared with more commonly used Reynolds-averaged Navier-Stokes (RANS) methods which are often used in industry. However, DES methods are used because of the high quality of data that can be acquired. As well as the full Class 66 train freight wagons will be simulated in 'isolated' and 'artificial consist' formats. The purpose of using these methods is to determine whether the nature of the flow around a wagon in a train can be more economically replicated by only simulating the flow around one.

Instantaneous pressure iso-surface around an isolated wagon at 30 degrees yaw



Instantaneous pressure iso-surface around artificial consist wagon at 15 degrees yaw

Simulation of track switches using finite element methods

Collaborative research between the Birmingham Centre for Railway Research and Education (BCRRE) and Network Rail was conducted to establish the effect of introducing new parts to two current track switch mechanisms. The work was carried out using Abaqus and aimed to determine whether a train going through the switch, if it is locked the wrong way, would de-rail the train or cause permanent damage to the mechanism. The simulations allowed investigators to determine the stress levels on every deformable part within the mechanism.

Full-depth switch layout

New design of stretcher bar