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The effect of tail geometry on the slipstream and unsteady wake structure of high-speed trains

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Abstract

The effect of varying the roof-angle of the tail of a generic high-speed train on the unsteady wake structure and corresponding slipstream is investigated in a 1/10th scale wind-tunnel experiment. Insight into the slipstream and unsteady flow features are gained from 4-hole dynamic pressure probe measurements, surface-flow visualisations, measurements from a two-dimensional array of total pressure probes, and frequency analysis. The results show that increasing tail roof angle leads to a transition from an unsteady wake with a pair of streamwise vortices that exhibit sinusoidal, antisymmetric motion to an unsteady wake dominated by large-scale separation with vortex shedding from the sides of the train. It is the interaction of the streamwise vortices with vortex shedding from the sides that results in the widest unsteady wake, and consequently, the largest slipstream velocities.

Keywords: slipstream, high-speed train, wake, roof angle, tail geometry, vortex shedding

1. Introduction

The wake of a HST is where the largest *slipstream* velocities are found to occur [1, 2, 3, 4]. Slipstream is the air flow induced by a vehicle's movement. In practice, it is measured at a fixed distance from the vertical centreplane of the train. It is an important consideration for the aerodynamic performance but also for the safe operation of high-speed trains (HSTs). Such flows can be hazardous to commuters waiting at platforms and to track-side workers [5] due to the significant pressure forces. Regulations are in place that limit the magnitude of slipstream velocities a HST can induce [6, 7].

The importance of streamwise vortices to the wake structure of a HST has been identified in literature [1, 8, 9]. In particular, the authors have associated the high slipstream velocities in the wake to the presence of a time-averaged streamwise vortex pair [3, 10]. As the vortices move downwards and outwards beyond

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