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Optimization of emergency ventilation mode for a train on fire stopping beside platform of a metro station

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Abstract

This paper presents a computational fluid dynamics (CFD) simulation investigation of most effective cooperative operation mode of the tunnel rail track area exhaust system and the platform ventilation system for the emergency scenario of a train on fire stopping beside the platform of a subway station. CFD simulations are carried out by fire dynamics simulator (FDS) to analyse and compare the computed field distributions of smoke temperature and visibility, as to find out the most optimal cooperation mode of these ventilation systems. Results show that only starting the over track exhaust (OTE) system can control the smoke more effectively than starting both the OTE system and the under platform exhaust (UPE) system at the same time. In addition, setting the platform ventilation system as exhaust pattern can provide better control performance than setting it as air supply pattern, in counteracting the smoke flowed into the platform from the fire train. Therefore, it is found out and suggested that in such an emergency condition, the most effective strategic cooperative ventilation mode is only starting the OTE system of the tunnel rail track area with the aid of activation the smoke exhaust pattern of the platform ventilation system.

Keywords

subway train fire,
smoke exhaust mode,
temperature field,
visibility

Article History

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1 Introduction

1.1 Background and literature review

Fire safety is becoming more and more important for subway rail due to its rapid development in recent years. Fire occurred in the subway can cause catastrophic results of big loss in human life and property due to high traffic and intensive crowds (Chen et al. 2003). For example, fire at King's Cross subway station in 1987 caused 31 deaths and over 100 serious injuries; fire at subway station of Dague Korea in 2003 caused even more serious in which 198 people were killed by the toxic smoke.

Smoke is the most fatal factor in fires, especially in a subway fire where much toxic gases are released due to incomplete combustion. In addition, the subway construction is a relative confined space except for a few stairs connected to the ground. Therefore, smoke is more difficult to be discharged and thus accumulated in the station. When a fire is occurred in a subway station, the mechanical emergency ventilation system should be installed to exhaust the smoke out. However, in order to provide more reliable fire safety, appropriate smoke exhaust mode should be carefully considered. Subway station fires can be divided into two categories according to fire positions: fire at platform and fire in the tunnel connecting platforms.

In case of the tunnel fire, a number of studies have been reported in the literature since 1950s (Thomas 1958). The commonly existed longitudinal ventilation airflow in the tunnel contributes an influence of inertial force to the buoyancy driven dispersion of the smoke flow (Hu et al. 2010). A scale model experiment has also been conducted to understand fire phenomena in the near field of fire source in a tunnel (Kurioka et al. 2003). Computational fluid dynamics (CFD) fire simulation tools are widely applied in predicting the properties of tunnel fires (Vidmar and Petelin 2007; Li and Chow 2003; Yuan and You 2007; Bari and Naser 2005; Jain et al. 2011). Hu et al. (2007a) have investigated the smoke spread and carbon monoxide transportation in a long channel by using CFD techniques. Critical ventilation velocity (V_c) has been studied as an important parameter for the smoke control (Hu et al. 2008a). A study of an optimal

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