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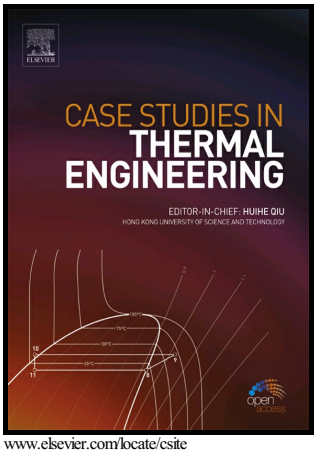

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Influence of mechanical smoke exhaust on smoke spread in underground tunnel

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Abstract

The model of a tunnel in Beijing is established, and the smoke reflux, the smoke reflux length and the influence of longitudinal wind speed on temperature distribution of the tunnel vault are studied using numerical simulation method. The length of the tunnel is 150 m, the cross section is circular, the height of the tunnel is 6.3 m and the width is 6 m. The simulation results show that the smoke reflux length of the subway tunnel fire decreases with the increase of the longitudinal positive pressure wind speed, and the reflux length decreases linearly with the increase of wind speed when the reflux length is more than 10 m. The gradient of the reflux length decreases with the increase of the wind speed when the distance from the fire source decreases. The temperature curve of tunnel vault is consistent. Under the same fire source heat release rate, the flue gas temperature decreases with the increase of ventilation wind speed, and the distance between the highest temperature of the ceiling and the fire source decreased with the increase of the longitudinal ventilation wind speed.

Keywords: Smoke spread; Reflux length; Numerical simulation

1. Introduction

Statistical results show that more than 85% of the deaths in the fire are due to the effects of smoke [1-2]. The subway is located in a small underground space, and a large amount of combustible materials are accumulated inside. Once a fire occurs, the toxic smoke generated by incomplete combustion of the fuel will spread rapidly in this confined space, which will directly affect the safety evacuation and fire rescue of firefighters. By opening the emergency ventilation of the subway system, the flue gas flow in the tunnel can be effectively controlled, the temperature in the tunnel can be reduced, and the passenger's exposure to excessive amounts of smoke in the train can be reduced, so as to provide safe passageway for evacuating and rescuing passengers and firefighters in a timely and safe way.[3]. Therefore, understanding the movement of smoke in subway fire is of great significance to the research and control of fire smoke.

In view of the study on the flue gas spread of the subway tunnel, many scholars focus on the setting of the exhaust port, the flue gas spreading speed and the diffusion distance, while the study of flue gas spread under different fire power and different longitudinal wind speed is relatively less. Dong-Ho Rie [4] et al established a 1:40 model bench to study the mode of mechanical smoke exhausting in the subway station, and combined the numerical simulation to study the optimal mode of the exhaust port opening in the subway station. Shi [5] et al. carried out a full-scale fire test in the subway station tunnel to study the longitudinal propagation velocity of smoke in an interval tunnel and the vertical and horizontal temperature distribution of flue gas under the condition of tunnel smoke longitudinal propagation velocity, the vertical index change characteristics of flue gas flame tilt angle and the gas temperature rise of the ceiling were analyzed. Zhao [6] analyzed the diffusion, distribution and movement of smoke in the subway tunnel using the fire inspection and acceptance results of Guangzhou Metro corporation. Vauquelin [7-8] and other scholars choose light gas to simulate hot flue gas, using 1:20 scale model to study smoke movement in a horizontal tunnel, the relationship between the fire heat release rate, smoke diffusion distance and exhaust wind speed was obtained. Furthermore, it was pointed out that the induced wind speed was an important index to evaluate the effect of smoke exhaust. Yan [9] carried out full-scale experimental study and numerical simulation of tunnel fire with top opening, measured the smoke flow velocity field and the temperature field, and used the data to verify the accuracy of numerical simulation results. E. Blanchard、P. Boulet [10] et al studied the critical wind speed, the flue gas temperature distribution and the smoke diffusion rate during the different fire location using FDS software, and compared the simulation results with the experimental data of the 1:3 model. Feng [11-12] used the network model software to simulate and analyze the relation between the smoke reflux length and the critical wind speed in the subway tunnel.

In this paper, the critical wind speed of full-scale tunnel under different fire power is studied by numerical simulation. The relationship between the critical wind speed and the power of the fire source as