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Case Study

Preliminary study of water mist suppressing ghee flame in historical building in the northwest China

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Abstract

In order to protect historical buildings in the northwest China from fire, the most of which are temples for Buddhism, water mist suppression system is chosen due to less damage on water-soluble decorations. This study is to investigate the feasibility and efficiency of water mist suppressing fire occurred in historical buildings. Eternal ghee lamp over the years is serious fire hazard for these temples. In this paper, the interaction of water mist and ghee flame under different external radiant heat fluxes is studied. Water mist was generated by a downward-directed single pressure nozzle. The heat release rate, carbon dioxide and carbon monoxide concentrations, and other important parameters of the interaction under various experimental conditions were measured with cone calorimeter. It is indicated that water mist can assuredly suppress ghee flame. But ghee combustion is enhanced for a short time just on discharging water mist, and then ghee flame is extinguished quickly under continuous water mist application.

Keywords: Water mist; Ghee flame; Historical building

1. Introduction

All historical buildings, which have not been brought under the control of modern fire precautions, must have problems in fire safety, because the techniques of our 21st century were not available when such buildings had been erected. Even in cases where later on our ancestors provided some improved fire protection to these buildings the probability of fire occurrence and the extent of fire damage was reduced only according to the state of the art of that time. As development of the "state of the art" is always a time depending continuing process the latest, deemed, as the best is better that the previous. Consequently, there will always be the question of the degree of fire protection and the amount of expenses which shall be made available for heritage which is unique and is lost for ever once it has been destroyed.

In the northwest China, especially in Xizang and Gansu Provinces, there are many historical buildings, the most of which are temples for Buddhism. These temples always have long history, for example, the Budala Palace in Xizang Province was built seven centuries ago. However, these temples also suffer from fire hazard. According to the tradition of the northwest China, ghee lamps are always on for the respect to Buddha, which is the main fire hazard for these historical buildings. In 1985, there are a big fire occurred in the Labuleng Temple in Gansu Province, built in 1709, which lasted 16 hours, and made the Big Classics Hall be burned to ashes and many classics, cultural relics and jewelry be crumbled to dust. The fire investigation showed that the fire was initiated from a ghee lamp, which ignited the nearby wood stained with ghee due to wind [1]. Therefore, it is necessary and important to establish fire suppression system for these historical buildings.

Water mist is now commonly used in fire extinguishing systems as an alternative to gas protection with halogenated agents. There is another advantage of using smaller amount of water to give less water damage, which is especially useful for water-soluble decorations in historical buildings. The work done in Norway to develop a low-water-flow system to control fires in wood-stave churches without causing excessive damage to water-soluble paintings on the walls represents an

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innovative application of water mist [2]. The potential to use water mist in libraries is under development at the University of Maryland, in conjunction with the Reliable Automatic Sprinkler Company [3]. The water mist fire suppression systems have been reviewed [4–7].

This study is to investigate the feasibility and efficiency of water mist suppressing fire occurred in historical buildings in the northwest China, the most of which are temples for Buddhism. The first work is to study the interaction of water mist and ghee flame, which is the main fire hazard for these temples. The next section gives the experimental details. Section 3 presents the experimental results and discussions, followed by conclusions and future work.

2. Experimental details

2.1. Generation of water mist

Water mist was generated by a single pressure atomizer as shown in Fig. 1. A commercial full-cone nozzle with an effective angle of about 90° was used to generate the water mist. Water should be filtered before delivering into the nozzle. The pressure and the volume flux characteristics of the water mist nozzle used in the tests are shown in Table 1.

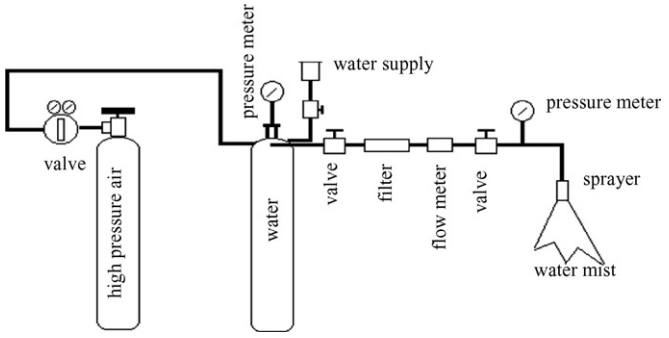

Fig. 1. Generation of water mist.

The particle size, velocity distribution and mist volume flux of the discharged water mist flow were measured experimentally by Laser Doppler Velocimetry and the Adaptive Phase Doppler Velocimetry system (LDV/APV). The measuring techniques and the system configuration have been described in detail before [8,9]. This system is based on the light scattering theory of non-conductive spherical particles and the characteristics of water mist. Major components include laser, light beam optics, a transmitting system, a collecting system, photodetectors, splitting signal processing electronics, an external data input device and a computer with software.

Using LDV/APV, the radial distribution of the water mist characteristics is shown in Fig. 2. The relationship between the droplet size and the nozzle axial is given in Fig. 2a, and the axial mean velocity of the water mist under the pressures of 0.4 and 0.7 MPa are shown in Fig. 2b. From Fig. 2, the volume mean diameter of the water mist is about 61 μm, which accords well with the definition of water mist.

2.2. Experimental methods

A standard cone calorimeter following ASTM E1354 with a small water mist system was used [10], a schematic diagram of which is shown in Fig. 3. The cone calorimeter was developed to measure the heat release rate from a burning surface and analyze the combustion products when a constant flow of air is provided into the confined space. The combustion characteristics such as heat release rate, combustion efficiency, burning delay time and gas concentration can be determined. This apparatus was modified in this paper to study the interaction of water mist with ghee flame in a confined space. Combustion characteristics can be measured without and with water mist. The experiments were performed in a glass-walled enclosure of size 0.6 m by 0.6 m by 0.7 m in a cone calorimeter. The fuel sample was placed on an electronic balance under different radiant heat fluxes. In this paper, radiant heat fluxes of 50 and 70 kW/m^2 (the corresponding temperatures are 800 and

Table 1
The pressure and the volume flux of the water mist nozzle

Pressure (MPa)	0.2	0.3	0.4	0.5	0.6	0.7
Volume flux (ml/min)	68	88	103.5	112	125	134

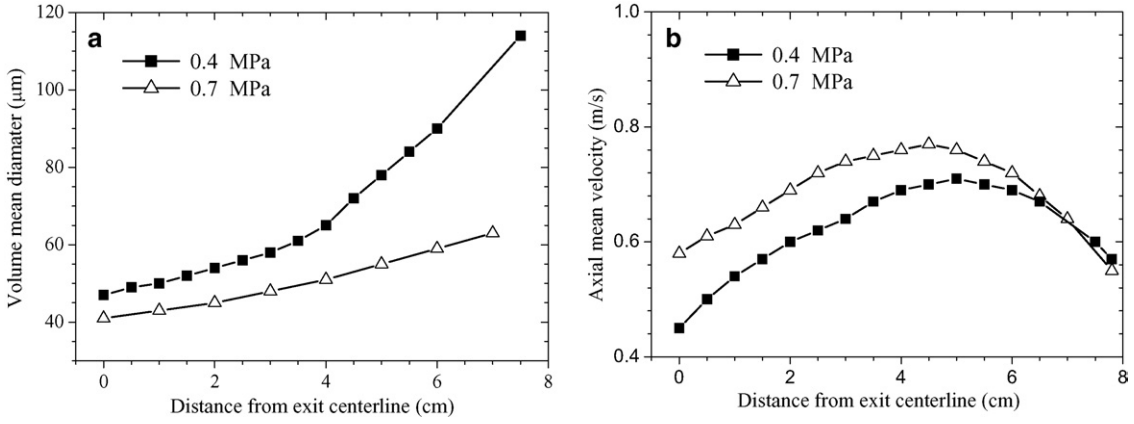

Fig. 2. Radial distribution of the water mist characteristic values: (a) volume mean diameter, (b) axial mean velocity.